U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

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

SOIL SURVEY OF THE RIVERSIDE AREA, CALIFORNIA.

BY

J. W. NELSON, IN CHARGE, AND R. L. PENDLETON, OF THE UNIVERSITY OF CALIFORNIA, AND J. E. DUNN, A. T. STRAHORN, AND E. B. WATSON, OF THE U. S. DEPARTMENT OF AGRICULTURE.

MACY H. LAPHAM, INSPECTOR, WESTERN DIVISION.

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

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., January 31, 1917.

SIR: I have the honor to transmit herewith the manuscript report and map covering the survey of the Riverside area, California, and to request that they be published as advance sheets of the field operations of the Bureau of Soils, 1915, as authorized by law.

The selection of this area was made after conference with the State officials cooperating with the bureau in the work of surveying and classifying the soils of California.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

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

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SOIL SURVEY OF THE RIVERSIDE AREA, CALIFORNIA.

By J. W. NELSON, In Charge, and R. L. PENDLETON, of the University of California, and J. E. DUNN, A. T. STRAHORN, and E. B. WATSON, of the U. S. Department of Agriculture.—Area Inspected by MACY H. LAPHAM.

DESCRIPTION OF THE AREA.

The Riverside area occupies the eastern part of what is known as the "Valley of Southern California." It comprises the western part of Riverside County and the southwestern corner of San Bernardino County. The area lies about 35 miles east of Los Angeles. It is bounded on the north and northeast by the Sierra Madre and San Bernardino Mountains, respectively. The Santa Ana Mountains and the associated Puente Hills, with the Box Springs Mountains and various connected or detached series of broken elevations, form the curved boundary on the south. The western boundary is a north and south line extending across the open valley a short distance west of Ontario. The Jurupa Mountains, Mount Rubidoux, and several lower elevations are included in the southern part. The area comprises 606 square miles, or 387,840 acres.

FIG. 1.—Sketch map showing location of the Riverside Area, California.

This survey covers the greater part of the area included within the earlier soil survey of the San Bernardino Valley, California.[1]

Topographic sheets of the United States Geological Survey were used as base maps in the prosecution of the field work, with some revision made necessary by recent changes in the location of roads or in other cultural features.

The partly inclosed valley in which the Riverside area lies has two openings to the west, one in the vicinity of Lordsburg and San Dimas, and the other west of Pomona. These are several miles beyond the western boundary of the area surveyed. They form outlets to Los Angeles and other centers of population. The mountains to

[1] Soil Survey of the San Bernardino Valley, California, Field Operations of the Bureau of Soils, 1904.

the north and east are high and rugged and have through erosion supplied most of the alluvial material transported into the valley and now constituting the valley filling. These vast deposits occur mainly as a series of moderately to steeply sloping, coalescing alluvial fans, which gradually spread out valleyward into an extensive plain with a slope southward to the Santa Ana River. From the Santa Ana River to the mountains north of Cucamonga, a distance of about 16 miles, there is a fall of about 2,000 feet, the greater part of which occurs north of the Atchison, Topeka & Santa Fe Railway. The area ranges in elevation from about 500 to 2,750 feet above sea level. The principal surface irregularities occur in the region northwest and west of Riverside. A few isolated knobs and low ridges occur over the recent-alluvial plains from Upland eastward. These are remnants of an older surface not yet entirely removed by erosion.

Along the lower courses of the Santa Ana River and Lytle Creek small bottom-land areas have been developed, ranging from about one-fourth to 1 mile in width.

The Santa Ana River, which traverses the area in a southwesterly direction, is the principal drainage way. Lytle Creek, entering the valley northwest of San Bernardino, is its largest tributary. This stream, like many smaller creeks, is intermittent. A large number of small streams from the mountains on the north and east carry large volumes of water during heavy rains, but ordinarily they sink into the gravels and sands of the extensive sloping fans and seldom maintain a continuous flow to the main drainage way. The streams are not deeply intrenched, and many overflow their banks in the rainy winter season. Frequently new channels are formed as the old ones become clogged with rock débris.

The valley portion of the Riverside area is structural and, although the main drainage ways appear to be quite well established, most of the subsidiary channels are still subject to considerable change in the direction of their courses. The streams have good fall except in the region south of San Bernardino, where a natural dike crosses the valley. This retards the movement of both surface and underground waters, resulting in semiswampy conditions and the presence of a high water table.

The population of the area surveyed more than doubled in the period from 1900 to 1910. Most of the people live in towns and cities, which range in population from a few hundred to 15,000 or more. A large number live on farms. The area is thickly settled except along the northern boundary and in the sections between Etiwanda and Rialto and west and southwest of Bloomington. A

large part of the population consists of homeseekers from Eastern States. There are some Japanese and Chinese gardeners in districts in which trucking is important, but they constitute only a small percentage of the population.

Nearly all sections of the area are well supplied with good roads, schools, churches, libraries, and rural mail-delivery and telephone service. Riverside, San Bernardino, Redlands, Ontario, Colton, Corona, Upland, and Rialto are the leading cities and towns. There are several canneries, many citrus-fruit packing houses, and a number of factories in the area.

Good transportation facilities are provided by a number of electric lines and three steam railroads—the Atchison, Topeka & Santa Fe, the Southern Pacific, and the Los Angeles & Salt Lake.

The chief industry is the production of citrus fruits, which are shipped to all parts of the United States. Most of the dairy products and truck crops are consumed locally, but some are shipped to villages and towns to the east and north.

CLIMATE.

A wet season and a dry season, coinciding with winter and summer, respectively, characterize the climate of the Riverside area. The rainy season begins about the last of September and ends about the last of May. About 90 per cent or more of the total rainfall occurs in this period, and the remainder closely precedes or follows it. There is frequently a period of 100 or more consecutive days without rain in the dry season. The precipitation varies greatly from year to year. It is heaviest along the foothills surrounding the area and lightest near the middle of the valley. The distribution of the rainfall and the character of the soil are the main factors controlling the range of crops where irrigation is not possible. Heavy rainfall occurs at times over extensive areas, and when this continues for several days the streams become swollen and sometimes do considerable damage. The rugged, steep nature of the near-by mountains, with their shallow soil and scant vegetation, makes the run-off rapid, and huge bowlders frequently are moved by the streams considerable distances out into the valley. During such periods a great amount of water is lost as "run-off," especially where the soils are heavy or tend to pack.

Snow, hail, and thunder storms are rare in this area, although they are not infrequent in the high mountains to the north and east. The snowfall reaches considerable depths in the mountains and seldom entirely disappears until near midsummer.

The following table shows the mean monthly and annual precipitation as recorded at Weather Bureau stations located in different parts of the area:

Mean monthly and annual precipitation at various stations in the Riverside area.

Month.	Chino, San Bernardino County.	Corona, Riverside County.	Riverside, Riverside County.	Redlands San Bernardino County.	San Bernardino, San Bernardino County.	Upland, San Bernardino County.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	3.96	3.51	2.01	2.83	3.33	4.93
February	2.59	1.88	1.98	2.81	2.99	3.40
March	3.74	2.34	2.34	3.10	2.91	5.27
April	.48	.67	.68	.69	1.17	.99
May	.46	.10	.35	.71	.60	1.04
June	.03	.00	.05	.11	.08	.15
July	.02	.05	.02	.02	.04	.04
August	.02	.02	.14	.34	.15	.05
September	.10	.34	.14	.34	.14	.25
October	.79	.30	.54	.71	.60	.88
November	1.33	.48	.77	.95	1.39	1.33
December	1.90	2.40	1.57	2.35	2.57	2.65
Year	15.42	12.09	10.59	14.96	15.97	20.98

The extreme temperatures vary considerably in different parts of the area. The cool ocean breezes are gradually warmed as they pass eastward and frequently result in hot winds in summer. The temperature at times exceeds 100° F. Both the mean annual and the maximum temperatures are several degrees higher in the eastern part of the area surveyed than in the western part. The temperatures are noticeably influenced by topography and wind movement, particularly on the steeper foothill slopes and alluvial fans and at points where canyons emerge from the mountains. Such areas have good air drainage and are usually free from damaging freezes. The lower and flatter areas, however, serve as catchment basins for cold-air currents in winter and are less desirable for the citrus fruits. Tomato vines have been known to live and bear for three years in especially favored localities, and sunflowers bloom every month in the year in nearly all parts of the area.

The following table shows the maximum, minimum, and mean temperatures, by months and for the year, as recorded at various points in the area:

Monthly and annual maximum, minimum, and mean temperatures at various stations in the Riverside area.[1]

Month.	Chino.			Riverside.			Redlands.			San Bernardino.			Upland.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
January	.....	.....	51.1	87	21	51.1	85	18	51.0	87	18	51.5	83	26	50.0
February	.....	.....	53.4	90	24	52.7	88	25	52.9	90	22	53.7	87	22	52.0
March	.....	.....	55.3	94	25	55.9	95	29	55.5	95	26	55.5	88	24	53.6
April	.....	.....	60.8	104	31	60.4	100	32	60.7	103	29	59.8	98	32	57.9
May	.....	.....	65.4	103	33	65.2	105	35	64.4	108	33	63.7	101	36	60.2
June	.....	.....	72.2	107	40	70.6	110	40	71.7	112	37	69.8	105	39	67.1
July	.....	.....	77.7	110	44	76.3	113	49	77.4	111	42	75.6	108	42	72.9
August	.....	.....	76.4	111	45	76.4	112	47	77.2	111	42	75.7	106	42	72.9
September	.....	.....	72.3	112	41	72.1	109	41	72.2	111	38	71.1	105	44	70.0
October	.....	.....	65.3	103	31	64.2	102	37	65.7	105	31	64.2	98	39	63.6
November	.....	.....	57.0	95	27	58.2	95	28	58.1	99	24	57.4	90	30	57.2
December	.....	.....	52.2	88	21	53.4	84	25	52.9	88	19	52.4	86	26	52.1
Year	.....	.....	63.2	112	21	63.0	113	18	63.3	112	18	62.5	108	22	60.8

[1] Computed from records covering periods of 14 to 30 years.

The following table shows the average and extreme dates of the last killing frost in the spring and the first killing frost in the fall, as compiled from Weather Bureau records at several stations:

Dates of killing frosts in the Riverside area.

Station.	Elevation above sea level.	Average date of first killing frost in fall.	Average date of last killing frost in spring.	Earliest killing frost in fall.	Latest killing frost in spring.
	Feet.				
Chino	714	Dec. 19	Feb. 15	Nov. 21	Mar. 4
Riverside	851	Dec. 16	...do.....	Nov. 12	Apr. 2
Redlands	1,352	Dec. 17	Feb. 12	Nov. 24	Apr. 9
San Bernardino	1,054	Nov. 18	Mar. 14	Oct. 23	Apr. 15
Upland	1,750	Dec. 17	Feb. 16	Nov. 22	Apr. 2

The winds are prevailingly from the west, but occasionally in the winter and spring strong winds enter the valley from the north through the Cajon Pass and cause some damage to citrus fruits in that part of the area. Windbreaks are of great value in exposed places. There are occasional hot winds from the desert regions to the east. These are dry and oppressive and are known locally as "Santa Anas" or "Santa Ana winds." The winds seldom cause dam-

age, except on the lighter textured soils, where serious injury often occurs as the result of drifting sand.

Some fog occurs in the winter months, and occasionally in the summer the sun is obscured by fog during part of the forenoon. The humidity is lowest in the eastern part of the area and gradually increases westward.

In general, the climate is very healthful and favorable to the production of a wide range of fruit and other crops.

AGRICULTURE.

Prior to 1771 the Riverside area was occupied by Indians, and little or no attempt was made to grow cultivated crops or to raise cattle. The mission padres entered southern California shortly after 1770, and a primitive agriculture was developed, consisting of the production of grapes, olives, figs, and grain and garden crops around the missions. The low-lying areas usually were selected, on account of the more favorable moisture conditions, and crude canals were constructed for irrigation.

Large tracts of land were granted to individuals by Mexican officials, and cattle raising became a thriving industry. Sheep were introduced about 1860, and sheep raising soon became the leading interest, continuing so for 20 years or more. Settlement and development were retarded considerably by the extent of the land grants. These were gradually subdivided, and the areas favorably situated for irrigation were the first to be utilized for intensive farming. Such crops as grain and grapes, which would mature without irrigation, were grown on the uplands, and many sections of the area in which irrigation has not been developed are still devoted to these crops.

A few seedling orange trees were planted at various places in the area, and it was soon learned that the climatic conditions were favorable for citrus fruits. The settlement of the Riverside colony in 1871 marked the beginning of a decided advance in horticulture. A canal was constructed leading from the Santa Ana River to the higher lands, which were divided into small tracts for development. About 1,500 acres had been planted by 1875, principally to grapes, which were more profitable at that time than other fruits.

The Washington Navel orange was introduced in 1873 by the United States Department of Agriculture. The success of this orange showed the possibilities of the region for such fruit, and extensive plantings were made in various parts of the area as rapidly as nursery stock could be grown. The presence of large quantities of underground and surface water in different parts of the area has made the production of a wide range of profitable crops possible.

Oranges now rank first in importance among all the crops grown in the area, occupying about 45,000 acres in 1915. Orange growing is principally developed on the mountain foot slopes and recent-alluvial fans, in the areas of the older valley filling, and in favorable locations around the Jurupa Mountains. The main centers of the industry are Redlands, Riverside, Upland, Rialto, High Grove, Arlington, Highlands, Corona, and Bloomington. In an extensive area roughly forming a triangle, with points at Ontario, Corona, and Rosena, there are practically no groves, mainly because the region comprises a plain without sufficient relief to afford protection from frost and wind, has unusually light textured soils, and is inadequately supplied with water for irrigation.

About 90 per cent of the oranges grown are produced on the sandy loams, fine sandy loams, gravelly sandy loams, and gravelly loams of the Hanford, Placentia, and Ramona series and the high-fan phase of the Yolo silty clay loam. The trees bear regularly and are heavy feeders. They respond to liberal applications of organic matter either as manure or as cover crops plowed under. Large quantities of commercial fertilizer are used. Applications are made at different times in the year. Many mixtures are used, with marked differences in results even from the use of the same combination, and the growers have not yet determined by experience the most efficient and economical treatment for the different soils.

It is customary to plow the groves once a year, and clean culture is the rule, though in some cases no tillage is practiced, and a surface mulch of straw, hay, or other coarse material is maintained to check evaporation and promote the development of the young feeding roots in the highly fertile upper few inches of soil. In some groves hoed crops are grown until the trees come into bearing.

Usually the groves are given 5 to 8 irrigations a season, the number depending upon the lateness of rain in the spring and the time of its occurrence in the fall, the winds, temperature, and the character of the soil and subsoil. Where possible the water is run in a sufficient number of furrows to wet the land to a depth of about 4 feet for bearing trees. From 5 to 7 acres are covered by 1 miner's inch of water, at a cost varying from about $2.50 to $20 an acre per year. Smudging for protection from frost is practiced in most of the groves, but is considered unnecessary on the more favorable slopes. Smudging materially increases the cost of production.

The Washington Navel and the Valencia are the main varieties grown, the former being the more popular. More than 90 per cent of the fruit produced is of these two varieties. The Navel orange is harvested from December to May, inclusive, and the Valencia from May to August, inclusive. The yields vary widely, depending

upon the care given the trees, the soil, fertilization, topographic location, water supply, and age of the groves. The trees begin to bear about the fourth year, and reach their maximum production at about 12 to 18 years. Statistics from the Citrus Protective League give the average annual yield per acre for a period of 5 years as 157.6 packed boxes. This is for a large acreage and is much below the average where conditions are most favorable. The maintenance cost varies greatly, but ranges from about $75 to $150 an acre per year.

A small acreage is devoted to grapefruit. Where this fruit is given good care and grown on adapted soils it is very profitable.

Small plantings of lemons were made in various parts of the area many years ago. The acreage has increased greatly in recent years. About 7,000 acres are now in lemons, mainly in plantings not yet in bearing. Lemons are grown in the same localities as oranges, but have been planted only in a very small way in the Redlands, High Grove, Riverside, and Arlington districts. The large, steeply sloping alluvial fans south of Corona and east of San Antonio Canyon seem well suited to lemons, and there are extensive areas in other sections that may be utilized for the culture of this fruit if water can be obtained. The trees are thrifty and bear very heavily in favorable years. About 90 per cent or more of the plantings have been made on the high-fan phase of the Yolo gravelly loam and the gravelly sandy loam, sandy loam, loam, and gravelly sand of the Hanford series. The physical properties of these soils are unusually favorable for deep root development, and, together with their good drainage, thorough aeration, and relatively rapid absorption of water and heat, appear to meet the exacting demands of this crop. These soils are also well suited to cover crops, which makes it possible to supply large quantities of organic matter if desired. Lemons are a long-season crop, and usually require more attention for frost protection than do oranges. They are also sensitive to treatment, and their production generally entails more care and greater expense than does the growing of oranges. The methods of irrigation, tillage, cultivation, and growing cover crops used for oranges are also employed in growing lemons. Pruning is done once each year to remove dead limbs and keep the bearing wood near the ground. The Eureka and Lisbon are the main varieties grown. From 75 to 90 trees are planted to the acre. According to information obtained from growers and from the Citrus Protective League, the annual maintenance cost is $30 to $100 per acre up to the end of the fifth year. The maintenance cost after this usually is slightly more than for oranges. Yields vary greatly, depending upon the many factors that influence the growth of the crop. The average annual yield for a 5-year period over a large acreage in the southern part of the area is reported as 196.2 packed boxes of 75 pounds

each per acre, and the average cost of caring for the groves as about $1 a box. Land devoted to lemons varies greatly in value, but usually brings the highest price of all fruit lands.

Lemon production is very highly specialized, and neglect of any of the essentials is likely to result in injury to the grove and loss to the grower. California produces about one-half the lemons consumed in the United States, and there is apparently opportunity to increase the production in the area surveyed.

Peach growing is a very important and well-established industry, largely confined to the region southeast and northeast of Ontario. Small plantings were made at various places in the area many years ago, mainly to supply local requirements. There are now about 6,000 acres planted to this fruit, and a cannery has been built to handle the product. About 95 per cent of all the peaches grown are produced on two very closely related types of soil, the Hanford sand and Tujunga sand. These soils have proved well adapted to this fruit, and usually give good returns. They are loose and are drifted more or less by the wind, but the soil is deep and contains sufficient silt and fine sand to make it absorptive and retentive of moisture, and irrigation is not necessary. Some manure and coarse material are used, but cover crops are seldom grown, as they are likely to be destroyed by the drifting of the sand. Practically no commercial fertilizer is used, but the manure available is spread around the trees. The trees come into bearing the third year; some profit is realized the fourth year, and the trees generally continue to produce profitably until about 15 years of age. Egyptian corn is sometimes grown among the trees until bearing begins, after which clean culture is the rule.

The Muir, Lovell, Tuskena, and Phillips Cling are the leading varieties. Yields of 2 to 5 tons per acre are obtained, and in a few cases much higher yields are reported in favorable years. The fruit is contracted for at a certain price per ton for a period of years, or is sold at the market price at the time of harvesting. Prices vary from $18 to $25 a ton at the cannery. The cling varieties usually are in greater demand. The maintenance cost in growing peaches is very low. There is a very scant weed growth in the orchards, no fertilizers are used, irrigation is not practiced, and a natural surface mulch is maintained, which greatly reduces the need of cultivation. Some growers contract at the rate of $10 an acre per year for plowing, cultivating, and pruning, and many do the work themselves. Hauling the product to market or shipping points is costly, owing to the very sandy roads, and ranges from $2.50 to $4.50 a ton, depending on the location. Unplanted land suited to peach culture sells for $75 to $200 an acre, depending upon the quality of the soil, the location, and the leveling required.

Apricots do well on a wide range of soils, but are principally confined to the Hanford and Tujunga sands southeast and northeast of Ontario. There are some smaller plantings north of Corona, around Bloomington, and at various other places in the area. The acreage is very small compared with that in peaches. The fruit is sold fresh, dried, or canned. The trees are vigorous growers and yield well. They respond to the same treatment given peaches, but require more pruning. They are usually longer lived than peach trees and are not seriously affected by pests. The fruit is as a rule successfully grown without irrigation on the light-textured soils, but irrigation is practiced on other types.

Climatic conditions are not very favorable for apple culture. The most extensive plantings are about 1 mile north of Devore, along the slopes of the Cajon Canyon, at an elevation of about 2,500 feet above sea level. While most of the trees are young, they appear to be in good condition. Early-maturing varieties seem to do best. The apples are grown mainly for home consumption.

A few pear trees have been set out in different parts of the area, but little attention has been given to the possibilities of pear growing. Within the last year or two several small areas have been planted to pears on the high alluvial fans northwest of Rialto, but the trees are not yet in bearing. Both apples and pears require irrigation, good care, and protection from pests.

Grape culture has long been a source of considerable revenue. There are about 16,000 acres in bearing vines. One-fourth of this acreage is in one vineyard owned by the Italian Vineyard Co., located at Guasti. Viticulture is mainly confined to the section around Guasti, Wineville, and Declez and northwest of Rosena. About 95 per cent of the grapes are produced on the gravelly sands and sands of the Hanford and Tujunga series. These light-textured soils give very good returns. They contain a large percentage of silt and fine sand in the subsoil and substratum and are absorptive and retentive of rainfall. The soils are very permeable, and roots in many places reach a depth of 10 feet or more. No irrigation is practiced, except locally where table or raisin varieties are produced. The vineyards are plowed early in the spring and kept cultivated during the summer to conserve moisture. No fertilizer is added, and the fruit is produced on the current year's growth, without trellising.

Many varieties are grown, but the Zinfandel and Burger are the most popular. The grapes are grown mainly for wine making, and several large wineries are located at various places in the grape-growing section. The vines come into bearing when about 3 years old and yield well for many years under favorable conditions. The cost of production in this area is not high, and yields of 2 to 5 tons per acre are obtained, depending largely on the age of the vines, the

rainfall, pests, and care. Careful pruning is practiced each year, and the large quantities of brush removed are burned in sheet-iron wagons which move through the vineyard as the brush is gathered. The soils utilized for grape growing appear very well adapted to the purpose. Few other crops would thrive under similar conditions without irrigation and the use of fertilizers. Most of the labor is performed by Italian day laborers.

Olives have been grown in a small way since the earliest settlement of the area, and the plantings were more extensive formerly than now. Poor varieties were planted, and it was thought that no irrigation and very little care were necessary. As a result very low yields were obtained, and olive growing declined rapidly. Many of the early plantings were removed or grafted to more desirable varieties, and in recent years it has been found that irrigation, good care, and fertilizing are necessary for success. Many trees are planted as borders around citrus groves and other orchards; these usually yield well and are quite profitable. Most of the fruit is pickled and consumed locally. The largest acreage in olives is south and east of Declez, and less extensive plantings are located in other places throughout the area. The gravelly sand, sand, and sandy loams of the Hanford and Tujunga series are most extensively used for this crop.

Figs are grown in a small way, mainly as border trees, but little attention is given to their production, and they occupy a very unimportant place among the crops of the area.

Large quantities of vegetables and small fruits are produced along the Santa Ana River bottoms northwest of Riverside and in favorable areas near all the larger towns. A large part of these crops is consumed locally, and considerable quantities are shipped outside the area. In general, both vegetables and small fruits produce heavy yields. Irrigation is generally necessary, and the light-textured soils give best returns.

Walnuts are grown commercially in a small way, mainly on the Hanford fine sandy loam and loam and in small tracts on other soils. These trees are grown also in borders and in groves around farm buildings. They do best on deep and rather light textured soils. The land is plowed in the spring and cultivated at intervals throughout the summer to conserve moisture and kill weeds. The irrigation given depends upon the soil, age of the trees, and location. Water is generally applied 2 or 3 times, and in rather unfavorable locations as many as 5 to 7 times. The trees are generally set 40 to 45 feet apart, but experience indicates that a distance of 50 to 60 feet is more satisfactory. Peaches, apricots, grapes, and apples are used as fillers, but apples are not favored, on account of the codling moth which also attacks the walnut. The average maintenance cost, in-

cluding picking and hauling, is about $50 an acre. Yields range from about 800 to 1,500 pounds per acre, and the price in recent years has varied from 12 cents to 17 cents a pound. Blight is the principal disease affecting the trees, and considerable difficulty has been experienced in controlling it. The Placentia, Eureka, Prolific, and El Monte are most popular varieties of walnuts. Cover crops are not extensively grown, but in places it is a common practice to grow alfalfa in the middles for a few years. Melilotus, barley, oats, and vetch are grown to some extent for green manure. Intertilled crops, such as potatoes, beans, corn, onions, squashes, tomatoes, and various other vegetables are successfully grown among the trees in many places until they begin to bear. In some instances only a few furrows are plowed along each row of trees the first year, and the tilled area is gradually increased as needed, until all the intervening space is used.[1]

A number of other fruits, nuts, and subtropical crops are grown in a small way, but their commercial possibilities have not been demonstrated.

Alfalfa has been grown for many years and ranks as a very important crop. It is grown to a greater or less extent throughout the area, but the section several miles south and southeast of Ontario produces more than one-half the total for the area surveyed. From 12,000 to 15,000 acres are devoted to alfalfa, and the acreage is steadily increasing. The crop does well on a wide range of soils but is grown principally on the sands and sandy loams of the Hanford and Tujunga series. It is longer lived on the heavy soil types than on the sands and sandy loams, but its rapid growth and heavy yields on the lighter textured types make it one of the most valuable crops that can be grown. From 5 to 8 cuttings per year are obtained, with yields of three-fourths ton to 1½ tons per acre to the cutting. In some cases lower or higher yields are obtained, depending upon the soil, care, age of the stand, and irrigation. On the sands the yield frequently begins to decline somewhat after the fourth year, and frequently the crop becomes unprofitable after the seventh or eighth year. According to farmers growing the crop, it is moderately profitable if fed to dairy cows when produced on land costing $75 to $125 an acre and where the water lift is not over 50 to 65 feet. Where the lift is 100 feet or more, the cost of water ranges from $12 to $25 an acre per year. The first crop is produced without irrigation in most cases, and one irrigation is given to each succeeding crop. Much of the alfalfa is fed locally to dairy cows, a large

[1] See "Walnut Culture in California," Bul. No. 231, Agr. Expt. Sta., Berkeley, Cal.; also "The Persian Walnut Industry in the United States," Bul. No. 254, Bureau of Plant Industry, U. S. Dept. of Agr.; also "The Walnut in Oregon," Bul. No. 92, Bureau of Plant Industry, U. S. Dept. of Agr.

quantity is baled and sold, and some is used as pasturage for hogs. Pumping is the main source of water supply for irrigating this crop.

Although farming in this area consists mainly of the production of intensive crops, there are about 50,000 acres devoted to the production of grain and grain hay. Barley is the principal grain crop, and most of it is cut for hay. Grain is grown without the use of fertilizers or irrigation, and on a wide range of soils, but the largest acreage is on the light types of the Hanford and Tujunga series. If the rainfall is heavy and well distributed, much of the grain is left to mature, while in dry years most of it is cut for hay. The yields vary widely but are highest on the bottom lands. About one-third or more of the area devoted to grain growing is fallowed each year to allow the land to store up moisture. In some places grain is grown continuously for many years, with resulting low yields. From one-half ton to 2 tons of hay per acre are obtained each year. The hay is baled in the field and is sold immediately, fed to cattle, or stored for higher prices. Grain is sown in the fall when sufficient rain has fallen to germinate the seed. Grain and grain hay are not profitable crops with the present land values and are usually grown because of lack of water for irrigation of intensive crops.

Some oats are grown on the moist river-bottom soils. Where irrigation is possible, good yields of oats of high quality are obtained. A small acreage is devoted to corn which is grown both in separate fields and in nonbearing orchards. Field corn, sweet corn, and popcorn are produced.

A total area of about 2,000 acres is devoted to sugar beets. About 90 per cent of this crop is grown on the Chino silt loam and silty clay loam, several miles south of Ontario. The American Beet Sugar Co. has about 2,500 acres in beets each year, a large part of which is in this area. A considerable acreage also is planted by private farmers. Data obtained from the company operating at Chino give the average yield for a 5-year period on the company's farm as 10.31 tons per acre, and on private farms as 12.41 tons per acre. The average sugar content of the beets grown on the company's lands is reported as 17 per cent, and that of beets produced on other farms as 17.6 per cent.

Little or no commercial fertilizer is used, but all the manure available is applied to the fields. A good crop rotation on the poorer lands consists of beets 2 years and alfalfa 3 years; on the heavier lands beets 2 years and grain 2 years, with the plowing under of a volunteer growth of grain for green manure, gives good results. In some seasons it is not necessary to irrigate some of the heavier lands for beets, but the lighter soils require two to three irrigations, de-

pending upon the character of the subsoil. The beets are harvested in July and August.

The average cost of production of beets, delivered at the factory, varies from $30 to $40 an acre, depending upon the land, roads, and distance from the factory. Some alkali is present in the soil used for beet culture, but it is mainly confined to the surface 12 to 24 inches and has little effect upon the yield, except where it is concentrated and when a period of warm, clear weather occurs immediately after planting. Under such conditions the beets are often small and yellow, and the yields are low.

Thinning is frequently done by contract at $4 per acre, and topping and loading at 50 cents for 10 tons. The labor employed for beet culture is mainly Mexican. Day labor without board is rated at $1.50 a day for Mexicans; Americans are paid $55 a month without board. Some sugar-beet seed is produced on the Chino ranch, but the yields are rather low. In 1914 an average of 90 to 100 pounds per acre was obtained from a tract of 300 acres.

A large acreage in the Riverside area is devoted to potatoes, and good yields are obtained. This crop is produced mainly on the sandy loams and loams and is grown quite extensively among nonbearing fruit and walnut trees. Early varieties are produced, and the greater part of the crop is harvested by the last of July. Some sweet potatoes also are grown, but the acreage is very small. They yield well and should prove very profitable on the Hanford and Tujunga sands and sandy loams. A large area is well adapted to this crop. A rotation of sweet potatoes and alfalfa has proved very profitable. The growing of alfalfa on the light soils puts them in good condition for sweet potatoes. Potatoes are sold mainly at local markets and bring fair prices.

Dairying has received steadily increasing attention for many years and now has an important place in the agriculture. Owing to the favorable climate, good markets, and transportation facilities, and the large quantities of alfalfa and grain hay produced, dairying offers attractive opportunities. The industry is centered in those sections where feed can be most cheaply produced and where citrus fruits do not thrive. Considerable attention is now given to the improvement of dairy stock, and hog raising has been introduced as an important adjunct to dairying.

Bees and poultry are of some importance in the area, and the sale of honey and poultry products has been profitable both to the few farmers who have specialized in these lines and to small farmers and fruit growers who engage in them incidentally.

The present agricultural practices are generally up to date; considerable attention is given to modern methods of soil improvement

and the control of pests. Rural communities have the advantages of good schools, churches, and libraries, improved roads, daily mail delivery, and telephone service.

SOILS.

The Valley of Southern California, a part of which is included in the Riverside area, is structural in origin and has served for a long period as a catchment basin for alluvial sediments washed from the surrounding mountains and hills. During this period the elevation and subsidence of the region greatly influenced the deposition of the material. The accumulated material varies widely in depth, but in most places it is many hundreds of feet deep, and only in rare instances along dikes or in hilly or mountainous areas has bedrock been encountered in well borings. The deep covering over the valley floor is very young geologically, and erosion has only furrowed and altered the more elevated and marginal areas. Most of the soil forming the present surface covering has been contributed by the Sierra Madre and San Bernardino Mountains to the north and east. Noticeable accretions are added annually. South and east of Ontario the sediments have been spread over a wide area, which has the appearance of an extensive plain, but along the base of the mountains extensive, coalescing, steeply sloping alluvial fans prevail. Occasional elevated areas of older valley-filling material occur in conspicuous developments interrupting the recent sediments and as a fragmentary margin of highly weathered material skirting the base of the mountains. Most of the material has been moved a relatively short distance, and the torrential character of the streams during the time of deposition has resulted in extensive areas of very coarse textured soils.

The materials from which the soils are derived are separated into four groups: (*a*) Residual materials, (*b*) old valley-filling materials, (*c*) recent alluvial-fan and flood-plain deposits, and (*d*) wind-laid material. In addition, the miscellaneous types of Riverwash, Rough broken land, and Rough stony land are mapped.

The recent alluvial-fan deposits cover about two-thirds or more of the total area surveyed. The old valley-filling material ranks second in extent and the residual soils third.

Each of the groups named includes soils differing essentially in color and depth of soil material, topographic position, age and degree of weathering, and mode of formation. In all, 35 distinct soil types are mapped, grouped into 13 soil series. The soils of each series are similar in origin, mode of formation, color, and other characteristics, and differ in these features from the soils of other series. The soil types within the series are separated on the basis of texture.

The general characteristics of the different soil groups are discussed below.

Residual material.—The residual soils have been formed by the weathering and disintegration of rock in place. The material is unassorted and retains the position held by the parent rock except for minor changes caused by percolating and surface waters. Small areas of colluvial soil, consisting of footslope débris transported mainly by gravity, are included with this group. The soils are variable in color, texture, depth, stone content, density of subsoil, organic matter and lime content, and origin. The residual soils occur mainly in the low mountains and hills west and south of Riverside, and extend as a narrow, irregular margin along the foothills to a point several miles northwest of the Santa Ana Canyon. The residual soils are less important agriculturally than the alluvial soils, chiefly because of their more uneven surface, shallower depth, and the greater cost of obtaining water for irrigation. Favorably located areas, however, are profitably devoted to citrus fruits.

The rocks giving rise to this material have weathered quite uniformly, and in granitic areas the unaltered material usually lies much more than 6 feet below the surface. Granitic rocks, with small areas of sandstone, shale, and conglomerate, are the principal formations giving rise to the residual soils of this area. These soils are classed in three series—the Holland, Sierra, and Altamont. A small total area of soil material recognized in previous surveys under the Aiken and Olympic series is included. If more extensively developed, these soils would be mapped separately.

The surface soils of the Holland series are prevailingly brown. When wet they have a slightly reddish cast in places, and when dry they sometimes approach the reddish color of the Sierra series. The subsoil usually is redder and heavier than the surface material, but closely resembles it in some places. Partially disintegrated granite bedrock is encountered at various depths, usually less than 6 feet. These soils occur principally in the hills and mountains southwest and west of Arlington and southwest of Riverside. They are well drained and are free from alkali. They are residual from granitic rocks. The surface is rolling to hilly or mountainous. As encountered in this survey the Holland soils are prevailingly light in texture. Two types, the sandy loam and loam, are mapped.

Where typically developed, the Sierra soils are prevailingly brownish red, or reddish brown to light red. The soils are much redder when wet than when dry. When dry they sometimes approach in color the brown of the Holland series. They are underlain by reddish-brown or brownish-red to red subsoils, usually heavier and redder than the surface material. The subsoils are com-

pact and very hard when dry, and grade into partially weathered granite at a depth of 2 to 6 feet or more; the bedrock lying nearer the surface on ridges, hilltops, and steep slopes, though it rarely outcrops. The surface soil and subsoil usually are gritty, and the material becomes coarser at lower depths. Small areas not too steep for tillage but covered with shallow soils containing some rock outcrop and small rocky hilltops are included. The soils are residual from granite, gneiss, and schistose igneous rocks. The topography is moderately rolling, sloping, or hilly. The soils are developed principally along the lower boundary of the survey south of Riverside and in small areas among the lower mountains west of that place. They are well drained and are free from alkali. A single type, the Sierra loam, is recognized.

The Altamont series includes types with brown to dark-brown surface soils and brown or reddish-brown subsoils. In some variations of the types the color of the surface soil may be light brown or slightly reddish brown. Bedrock usually is encountered at depths of less than 6 feet, although it may occur at considerably greater depths locally. In areas derived from metamorphosed formations, rock fragments in varying quantities may be present in both surface soil and subsoil. This series occurs on the lower mountain slopes and in hilly regions of sedimentary rocks, mainly shales, sandstones, and conglomerates. Erosion has generally been active, and the surface is more or less dissected. Rock outcrop is sometimes present. As mapped in this survey the series includes small areas of material derived from igneous or metamorphosed igneous rocks and not properly belonging with the Altamont series. The Altamont clay loam is the only type of this series mapped in this area.

Old valley-filling material.—The soils derived from old valley-filling material have undergone marked changes in surface soil and subsoil features through weathering in place since their deposition. The group generally is characterized by compact subsoils, which are heavier as a rule than the surface material. A noticeable translocation of minerals in the soil mass has frequently occurred, and the group may be considered as residual from unconsolidated material. These soils are more thoroughly weathered, are frequently redder in color, and contain less organic matter than more recently formed soils. Hardpan or a gravelly substratum is present in places. The material is subject to erosion and is slightly influenced by reworking during rainy periods and by the addition of some alluvial deposits.

The soils of this group occur mainly in the region west and southwest of Riverside and as a margin of irregular, deeply dissected remnants of old-alluvial deposits projecting into the valley from

the mountains along the north and east side of the area. Conspicuous, though smaller, bodies occur as knobs or ridges northeast of Upland and in a number of other places. These are remnants of an older surface that has not been entirely removed by erosion or buried by the new accumulations now being spread over the valley floor.

The bodies flanking the mountains are sloping, and their outward extensions are often sharply separated from the lower, more recent material by a steep escarpment, usually 50 feet or more in height. South and east of Redlands the group occupies a series of eroded hills and ridges with gentle footslopes. The large fan south and west of Corona has not been severely dissected by erosion, and while apparently not so old as other similarly located bodies of material belonging to this group, it has noticeable features indicating sufficient age to class the greater part of it with the old valley-filling deposits. Those areas west and southwest of Riverside show the least effect of weathering and erosion and are included in the group principally because of their heavier or more compact subsoils and redder color. The material is generally well drained, but local areas having a high water table contain accumulations of alkali. Granitic and schistose igneous rocks have contributed most of the old valley-filling material, except in the region south and west of Corona, where shales, sandstones, and conglomerates constitute the greater part of the parent material. The old valley-filling material is the oldest alluvium in the area, and was mainly deposited at a time when the region had a lower elevation than at present. They are more favorably located than the residual soils for irrigation, but generally less so than the recent-alluvial group. The virgin soils are generally treeless, but are frequently covered with brush.

Five soil series of the old valley-filling material, the Placentia, Madera, Ramona, Antioch, and Montezuma, are recognized and mapped.

The surface soils of the Placentia series where typically developed have a pronounced reddish-brown to red color, but frequently approach the brown of the Ramona series when dry. They are redder when moist, and the heavier types are inclined to be sticky when wet and rather hard and compact when dry. The subsoils are redder than the surface soils and are heavier in texture. Small to moderate quantities of mica are present. Usually lime and organic matter are present only in small quantities. A gravelly substratum is present locally in the soils occupying the remnants of old deposits skirting the base of the larger mountains. The series is quite extensive in the Riverside area, occurring principally along the northern and eastern boundary of the survey and in well-developed, gently sloping areas in the vicinity of Riverside, Arlington, Pedley, and Redlands. Drainage is well established, and no alkali is present. Igneous and

metamorphosed igneous quartz-bearing rocks, principally granite, gneiss, and schist, are the main sources of the material in the Riverside area, with minor contributions from sedimentary rocks. The higher areas usually are dissected, moderately rolling, or sloping, and support a moderate to dense growth of ceanothus or other brush. Four types, the Placentia gravelly loam, sandy loam, loam, and clay loam are recognized. As mapped they include areas, too small to be mapped separately, of material derived mainly from sedimentary rocks or from a variety of rocks, and of soils having a dense red hardpan.

The Madera series comprises brown soils. The lighter textured types usually are light brown, grayish brown, or slightly yellowish brown, and the heavier members dark reddish brown or dark brown. The subsoils are often redder than the surface material and usually are heavier in texture, frequently grading into clay loam or clay. They usually are compact and rest at various depths below the surface upon an indurated brown to red hardpan, which varies greatly in thickness. Friable, open-textured material is encountered under the hardpan, and mica usually is present in small quantities. The soils of this series are well drained and free from alkali. In this area the material is derived principally from granite schists, but as typically developed in previous surveys it is derived from a variety of rocks. The topography is gently sloping, and low mounds frequently occur. The series is represented by one type, the Madera sandy loam.

The Ramona series includes brown and dark-brown surface soils, the color in places varying to grayish brown or slightly reddish brown. When wet these soils frequently have a reddish cast in the field. The subsoils are brown, dark brown, and in places reddish brown. They are quite compact and are heavier in texture than the surface material. The substratum as a rule is not quite so heavy in texture nor so red in color as the subsoil, but it is compact in most places. The Ramona series is most prominent in the region about Riverside and Arlington, but also occurs on old eroded fragments of an earlier surface along the base of the San Bernardino and Sierra Madre Mountains. Drainage is good. The material is principally derived from granites, gneiss, and quartz-bearing schistose, igneous and metamorphosed-igneous rocks. The material is not quite so thoroughly weathered, nor are the subsoils so heavy generally as in the case of the Placentia series. Three types are encountered in this area, the Ramona sandy loam, loam, and clay loam.

The Antioch series comprises types with brown to dark-brown soils, with variations of light grayish brown and, in rare instances, slightly reddish brown cast. The subsoil is heavier than the surface material. It is highly calcareous, and is gray, light gray, or light brown in color. The subsoil contains numerous lime concretions and

gray streaks, apparently due to a secondary process in which poor drainage has been important. The substratum consists of brown silts and clays. The soils of this series have a very gently sloping surface with a marked tendency toward "hog wallows" in many places. Some mica is present where the soil is influenced by Hanford material. Drainage is good, except in small local areas, which contain alkali. Sedimentary rocks have given rise to most of the material. In this area the Antioch loam and silty clay loam are encountered.

The surface soils of the types included in the Montezuma series are dark gray to black, and the subsoils brown, light grayish brown, or gray, highly calcareous clay loams and clays. The substratum is not so light in color nor so high in lime as the overlying subsoil. It is occasionally stratified, and like the subsoil is quite compact and free from gravel. Granitic rocks appear to be the main source of the Montezuma material as encountered in this survey. The series is represented by a single type, the silty clay loam, though several areas of typical Montezuma clay adobe too small to map occur within areas of the Placentia loam near Upland.

Recent-alluvial fan and flood-plain material.—The soils derived from recent-alluvial fan and flood-plain material are the most recently formed in the area. At the present time they receive large accretions in each rainy season. The group includes the lightest colored and lightest textured soils in the area. They range from stony sands to silty clay loams, are usually higher in organic matter than the soils of the other groups, and have more permeable surface soils, subsoils, and substrata. As mapped in this area they are prevailingly gray, brown, and black.

In the Riverside area the recent-alluvial soils have a greater extent than all other groups combined. They comprise extensive alluvial fans, projecting 15 miles or more into the valley in places, and river-flood-plain areas along the Santa Ana River and Lytle Creek. The upper part of the fans usually is steep, but elsewhere the surface is gently sloping to nearly level. Drainage is well established except in the region several miles south of Ontario and along the Santa Ana River and a number of minor creeks.

Granite, gneiss, and schistose, igneous, quartz-bearing rocks are the chief sources of the material except along the foothills in the southwestern part of the area, where sedimentary rocks are the chief contributing formations. Intermittent streams issuing from the near-by mountains have carried or rolled the material to its present position.

Probably three-fourths of the agriculture of the area is on this group of soils. They are used for extensive plantings of deciduous and citrus fruits, sugar beets, alfalfa, and grain. Four series of

soils—the Hanford, Tujunga, Chino, and Yolo—are recognized and mapped.

The Hanford series consists of brown soils, with variations to grayish brown, dark brown, and reddish brown. These variations do not usually occur in this area in well-defined developments except around Riverside, where the parent granitic material appears to weather into much redder soils. The surface soils and subsoils usually are uniform in texture and structure to a depth of 6 feet or more, but the subsoil frequently is somewhat lighter in color. The subsoils of the older alluvial-fan deposits and of areas in recent stream bottoms where stratification has occurred are sometimes heavier in texture than the surface material. Mica is present in widely varying quantities. The upper parts of the fans usually are steep, stony, and coarse textured and are frequently marked by shallow stream channels which carry large volumes of water during periods of heavy rainfall. Granite, gneiss, and schistose, igneous, quartz-bearing rocks, are the principal sources of the material giving rise to these soils, which is the most extensively developed series in this area. The native vegetation on the large fans consists of a moderate to heavy growth of chamisal and other brush, while along the streams cottonwood, willow, vines, and other moisture-loving plants prevail. The water table usually is low, except in a few local areas of restricted drainage. Ten soils of the Hanford series are recognized in this survey. They range in texture from stony sandy loam to silty clay loam.

The Tujunga series in the Riverside area includes light grayish brown to light brownish gray soils, with variations to medium gray or light gray. When wet, the soil is much browner than when dry, and in places it closely approaches in color the light-colored Hanford soils. The surface-soil and subsoil material is uniform to a depth of 6 feet or more, but frequently the subsoil below the depth of 18 inches contains a higher proportion of fine material and is browner and slightly more compact than the surface soil. Wind action has modified the surface somewhat east of Ontario and Upland. These soils are generally well drained and free from alkali, but the water table is sometimes near the surface in flat or slightly depressed areas along stream bottoms. Granitic and schistose, igneous, quartz-bearing rocks are the principal sources of the material. The series is represented by four types, the stony sand, gravelly sand, sand, and fine sandy loam.

The Chino series comprises types with dark-gray to black surface soils, with variations to dark brownish gray and in rare cases to very dark grayish brown. The soil in places has a grayish cast when dry. Below a depth of 18 inches the color gradually changes

to light gray or light grayish brown or, where the surface material is black, to dark gray. Below the depth of 18 inches the subsoil is slightly heavier in texture than the surface material, and is micaceous, calcareous, and readily permeable to roots and water. A marly subsoil, apparently the result of secondary accumulations of lime, occurs in poorly drained basinlike positions. The series is derived principally from granite, gneiss, and related schistose igneous rocks. It has moderate to poor drainage and in places contains alkali. The Chino silt loam and silty clay loam members are mapped.

The Yolo soils are typically medium brown. Variations to grayish brown, light brown, and dark brown are included and if sufficiently extensive could properly be mapped as distinct soils. The subsoil is brown, light brown, or slightly reddish brown and usually differs little in texture and color from the surface material. In places it is slightly heavier, but it is easily penetrated by roots and favors the free movement of water. The material giving rise to this series has originated principally from sedimentary shales, sandstones, and conglomerates. The surface is smooth and gently sloping, except in narrow valleys where there has been more or less dissection by streams. In these valleys the soils support a moderate to heavy growth of brush. Good drainage prevails, and no alkali is present. Three types are recognized in this area—the Yolo gravelly loam, loam, and silty clay loam.

Wind-laid material.—While wind action has had a marked influence on the lightest textured members of the recent-alluvial soils, it has merely modified the surface material, and only in several minor areas west of Colton and north of Rialto are the soils of wind-laid origin. These areas have an uneven, hummocky, or ridged surface and consist of deep deposits of medium-textured sand, drifted from areas of the Tujunga and Hanford sands. This group is of very little importance agriculturally, owing to its uneven surface and the difficulty of irrigation. It is represented in this survey by the Oakley series.

The Oakley series includes brown to grayish-brown soils. Both surface soil and subsoil are uniform in color and texture to a depth of 6 feet or more and are slightly micaceous. Moderate quantities of fine material are present, giving the soil a loamy character. The series is encountered mainly west of Colton. It occupies undulating areas, low rounded ridges, and hills which are slightly dunelike in places. One type, the sand, is recognized in this survey.

Miscellaneous material.—The areas of miscellaneous material in this survey are classed with Riverwash, Rough broken land, and Rough stony land. They include a range of soil materials which can not be satisfactorily differentiated and are in general nonagricultural.

The various soil types mapped are described in detail in the following pages of this report. The distribution of the soils is shown on the accompanying map, and the table below shows the actual and proportionate extent of each:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Rough broken land	43,136	11.1	Hanford coarse sandy loam	5,312	1.4
Hanford sandy loam	32,256	9.0	Tujunga gravelly sand	5,184	1.3
Reddish-brown phase	2,496		Holland sandy loam	4,736	1.2
Placentia loam	32,256	8.7	Holland loam	4,672	1.2
Hardpan phase	1,472		Placentia sandy loam	4,480	1.2
Hanford gravelly sand	30,976	8.0	Antioch silty clay loam	3,968	1.0
Hanford sand	26,432		Antioch loam	3,648	.9
Coarse phase	896	7.2	Oakley sand	3,264	.8
Wind-blown phase	640		Chino silty clay loam	2,624	.7
Hanford gravelly sandy loam	21,184	5.5	Ramona clay loam	2,368	.6
Tujunga sand	15,680	5.0	Placentia clay loam	2,176	.6
Low phase	3,776		Yolo loam	1,664	.4
Hanford stony sandy loam	17,216	4.4	Madera sandy loam	1,600	.4
Tujunga stony sand	16,320	4.2	Altamont clay loam	1,408	.4
Tujunga fine sandy loam	14,912	3.8	Ramona sandy loam	1,408	.4
Hanford fine sandy loam	11,840	3.5	Hanford silty clay loam	192	.4
Reddish-brown phase	1,536		Reddish-brown phase	1,216	
Sierra loam	11,136	2.9	Yolo silty clay loam	640	.3
Yolo gravelly loam	3,776	2.8	High-fan phase	512	
High-fan phase	7,232		Placentia gravelly loam	704	.2
Rough stony land	10,752	2.8	Hanford gravelly loam	576	.1
Ramona loam	10,240	2.6	Montezuma silty clay loam	448	.1
Hanford loam	4,736	1.7	Total	387,840	
Reddish-brown phase	1,856				
Riverwash	6,144	1.6			
Chino silt loam	5,312	1.6			
Sandy phase	832				

HOLLAND SANDY LOAM.

The Holland sandy loam, to a depth of 12 to 18 inches, is brown in color, but in places a slightly reddish brown, or when dry a grayish-brown, tint is apparent. The soil is micaceous, frequently gritty, and low in organic matter. It is friable and easily tilled. Prevailingly the type has a distinct subsoil, consisting of a reddish-brown or red, compact, gritty loam, but locally the soil continues uniform from the surface to the underlying rock. When dry the subsoil is very hard, and upon exposure in places it has cemented into a hardpan. It rests upon a substratum of partially disintegrated granite at various depths. The unaltered rock rarely is encountered within a depth of 6 feet. In places the type closely approaches a coarse sandy loam or loamy sand in texture, and a fine sandy loam

variation of considerable prominence is included, which if of greater extent would be recognized as a distinct type. Where deep, the type is quite retentive of moisture, but on steep slopes, ridges, and hilltops it usually is shallow and droughty. Some rock outcrop occasionally occurs in such places. A small acreage of old valley-filling material, occurring on small knobs, ridges, and slopes on the lower foothill extensions of the type, is included, as well as a few very small areas of Altamont sandy loam.

The Holland sandy loam is not very extensive. It is principally developed on the low mountains and hills south, southwest, and west of Arlington and north of Corona. The fine sandy loam bodies occur principally on the slopes of the mountain south and southwest of Arlington. The surface is rolling, hilly, or sloping, but it is usually smooth, and there are few deeply eroded ravines. The steeper and shallower areas lose their moisture quite rapidly, but elsewhere the drainage is normal and no alkali has accumulated.

Some reworking by alluvial agencies has had a tendency to deepen the soil on the lower and more gentle slopes. The clay-bearing minerals appear to break down rapidly, and weathering and movement of soil waters have rearranged the minerals to a noticeable extent in many places. Where erosion has been unusually active the redder and heavier textured subsoil is sometimes exposed at the surface.

The difficulty of obtaining water and the high cost of distributing it over the type have retarded its agricultural development. It is utilized mainly for pasture and for dry-farm grain and grain hay. In a few places, where water has been obtained, oranges, lemons, walnuts, and apricots have been planted and seem to do well. Some grapes and olives are grown without irrigation, with moderate yields. The type is readily accessible and quite favorably situated with respect to towns and shipping points.

Land values vary widely, depending on surface features, the availability and cost of water for irrigation, depth of soil, and location. The incorporation of organic matter is one of the principal needs of this soil.

HOLLAND LOAM.

The Holland loam consists of a brown to slightly reddish brown, smooth-textured, friable, micaceous soil, about 15 or 18 inches deep, resting on a subsoil of brown, reddish-brown, or red heavy loam to clay loam. It is frequently gritty and grades slowly into partially weathered granite at various depths. The granite is frequently near the surface on hilltops, steep slopes, or ridge crests, but lies deeper in the more gently sloping areas. Unaltered rock usually is encountered at depths of 6 feet or more; in rare instances it outcrops. In

places the type is high in sand, closely approaching a sandy loam or fine sandy loam. It usually is low in organic matter and tends to puddle if worked when too moist. The heavier soil and subsoil usually become very compact when dry, and in places where the latter is exposed it tends to form a hardpan. In places where the soil is deep and not too compact it is quite retentive of moisture, but where a heavy subsoil closely approaches the surface the type is inclined to be droughty. Areas of Rough broken land, rock outcrop, or old valley-filling deposits too small to differentiate are included with the type as mapped.

The Holland loam type is not extensive. The largest bodies occur north and northwest of Arlington and northeast of Corona. Two small areas are located southeast of Colton. The type is confined to hilly and mountainous areas and possesses a rolling to hilly and sloping topography. The surface is smooth, and no leveling is necessary to prepare the land for cultivation or irrigation. Drainage is good, and on the shallow and steep areas excessive. No alkali is present.

The parent rock giving rise to this soil is encountered at various depths below the surface. Practically all the soil material is derived from granite and schistose igneous rocks, and only a small amount of reworking has occurred. As in the case of other types of this series, the clay particles tend to filter down quite rapidly, and this process, with the action of percolating water, has had a tendency to rearrange the materials somewhat since the soil was originally formed. The upper slopes frequently merge into areas of Rough stony land, and usually are less well suited to agriculture than the lower and more gentle slopes where the soil is deeper and more easily handled.

Grain and grain hay are the principal crops grown. Moderate yields are obtained. Some citrus and deciduous fruits have been set out where water for irrigation has been obtained, and the trees appear to be doing well. Topographically, the type is well suited to fruit production. The controlling factors in its use for intensive crops are moisture, organic matter, topography, and soil depth. The type needs the incorporation of organic matter. Land values vary considerably and average about the same as for the sandy loam of this series.

SIERRA LOAM.

Typically, the Sierra loam has a pronounced reddish brown to red surface soil, extending to a depth of about 15 or 18 inches. The soil is generally friable and easily tilled. It has a low organic-matter content. The subsoil usually is redder and heavier than the surface material and ranges from a loam to clay loam. At varying depths it slowly grades into partially disintegrated granite, which in most

instances continues to depths of many feet before the unaltered rock is reached. The rock occasionally appears at the surface, however, as rock outcrop. The subsoil usually is gritty, and becomes coarser and quite sticky in its lower depths. When dry it is very compact. The entire soil mass is micaceous, and where deep is quite retentive of moisture. In a few places rock fragments occur to a very small extent in the soil section, but they in no way affect the physical properties of the type. The texture frequently approaches a sandy loam, and a sandy loam variation and small undifferentiated areas of Holland material and of rock outcrop are included with the type as mapped. It includes also minor areas of red soil derived from quartz-free igneous or metamorphic rocks, which if more extensive would be recognized as material of the Aiken series. This is developed principally in one small area east of Crafton.

The sandy loam variation represents bodies of the Sierra sandy loam, which if more extensive would have been differentiated and shown separately on the soil map. In places the soil of this variation contains considerable gritty material, and in the lightest textured areas it closely approaches a sand. At depths of 10 inches to 2 feet the soil grades into a sticky, reddish-brown to red loam, which is very compact when dry. Occasionally erosion has removed the surface covering from ridge crests and the steeper slopes, exposing the heavy red subsoil. Such spots are easily recognized by the pronounced red color and heavy texture of the soil. Roots do not enter the subsoil and substratum readily, because of the density of the material. In places this type has been modified to a small extent by alluvial agencies, which have had a tendency to increase the depth of the soil locally. The deeper soils occur on the more gentle slopes and where the parent material is the less dense.

The Sierra loam is not extensive. It occurs along the lower mountains from near Riverside southwest beyond Mockingbird Canyon, with several narrow, irregular bodies near Pedley and southwest of Bloomington. The sandy loam variation occurs in a narrow belt skirting the base of the low mountains about 3 miles west of Riverside. Most of the type lies between the 800 and 1,500 foot contours, and its situation gives it good soil and air drainage. The surface is hilly to sloping or ridged, but the land generally lies smooth and is easily prepared for crops and irrigation. Occasional small ravines occur, but they do not seriously interfere with tillage operations. Drainage is well established, and no alkali is present. The soil material is derived principally from granite. The rock is generally quite uniform and weathers into rounded hills and ridges. The clay-bearing minerals appear to break down readily, and the fine material filters down rapidly, forming a heavy layer at various depths below the surface. In local exposures this heavy material

tends to cement firmly, and it approaches a hardpan in places. During heavy rains some of the soil is eroded from the steeper slopes and carried to the base of the hills, where it forms alluvial soils of the Hanford series.

The type is principally devoted to pasture, on account of a scarcity of water for irrigation. Some lemons and oranges have been planted in recent years in the most favorable locations, and the groves are doing well. Moderate yields of grain and grain hay are obtained. Most of the land is held in large tracts, and this also has retarded development. Some depressions and valleys in the hills might serve as sites for small reservoirs to store water for local use; beyond this, water must be obtained from outside sources, so that irrigation development would be very costly. Some areas are not very well supplied with roads, but hauling to shipping points is made easier by a down grade. In the included sandy loam areas the highway facilities are better, and shipping points are within a reasonable distance.

The selling price of land of this type of soil ranges from $50 or less to more than $200 an acre, depending upon the quality of soil, location, and surface features. The supplying of water and the incorporation of organic matter are the main factors in the best utilization of the type.

ALTAMONT CLAY LOAM.

Typically the soil of the Altamont clay loam to a depth of 12 or 18 inches is brown, although variations of light brown or dark brown occur. The light-brown soil is of very local occurrence, however, and generally is confined to the shallower areas. The soil is friable and smooth textured when dry, but rather sticky when wet. The type is nonmicaceous. It contains a moderate amount of organic matter, especially in the deeper areas, and is tilled without difficulty under proper moisture conditions.

The subsoil, from 2 to 6 feet, is light brown to brown, and occasionally reddish brown, usually being lighter in color than the surface material. It is usually somewhat heavier in texture, but the surface material frequently continues uniform to the underlying rock. Lime is present in the subsoil in many places, but frequently the material to a depth of 6 feet is neutral to litmus or slightly alkaline. Bedrock usually is encountered at less depths than 6 feet, but it may be deeper, as is frequently the case on the gentler slopes and in ravines. The deeper areas usually are quite retentive of moisture, but where the bedrock is near the surface the type is inclined to be droughty. Little rock is present in the soil or subsoil, owing to the generally soft character of the underlying shales and sandstones. In places where metamorphism of the original rocks has occurred, or where con-

glomerate is present, rock fragments and gravel particles are encountered in both surface soil and subsoil. In places the soil tends to have an adobe structure, especially in the deeper areas and where the slope is gentle.

The areas mapped as of this type vary somewhat from typical in texture and other characteristics. The principal variation consists of included areas of Altamont fine sandy loam, which if of greater extent would be separated. The soil in these bodies consists of a brown to dark-brown, friable, open-textured, nonmicaceous fine sandy loam, extending to a depth of about 18 inches. The surface color varies considerably, depending on the direction of the slope, the amount of lime present, and the nearness of the underlying rock. The subsoil from 24 to 72 inches is generally somewhat heavier in texture than the surface material and at times approaches a light loam. It is brown to light brown in color and contains noticeable quantities of lime. Organic matter is present in appreciable quantities on northern and eastern slopes and where the soil is deep, but in shallow areas and on slopes most exposed to the sunshine the content is smaller. In slight depressions and in ravines the soil is somewhat heavier in texture and often approaches a loam. Local areas of light gravelly loam or gravelly sandy loam are included in this fine sandy loam variation. The soil retains moisture moderately well where deep, and is easily tilled.

The Altamont clay loam is of small extent. It occurs in a number of minor areas on the lower foothills in the southwestern part of the survey. A small area is also found northeast of San Bernardino. The included fine sandy loam variation occurs in small bodies several miles southeast of Corona. The type has a hilly topography, ranging from steep slopes to rounded, rolling hills, sometimes dissected by ravines. The surface generally is smooth. The type is well drained and free from alkali.

The texture of the soil varies widely with that of the underlying material. The parent rocks are sedimentary shales, sandstones, and conglomerates. These in rare instances are metamorphosed, giving rise to slightly stony areas and occasional rock outcrops. Erosion has had a tendency to keep the soil shallow on the steeper slopes, and local transportation and depositon by minor stream action has increased the depth in shallow ravines and on the lower or more gentle slopes.

Agriculture on this type is limited by its elevated and dissected surface. It usually lies too high for irrigation, and on this account its crop range is confined principally to the production of grain and grain hay and to grazing. A scattered growth of brush frequently occurs, and this adds to the cost of preparation of the land for crops. Few roads lead to the type, and it is not very favorably situated for

home sites, although in one area in the Santa Ana Canyon a small summer resort has been developed. Crop yields are moderate to low and are materially decreased by constant cropping.

This type is generally held in large tracts and is utilized in connection with lower, adjoining alluvial soils.

PLACENTIA GRAVELLY LOAM.

The Placentia gravelly loam is indicated on the soil map by gravel symbols in the color used for the Placentia loam. The surface soil, to a depth of 10 or 15 inches, varies in color from pronounced reddish brown to red. The subsoil to a depth of 4 or 5 feet is redder than the surface soil and grades into material of light reddish brown or yellowish-brown color. From the depth of about 15 inches to about 48 inches it consists of a heavy, compact clay loam to clay, tending toward hardpan in places. It offers a material check to the development of roots and to the circulation of air and water. When wet, both soil and subsoil have a distinctly reddish appearance in the field, but when dry they change to a reddish brown to nearly brown in places. Local areas of brown to dark-brown soils too small to map, small, well-developed stony areas, and minor areas of loam and sandy loam texture are included with this type. Varying quantities of gravel are scattered over the surface, but this material seldom interferes with tillage. The stony areas are largely confined to ravines, slight ridges, and the steeper slopes. The subsoil and substratum vary greatly in stone content. In places gravelly and stony substrata are present, but generally the underlying material consists of partially stratified or unassorted sand, gravel, and silt. In rocky areas the dense subsoil usually is not so pronounced, and disintegrating cobbles are frequently encountered in the soil mass. A moderate to small quantity of mica may be present in the soil and subsoil. Tillage is usually not very difficult. The type usually is low in organic matter, and the application of this results in greatly increased yields.

The Placentia gravelly loam is of small extent. It occurs in a number of small, irregular areas flanking the lower foothills in the northern part of the area. The surface is moderately to steeply sloping and is dissected at intervals by deep ravines. The type occurs between the 1,500 and 3,000 foot contours, and owing to its elevated position and pronounced slope it has good drainage and is free from alkali. The water table is deep, and there is little or no opportunity for the development of irrigation by pumping. Practically no leveling is necessary to prepare the type for irrigation, but it is necessary to remove stones and brush.

The material giving rise to this type originated from the near-by granites and schistose, igneous and metamorphosed-igneous rocks. It was laid down as alluvial, fan and footslope material by intermittent streams and in all cases has been transported a very short distance. Part of the soil material has resulted from the disintegration of bowlders, cobbles, and gravel in the soil mass since its deposition. A noticeable translocation of material has occurred in many places which, with the dissected topography, indicates that this is one of the oldest soils in the area surveyed. A pronounced escarpment usually marks its contact with the more recent valley soils.

The greater part of the type supports a moderate to heavy growth of chamisal and is utilized principally as pasture. Some grain and grain hay are produced, with moderate yields. Grapes and apples are grown successfully on the type near Verdemont. Irrigation is very important in the production of fruit on this type, and the scarcity of water has retarded development of the fruit-growing industry.

Land of this type of soil is held at $50 to $300 an acre, depending upon the location.

PLACENTIA SANDY LOAM.

The Placentia sandy loam where typically developed consists of a pronounced reddish-brown, friable, micaceous sandy loam, from 12 to 18 inches in depth, underlain to a depth of 4 or 5 feet by a red to reddish-brown, micaceous, compact, heavy loam to clay loam. The subsoil usually is dense and somewhat obstructs the downward movement of air, roots, and water. The lower subsoil and substratum are generally lighter in color and texture. In many places they closely resemble the surface material. In some parts of the type the material is nearly uniform in texture to a depth of 6 feet or more, but a rather compact layer is usually present between 15 and 30 inches. The soil assumes a reddish color when wet, but dries out to a brown or reddish brown in many places. The type has a moderate to low content of organic matter and is deficient in lime. It is tilled without difficulty. Applications of organic matter give increased yields and add to the water-holding capacity of the soil.

Local areas are red in color, and in places the lower subsoil is yellowish brown. Stony and gravelly areas and bodies of the Hanford and Ramona sandy loams, too small to show separately, are included with this type.

The principal occurrence of the Placentia sandy loam is in the vicinity of Pedley, West Riverside, Arlington, and Glenavon. It is also mapped in a few minor developments along the base of the San Bernardino and Sierra Madre Mountains.

The type has a gently sloping topography except on the higher elevations, where the grade is usually steep and the surface dissected. Drainage is good. The soil is quite retentive of moisture where well handled. The water table is deep, and alkali is rarely present.

The material forming this type is principally derived from granitic and schistose igneous rocks, but in a few local bodies the material is derived from a mixture of rocks. The soil material has been transported by streams to its present position; in most cases it has been carried only a short distance and has undergone only a slight degree of assorting. There has been considerable translocation of the minerals. In some cases some of the most highly soluble minerals have been partially dissolved and carried away.

Most of the areas of this type are highly developed to agriculture, being utilized principally for the growing of oranges. Some lemons have been produced successfully, and large areas are devoted to grain and grain hay. Alfalfa gives heavy yields. Walnuts and almonds grown as border trees do very well, but no extensive plantings have been made. Some sugar beets are grown, with good results. The type requires irrigation for fruits, sugar beets, and alfalfa. The areas are favorably located and are supplied with good roads.

The type has long been used for the production of citrus fruits, and its suitability to these and other highly intensified crops gives it a very high market value. Land prices in highly developed sections frequently exceed $350 an acre, but in places prices are much lower.

PLACENTIA LOAM.

The surface soil of the Placentia loam, extending to a depth of 10 to 15 inches, is typically pronounced reddish brown to red. When wet it has a distinctly reddish color, which, upon drying of the material, changes to reddish brown or even brown in some instances. The addition of organic matter tends to darken the color of the soil, and in places gives it a dark reddish brown cast. Older and more highly oxidized areas usually are redder in color. In texture the soil is moderately friable, but it is not so well granulated as are the loams of the recent-alluvial soils. It has a tendency to puddle somewhat if plowed when wet and frequently has a cloddy surface.

The subsoil to a depth of about 4 feet usually is redder than the surface material. Below that depth the color closely approaches that of the surface soil except locally, where it may be grayish, grayish brown, or even yellowish brown. To a depth of 4 feet the subsoil usually has a close structure and is heavier in texture than the surface material. In places it is a clay loam or clay and noticeably interferes with the movement of air and water and the development of roots. Below a depth of 4 or 5 feet the subsoil generally is lighter in tex-

ture, and frequently resembles the surface soil. Mica is a common constituent of soil and subsoil, but may be nearly absent in the oldest and most highly weathered areas. The lower subsoil or substratum is variable. It frequently is gravelly and stony along the foothills on the high ridges south of Redlands. In other places gravel may be almost lacking, as in the region about Riverside and Arlington.

The soil usually is lower in organic matter and less permeable to roots and water than the more recently formed soils. In places the surface soil and subsoil contain noticeable quantities of coarse, gritty material, and frequently they are silty and smooth textured. North of Corona, toward the Santa Ana River, the type is hilly, and varying quantities of gravel and cobbles frequently are present on the tops of ridges and hills, but the areas so affected usually contain less than 5 acres each.

Hardpan, varying in thickness from a few inches to several feet and occurring as local, intermittent lenses, is sometimes present, usually on low, subdued ridges and slopes. The hardpan is dense, and where near the surface it interferes with tillage and root development. Blasting has proved very effective in such places. Where areas with hardpan are of sufficient extent, they are differentiated as a hardpan phase.

Three included bodies of dark-gray soil, similar to the type recognized in previous surveys as the Montezuma clay adobe, occur about 1½ miles northeast of Upland. These areas are too small to differentiate. They occur as irregular bodies along the hillsides and lower slopes. One small area of about 50 acres of reddish-brown loam, derived from basic igneous rocks, lying near Crafton, also is included. This is a nonmicaceous soil, differing from the Placentia loam in origin.

Other included small bodies of loam derived mainly from shale, sandstone, and conglomerate material, with included fragments of igneous or volcanic rocks, occur as fragmentary projections skirting the foothills from a point south of Corona northwest to the Santa Ana Canyon. These usually occupy an elevated position above the surrounding soils and are recognized as included bodies of the Kimball loam, which if more extensive would be differentiated upon the map. Cobbles are sometimes present in this soil on ridge crests, in ravines, and locally over the surface of the more dissected areas, but they are of little importance.

The Placentia loam is the most important type occurring between Riverside and Arlington. Other important areas lie above the Santa Ana River bluffs, from Riverside westward nearly to Rincon. A very important and well-developed body occurs south of Redlands. A prominent area lies about 2 miles northeast of Upland, and a few small, irregular bodies occur along the northern boundary of the

survey. A small area occurs around Glenavon, and other minor bodies are mapped southeast of Colton and west of Arlington.

Those areas of the type occurring as old, elevated remnants along the base of the higher mountains have a moderately to steeply sloping topography. They are dissected at intervals by deep gulches and have steep faces where they break into the valley below. From Redlands south to the base of the hills the type has a smooth, gently sloping surface, but it gradually merges into a series of rounded ridges, hills, and steep slopes. (Pl. I, fig. 1.) These dissected areas represent an older surface over which the type varies considerably and is subject to much active erosion. Except for a somewhat dissected area east and southeast of Pedley, that part of the type lying west and southwest of Riverside has a gently sloping or slightly undulating to nearly level surface, with few sufficiently developed irregularities to interfere with tillage. North of Arlington the type has a slightly hummocky surface in places, but elsewhere little or no expense is necessary to prepare the soil for irrigation. Good drainage is the rule, and no alkali is present except along the lower margin of the area about 2 miles west of Arlington. The water table is deep over most of the type, and there is apparently little possibility of the development of irrigation by pumping over the higher lying areas. The type absorbs moisture quite readily and is responsive to applications of organic matter.

Granitic and schistose igneous rocks have given rise to most of the material forming this type. Small quantities have been added from basic igneous rocks and sedimentary formations, as in the Kimball loam variation. Much of the material has been moved only a short distance and contains varying quantities of coarse, stony material. Some assorting has occurred. The deposits have a wide range in age. Many of the stones contained in the soil mass have weathered, and a pronounced translocation of material has occurred over much of the type, giving it a heavy subsoil which has developed locally into a hardpan. Some alluvial reworking by minor streams has taken place over parts of the type, and occasionally the fresh deposits are of sufficient depth to be classed as recent material. The material in the region of Riverside and Arlington and in a few other places is much younger than that of the greater part of the type and has undergone much less change in mineralogical composition. Some of it closely approaches recent valley-filling material in physical properties, but usually there are noticeable indications of the soil mass having undergone pronounced changes by weathering since its deposition. A few subdued granitic knobs and granite outcrops in ravines, in areas too small to be indicated on the soil map, are included.

The Placentia loam is agriculturally one of the most important types in the area. It is very highly developed to agriculture in most places. Some of the earliest plantings of citrus fruits were made on this soil, and although some of the less favorably located areas have reverted to the production of alfalfa and grain, it is still one of the leading types for orange growing. For successful fruit production more attention must be given to maintaining a good physical condition than in the case of the more recent soils, on account of its tendency to become cloddy and its compact, heavy subsoil. Experience has shown that it is most in need of organic matter and that special care in irrigation is necessary to keep the soil moist to a good depth. The acreage of oranges on the type nearly equals that of all other crops combined. Lemons, apricots, peaches, grapes, walnuts, almonds, alfalfa, sugar beets, and grain are produced successfully in a small way. Some of the less favorably located and rougher areas are used for pasture. The higher land near the hills and mountains usually supports a moderate to heavy growth of chamisal. The yields of fruit vary considerably, depending largely upon the care given the soil and its permeability and upon damage by freezes and pests. Alfalfa, grain, and sugar beets yield heavily and appear to be well suited to the type. In most instances the land is well handled, and large quantities of commercial fertilizers are used. Clean culture is the rule for fruits, but in some cases hoed crops are successfully grown among the trees until they come into bearing. Most of the type is well located with reference to cities and shipping points. The highly developed areas of the type are well supplied with good roads, and no part of it is inaccessible.

Land values vary widely, depending upon the crops grown, the adaptation of the soil to particular crops, and its location with respect to markets, as well as upon the occurrence of freezes and the availability of water. In the well-developed areas suited to citrus fruits the price of land with a right to purchase water for irrigation is usually above $300 an acre. On the average, the land values apparently are too high to insure a reasonable rate of interest on the investment from the crops grown.

Placentia loam, hardpan phase.—The surface soil of the hardpan phase of the Placentia loam is red to reddish brown in color and about 12 to 20 inches deep. A layer of heavy, red clay loam to clay, 6 to 8 inches thick, usually occurs just below the surface soil, and this is underlain by hardpan. The indurated hardpan layer of red to brown material varies in thickness from a few inches to several feet. It is usually continuous throughout areas of the phase but in places may be somewhat fragmentary. The hardpan rests on a substratum of friable material which frequently resembles the surface soil in texture and color. The substratum is permeable and frequently con-

tinues uniform to a depth of many feet, but may vary somewhat in texture and color locally. The hardpan layer varies widely in density and thickness, even within short distances. It is generally nearer the surface on ridges, and in places is exposed. Small to moderate quantities of gravel or sand are sometimes contained in the soil. Mica is present in places. The entire soil section usually contains varying quantities of quartz grit, which distinguishes it from the more recent alluvial soils.

The soil is usually low in organic matter. It is tilled without great difficulty except where the heavy subsoil or hardpan lies near the surface. Freshly plowed fields usually have a cloddy tilth and require considerable working to be put into good condition. The phase is quite uniform in texture, but may be slightly sandy or very heavy in places. The hardpan is impervious to roots and water, and in rainy periods prevents the excess moisture from readily draining away, so that the soil becomes very boggy. Blasting is very effective in breaking up the hardpan, the size of the charge required depending upon the thickness of the cemented layer. (Pl. I, fig. 2.) The moisture-holding capacity of the phase depends mainly on the depth to the hardpan and the care used in cultivation.

The phase is very inextensive, occurring in two areas a short distance east of Glenavon. It has a gently sloping surface, slightly modified in places by low, rounded mounds several yards in diameter. The water table is deep, and no alkali is present.

This soil is devoted chiefly to the growing of oranges, alfalfa, grain, and grapes. The cost of preparation usually is high, on account of the hardpan and the unfavorable surface features, and trees are short-lived unless the soil is well prepared to a depth of several feet. The application of organic matter greatly increases crop yields. Irrigation is necessary for all crops except grain and grapes.

The phase is well located with reference to towns and shipping points and is reached by good roads. Land prices usually are high.

PLACENTIA CLAY LOAM.

The surface soil of the Placentia clay loam is about 12 to 18 inches deep and consists of a pronounced reddish brown, heavy-textured clay loam. Local areas of red, brown, and dark grayish brown soil with dark-gray spots occur at various places. The material has a distinctly reddish cast when wet, but the red becomes less pronounced when the soil is dry. The subsoil to a depth of about 4 feet is much redder than the surface soil. It usually consists of a heavy clay loam to clay. Below the depth of 4 feet it is lighter in texture, frequently resembling the surface material. The soil is very hard and compact when dry and puddles somewhat if tilled when wet. The surface

frequently becomes cloddy when tilled, and more care is required to get it into good physical condition than in the case of the lighter textured types or the heavy soils of more recent age. The heavy subsoil interferes with the downward movement of air and water and with root development, and when saturated the type remains cold until late in the spring. Some mica usually is present, and the soil contains a moderate supply of organic matter. Slight local depressions of clay occur, and some rounded cobbles are present locally in the soil mass. Occasionally a tendency toward hardpan exists.

The substratum, to depths of 10 feet or more, is variable, but usually consists of silts and clays. The type usually contains more gritty material than do similar soils derived from sedimentary rocks.

Several small bodies of this type are mapped southeast and north of Corona. One small area occurs south of Glenavon, one west of Arlington, and one southwest of Riverside. The total area is small. The soil is variable, owing to the manner of its deposition and the influence of erosion. The topography is uneven and hilly, with ridges and a slight tendency toward a hog-wallow surface in places. The area south of Glenavon and the one southwest of Riverside have smooth to gently sloping surfaces; the small area about 2 miles west of Arlington is nearly level. Drainage here is poor, and the soil is affected by alkali. Elsewhere the drainage is good. In places of restricted drainage, and where the soil is dark colored, lime is present in the subsoil in grayish streaks.

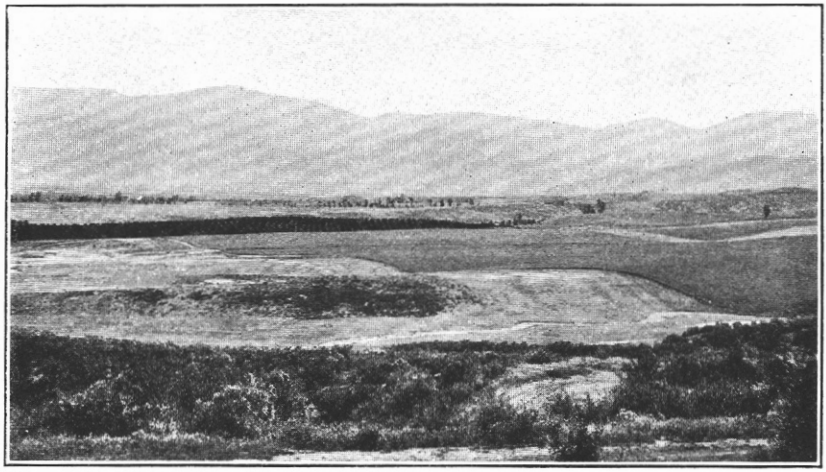
Granite and schists are the principal rocks giving rise to this soil. The material has undergone considerable change in mineral composition since it was deposited. The type is undergoing erosion in most places and, except for slight alluvial reworking locally, is slowly diminishing in extent.

The Placentia clay loam does not rank high agriculturally. Its heavy texture and unfavorable structure greatly limit its crop range. Grain and grain hay are the principal crops grown. In the most favorable areas citrus fruits, sugar beets, and alfalfa are produced. Yields are moderately good, but are variable.

All parts of the type are easily accessible. The price of land of this type depends upon the availability of irrigation water, surface features, and nearness to towns. The form of agriculture possible on the type depends mainly on the water supply, topography, drainage, and organic-matter content.

MADERA SANDY LOAM.

The Madera sandy loam to a depth of 10 to 15 inches consists of a brown to slightly reddish brown, gritty, friable sandy loam, sometimes of rather fine sandy loam texture and including, as mapped,



S8003

FIG. 1.—LOOKING NORTHEAST NEAR REDLANDS.

Showing rolling topography of the Placentia soils in this locality. Recent alluvial soils of Mill Creek fan in distance.

S8012

FIG. 2.—BLASTING HARDPAN IN PLACENTIA LOAM, HARDPAN PHASE, NEAR PEDLEY.

The land is being prepared for orange trees.

smaller areas of Madera fine sandy loam. The soil is generally shallow, but in places the hardpan characteristic of this series is not encountered above depths of 3 to 5 feet. A layer of heavier, reddish-brown material intervenes between the soil and the hardpan, but may be absent in places, where the hardpan is near the surface. The hardpan is brown, reddish brown, or red in color and varies widely in thickness. It interferes with root development and percolation, but can be successfully shattered by blasting where the land is to be planted to fruits. Gritty material often occurs in the hardpan. In many places north and northwest of Pedley the hardpan appears at the surface and closely resembles rock outcrop. The type contains mica in varying amounts and usually is not difficult to till where the heavy subsoil and hardpan are not too near the surface. Friable material occurs below the hardpan and serves as a favorable root zone when the hardpan is broken up. The type is inextensive. It occurs in small bodies on the mountain slopes near Declezville, northwest of Pedley, and east of Riverside. It has an undulating to gently sloping topography. The surface is slightly uneven in places. The type is well drained and no alkali is present. This soil is ordinarily undergoing erosion, and no fresh material is being added. The mineral and physical character of the material has been essentially changed through weathering since its deposition.

The type is generally of low value agriculturally because of its shallow soil, uneven surface, the occurrence of hardpan, and the high cost of water for irrigation. It is low in organic matter, the addition of which materially increases crop yields. Some grain, grain hay, grapes, alfalfa, and oranges are produced on the better areas, and with good care these crops give fair yields. Much of the type has never been tilled and is used for pasture. It supports a moderate growth of scrubby brush and a scant growth of grass.

The Madera sandy loam is well located with respect to roads and shipping points. The water supply and organic-matter content and the depth of the seed bed are the controlling factors in the development of a successful agriculture.

RAMONA SANDY LOAM.

The surface soil of the Ramona sandy loam is 15 to 18 inches deep, and brown in color, although variations of dark brown, grayish brown, or slightly reddish brown occur locally. In many places the color is slightly redder when the soil is wet. Small areas of Placentia soil are included. The soil is friable, slightly micaceous, and rather low in organic matter. The subsoil to a depth of about 48 inches is heavier than the surface material, consisting of a brown, reddish-brown, or dark-brown compact loam or clay loam. In the

upper part it is heavier in texture and usually redder in color than in the lower portion. The substratum closely resembles the lower subsoil in texture and color and is slightly stratified in many places. Some parts of the subsoil and substratum do not vary greatly from the surface material in texture, but they are generally quite compact. A small quantity of gravel and gritty material occurs locally over the type, and in places the texture closely approaches a light loam or loamy sand.

The soil and subsoil do not absorb water so readily as the more recently formed soils of the Hanford and Tujunga series, but when wet they retain moisture quite well. Applications of organic matter noticeably increase the water-holding capacity of the type and result in heavier yields. In places near the Hanford types the soil has been influenced somewhat by recent-alluvial wash, which has given it a more friable structure and higher mica content.

The type is of small extent and of little importance agriculturally. One small area lies northeast of Devore, one area about 2¼ miles west of High Grove, a small area at Casa Blanca, and one near Glenavon. The type has a slightly irregular and variable surface. It is undulating or gently to rather steeply sloping, with a tendency toward low, rounded hummocks locally. Very little leveling is necessary for irrigation, and the type is well drained and free from alkali. It is easily tilled.

The material composing the Ramona sandy loam originated principally from granitic rocks. Some alluvial reworking has occurred locally, but the soil mass has undergone less change generally than has that of the Placentia sandy loam.

The area northeast of Devore is untilled, but otherwise the type is all utilized. Grain, grain hay, oranges, and some grapes are grown. Important plantings of oranges have been made on the area west of High Grove, and good results are obtained. The type is quite productive. Irrigation, the addition of organic matter, and good tillage are the chief requirements for success with intensive crops.

Most of the type is well located with reference to towns, roads, and shipping points. The price of land varies widely, depending mainly upon the adaptation of the type to high-priced crops.

RAMONA LOAM.

The Ramona loam, to a depth of 12 or 18 inches, is variable, but where typically developed it consists of a rather friable, light-textured, gritty loam. It ranges in color from brown to grayish brown and in rare instances is slightly reddish brown, especially when wet. The subsoil is quite irregular in texture. It usually ranges from a

brown to reddish-brown, compact sandy loam to heavy, gritty loam, about 48 inches deep. The subsoil is not as heavy as in the case of the Placentia loam, but the material below a depth of about 15 to 20 inches usually is heavier in texture and much more compact than the surface soil. Locally there is some tendency toward the formation of a hardpan. In places the soil is nearly uniform in texture to a depth of 6 feet or more, except for the compact structure of the subsoil. The heavier textured subsoil usually occurs at depths of less than 6 feet. The type often closely approaches a gritty sandy loam in texture, and small quantities of gravel are present locally. The substratum closely resembles the subsoil. It shows a slight stratification in most places. A small quantity of mica usually is present in the soil and subsoil. Some reworking has occurred locally, the type here closely resembling the Hanford sandy loam. The soil is not very retentive of moisture. It is tilled without difficulty and responds readily to applications of organic matter.

The material forming this type was derived principally from granite, gneiss, and schistose igneous rocks, though an included variation is derived mainly from sedimentary and metamorphosed sedimentary rocks. The line of demarcation between soil and subsoil in most places is less clearly marked than in the Placentia loam, and the translocation of the minerals has not progressed so far. Except for a small amount of reworking and the adding of small quantities of fresh alluvial material in the areas next to the hills, the type is slowly undergoing erosion and internal mineralogical and physical changes not noticeable in more recently formed soils. Locally the type occupies an intermediate position between the typical Ramona and Hanford soils, and in no place is it so highly oxidized as are the Placentia soils.

In the included bodies derived mainly from sedimentary rocks, and not conforming to the Ramona series in origin, the subsoil consists of a brown, reddish-brown, or red heavy loam to clay. This rests on a substratum of brown or slightly reddish brown material of somewhat lighter texture than the subsoil. Both subsoil and substratum are compact. A small quantity of gravel frequently is present in the soil section, but this in no way interferes with tillage. The soil here is nonmicaceous and somewhat hard when dry, but works into a friable seed bed without difficulty. It usually is low in organic matter, and readily responds to applications of this material. Small gravelly ridges occur in places, and where erosion is active, the reddish, heavy subsoil has been exposed in patches. This variation occurs in several areas southwest and west of Corona. Its total area is small. The surface is sloping, somewhat uneven in places, and dissected at intervals by ravines. Much of the rainfall

is lost as surface run-off, because of the rather compact condition of the surface soil. No alkali is present, and leveling is unnecessary for tillage or for irrigation.

The principal areas of the typical Ramona loam occur east and southwest of Riverside, around High Grove, and south of Wineville. A number of small areas are mapped along the base of the mountains northeast of San Bernardino. The type has a very gently sloping to gently undulating topography generally, but in places it is quite steep and considerably eroded. The surface is nearly always smooth, and leveling for irrigation is seldom necessary. Deeply dissected ravines are common in the steeper areas. The type is well drained and is free from alkali.

The Ramona loam is of small extent, but is very highly developed to intensive crops over most of its area. Oranges are the principal crop grown. The condition of the trees and the yields vary widely, depending on local soil conditions, the occurrence of frost, and the care given the trees. Some of the earliest citrus plantings were made on this type, and the acreage is increasing each year. Some grain, alfalfa, miscellaneous deciduous fruits, and nuts are produced successfully, but on the whole the high land values make most general farm crops unprofitable. Some of the higher and less favorably located areas are still devoted to grazing, mainly on account of a scarcity of water for irrigation. Large quantities of commercial fertilizer are used for citrus growing, but best results appear to be obtained where liberal additions of organic matter are made. The adding of organic matter, the supplying of water, and the careful preparation of the soil to a depth of several feet are important requirements in the production of intensive crops on this type.

The greater part of the type is well located with respect to roads, towns, and shipping points. Land prices range from $50 an acre for the most unfavorably located areas to $500 or more an acre for the best land.

RAMONA CLAY LOAM.

The Ramona clay loam, to a depth varying from 10 to 15 inches, consists of a brown, dark-brown, or grayish-brown, slightly micaceous, heavy-textured clay loam. Locally the color is slightly reddish brown. In such places the type closely resembles the Placentia clay loam, from which it is ordinarily differentiated mainly on the basis of color. The subsoil is a brown to reddish-brown, compact, rather heavy clay loam or clay. Below the depth of 4 or 5 feet it becomes somewhat lighter in texture and color, continuing in compact, semistratified beds to a depth of many feet. The soil tends to puddle in the lower lying and flatter areas, and the fields usually become more or less cloddy when plowed. A tendency toward the

formation of a hardpan exists in areas too small to differentiate upon the soil map. In places the type is light in texture, closely approaching a loam or gritty loam, and occasionally it occurs as a shallow deposit overlying granite, as in places northwest of Arlington. Some local, slightly depressed spots have a dark grayish brown or dark-gray soil and are inundated during periods of heavy rains. The subsoil is slightly streaked or mottled in places where drainage is not well established, and northwest of Arlington a grayish or light grayish brown calcareous deposit is encountered in places at depths of 5 or 6 feet.

The type is generally higher in organic content than the loam or sandy loam of this series, but it is much more difficult to till. When well handled it is quite retentive of moisture. It responds readily to applications of organic matter. Drainage is well established in most places, but water passes away rather slowly on account of the compact, heavy nature of the material, and the growth of crops is somewhat retarded in the spring by a cold root zone. The water table is high in the southern part of the area of the type, and moderate to large quantities of alkali have accumulated locally. The surface is slightly uneven and hummocky in places, but as a rule it is gently sloping or nearly level.

Granitic rocks have given rise to most of the material forming this type. Some alluvial reworking is occurring locally, and erosion is active over most of the type.

This type is not extensive. An important area occurs northwest of Arlington. Grain and grain hay are the principal crops grown, and fair yields are obtained. Alfalfa is an important crop locally and appears to do very well where drainage is good and water is available for irrigation. Some fruits are being planted in the most favorable areas. Owing to the position of the type and its general soil features, the deciduous fruits seem to do best. Land values vary widely; generally they are too high for the profitable use of this type for general farm crops. The type is well located, and good drainage, irrigation, and good tillage are the principal requisites influencing the growth of highly specialized crops.

ANTIOCH LOAM.

The Antioch loam is prevailingly brown to dark brown, but part of the type has a reddish-brown cast. The soil varies in depth from 18 to 26 inches. It is usually friable and easily tilled and moderately well supplied with organic matter. In places the surface layer is influenced by small additions of alluvial wash and wind-blown material from the Hanford and Chino soils, and as a result small quantities of mica are present. The subsoil to a depth of about 48 inches consists of a gray to light grayish brown, and in some places

brown or reddish-brown, heavy loam to clay loam. It frequently is highly calcareous, which is an important distinguishing feature of the Antioch series. Where lime is abundant the subsoil is much more friable than elsewhere. The gray, calcareous subsoil rests upon brown silts and clays, which usually are permeable to roots and water. When well tilled the type is quite retentive of moisture. In the lower and flatter places the soil has a compact, close structure, and puddles badly.

A moderate quantity of gravel is present in the subsoil in places, mainly along old stream banks. The type in the more rolling areas near the Santa Ana River is sometimes quite coarse and gritty and evidently contains material derived from granite. Some quartzite and granite cobbles occasionally occur on the higher ridge crests, making tillage somewhat more difficult than in other situations.

Local undifferentiated areas of clay loam are included in the more nearly level parts of the type. The soil here usually is compact and has a tendency to puddle. It requires considerable working to develop a good tilth. Varying quantities of lime concretions, which vary widely in size, are present in the subsoil.

The type includes a silty variation, which is poorly defined and of small extent. The soil here is variable in texture and marks a narrow transitional zone between the Chino silt loam and the Antioch silty clay loam. It contains more Chino and Hanford material than does the typical Antioch loam. The surface soil varies from grayish brown in the lower and more poorly drained areas to brown or dark brown in the higher situations. In most respects this soil closely resembles the typical Antioch loam.

A well-defined sandy loam variation also is included, differing little except in texture. This coarser soil in places has a reddish cast when wet, and sometimes appears darker in color, especially where influenced by adjoining Chino or Hanford material. Its substratum is variable, but usually consists of clay or silty clay which is semistratified and occasionally contains seams or lenses of gravel and sand along the banks of abandoned streams or in other breaks in the topography. The entire soil mass is permeable, and there is no tendency toward hardpan.

The Antioch loam occurs several miles northeast of Rincon. A small area of the sandy loam variation is found about 5 miles north of Corona. The type has a gently sloping surface in most places, but toward the Santa Ana River erosion has developed a hilly and ridgy topography. There is a tendency toward a hummocky surface over part of the type, and leveling is necessary for successful irrigation. The hilly and uneven areas are well drained and are free from alkali, but in the hummocky areas drainage is restricted and alkali spots occur.

Shales, sandstones, and conglomerates have contributed the greater part of the material forming this type. Minor contributions from granitic sources have also been made. The material is no longer being added to, and the soil ranks among the older soils of the survey. The material appears to have been brought by streams from the hills and mountains to the south and southwest before the present drainage systems were formed.

This type is of minor importance agriculturally. It is devoted mainly to the production of grain, grain hay, alfalfa, and sugar beets. Moderate to good yields are obtained in the most favorable situations. Yields are relatively low where the soil has a hog-wallow tendency, owing to the occurrence of poorly drained and puddled spots where water remains over the surface during rainy periods. Sugar beets and alfalfa require irrigation, and water is obtained without great difficulty by pumping. Much of the type is not well suited to fruit culture because of alkali accumulations, restricted drainage, and danger from freezes.

Deciduous fruits and nuts do well over the most favorable parts of the sandy loam areas, but citrus fruits are not grown. Alfalfa produces good yields where well supplied with water. Grain and grain hay are grown without irrigation, and give moderate yields.

Land prices on the Antioch loam vary widely, depending on the drainage, alkali conditions, the cost of leveling, the availability of water, and the location. Water for irrigation, good drainage, thorough tillage, and the incorporation of organic matter are the principal needs of this type, and alkali is a controlling factor in crop production.

ANTIOCH SILTY CLAY LOAM.

The Antioch silty clay loam, to a depth of 18 to 26 inches, typically consists of a brown, slightly reddish brown, or dark-brown, smooth-textured, friable, nonmicaceous clay loam. The subsoil to a depth of 48 inches is variable, but usually consists of a gray, grayish-brown, or brown calcareous clay loam to clay. The calcareous material characteristic of the subsoils of this series frequently occurs in streaks, pockets, or seams. In places the material is not calcareous; the subsoil here is brown to slightly reddish brown and is usually less friable. The lime seldom extends far into the substratum, which usually consists of a brown clay loam or clay. Locally slight stratification and sorting are apparent, and small quantities of gravel, cobbles, and sand are occasionally encountered where there is a sudden break in the topography, in old stream banks, and on ridges. The subsoil and substratum are heavy and compact in places, but there is no tendency toward hardpan. Lime concretions in varying quantities and of varying size are present in the subsoil over a part of the type. Water

enters the material rather slowly, but it is generally retentive of moisture and permeable to roots. The surface soil works up into a friable, well-granulated mass.

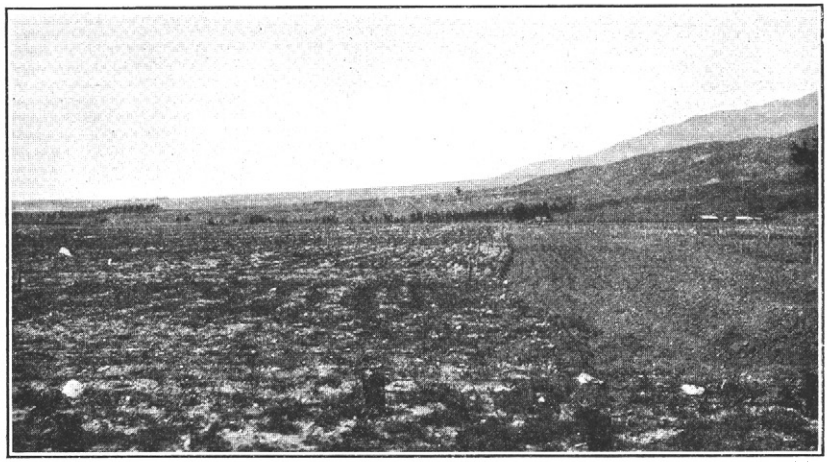
That part of the type north of the Santa Ana River contains many hog-wallow depressions in which water stands for long periods, giving the type a puddled, cloddy, and spotted appearance. The soils in such places usually are heavy and frequently approach a clay. A small area of distinct clay texture is included with the type. If more extensive this would be differentiated upon the soil map as a separate soil type. It consists of a dark-brown, brown, or dark grayish brown, heavy-textured, nonmicaceous clay, extending to a depth of 12 to 20 inches. In places the surface soil approaches an adobe structure, and it is usually compact and dense when dry. It contains a small percentage of sand in places, giving it a gritty feel. The subsoil to a depth of 48 inches is a clay to silty clay, generally gray to grayish brown in color. The lime tends to make the subsoil somewhat more friable, but generally it is heavy and rather poorly aerated. This clay soil is sticky when wet and forms a very cloddy seed bed if tilled when somewhat dry. It absorbs water slowly, but retains it quite well when once moist. The use of organic matter not only increases crop yields but improves the physical condition of the soil, increases the water-holding capacity, and lessens evaporation. The soil does not warm up quickly in the spring.

The Antioch silty clay loam occurs in several areas of moderate size a few miles north of Rincon. The area west of Chino Creek is gently sloping and dissected at intervals by ravines, but the surface is smooth. The area is well drained and is free from alkali. It is capable of producing a wide range of fruits and other crops, but development has been retarded by a scarcity of water. Elsewhere the type has a very gently sloping to nearly level surface except near the Santa Ana River, where erosion has dissected the land into pronounced rounded ridges, low hills, and ravines. The surface frequently is hummocky in the more nearly level areas, and stagnated drainage gives a semiswampy condition locally, with some accumulation of alkali in spots.

The clay variation included with the type occurs in one small area about 4 miles northwest of Rincon. Practically no leveling is necessary to prepare this land for irrigation, and the area has good drainage and is free from alkali.

The parent material of the Antioch silty clay loam has been derived principally from sedimentary rocks, with minor additions from granitic sources.

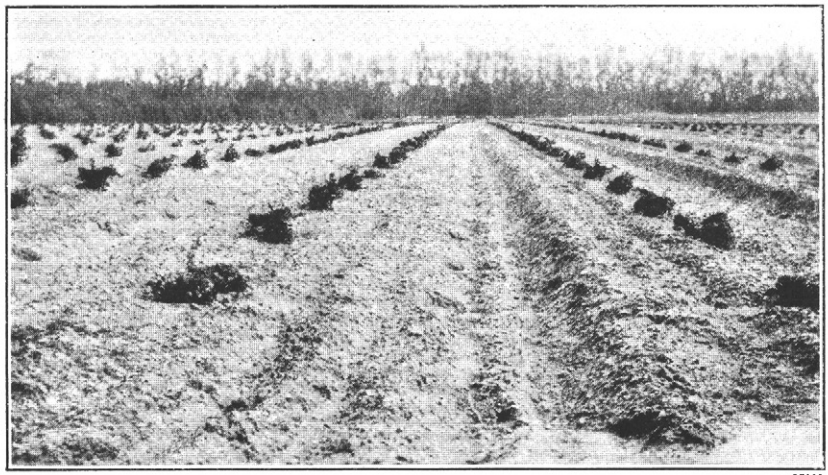
The Antioch silty clay loam is practically all under cultivation and ranks well as a general-farm crop and dairy soil. It is principally devoted to grain, grain-hay, alfalfa, and sugar-beet production.



S8011

FIG. 1.—STONY SOILS OF THE HANFORD SERIES ON LYTLE CREEK ALLUVIAL FAN, LOOKING EAST.

In the distance is seen the profile of the steeply sloping high alluvial fan of Day Creek.



S7998

FIG. 2.—VINEYARD ON HANFORD GRAVELLY SANDY LOAM NEAR ETIWANDA.

S7977

FIG. 1.—ORANGE ORCHARD ON HANFORD GRAVELLY SANDY LOAM NEAR ONTARIO.

S8006

FIG. 2.—GRAIN HAY ON HANFORD COARSE SANDY LOAM, ON ALLUVIAL FAN NEAR SAN BERNARDINO.

Small plantings of deciduous fruits have been made around farm houses, and the trees generally appear to do well. In places where the surface is hummocky, with intervening puddled spots and small areas of alkali soil, the fields have an irregular and spotted appearance, but elsewhere the yields are good. Alfalfa and sugar beets do very well where drainage is good; the latter crop withstands alkali conditions better than the former. Olives are grown to a small extent where the soil is well drained and uniform. Some dairying is carried on, with fair results. The lower and wetter areas are used mainly for pasture.

The included area of clay is of little importance agriculturally. It is primarily a dairying and general-farming soil. Grain, grain hay, and alfalfa yield very well when the soil is properly handled and are the principal crops grown.

Water for irrigation is available by pumping in the more nearly level areas of the Antioch silty clay loam. Irrigation is required for most crops other than grain. The type is not very well located with reference to shipping points and towns but is well supplied with good roads.

Land prices vary widely, ranging from $75 an acre for the more unfavorable parts of the type to $200 and more an acre for the best land.

Citrus fruits are not grown in that part of the survey where this soil is developed but should do well on the higher slopes near the hills to the west if water can be supplied. Drainage, removal of alkali from some areas, irrigation, and good tillage are the main requisites for success with crops on this type. An increase in the organic content greatly improves the yields.

MONTEZUMA SILTY CLAY LOAM.

The Montezuma silty clay loam to a depth of about 10 or 15 inches consists typically of a dark-gray to black, smooth-textured, rather friable silty clay loam. The subsoil is a gray or light grayish brown, highly calcareous clay loam or clay extending to a depth of 6 feet or more. It is noticeably heavier than the surface material and rests upon rather compact, semistratified deposits which are quite uniform to considerable depths. The substratum is grayish brown to dark gray in color. It contains less lime and is slightly lighter than the subsoil.

The type is well supplied with organic matter and contains little or no mica. Its high silt content greatly reduces the difficulty of tillage. Where well tilled it is retentive of moisture and responds with materially increased yields when organic matter is applied. When dry and in a finely divided condition the soil loses its dark

color to a great extent and assumes a gray to dark-gray tint. The lime is generally present in streaks or pockets through the subsoil, or the entire layer may be very marly and light in color. The lime apparently renders the subsoil more friable and enables roots and water to enter it with less difficulty.

A small area of the Montezuma loam a few miles northeast of Upland, having the same general characteristics as the Montezuma silty clay loam, is included with this type as mapped. It is more friable in structure, is quite silty and micaceous, and is more easily tilled.

The Montezuma silty clay loam occurs in two small areas, one just northeast of Colton and the other northeast of Upland. It has a smooth to very gently sloping, uniform surface, and is well drained and free from alkali. It occupies a position somewhat above that of the surrounding soils near Colton and includes a high, nearly perpendicular bluff along Warm Creek.

Although calcareous, this soil in this area appears to have had its origin principally in granitic rocks, the lime being a secondary feature, as is the case with the Chino and Antioch series. The parent material was deposited far out into the valley and has undergone changes through weathering and translocation of its mineral components since deposition. No new accumulations are being added, and the type is undergoing slow erosion and local reworking. The loam soil has not advanced quite so far in age as the typical silty clay loam, but it conforms in subsoil features with the old-alluvial deposits.

The Montezuma silty clay loam is of very little importance agriculturally. Grain, grain hay, corn, potatoes, and other crops are grown, and good yields are obtained where the soil is given proper attention. Land prices are quite high, owing to the favorable location of the type. Good tillage and irrigation are the main requirements in farming.

HANFORD STONY SANDY LOAM.

The Hanford stony sandy loam is indicated upon the soil map by stone symbols in the color used for the Hanford sandy loam. It resembles the gravelly sandy loam of this series in color and texture of the fine material and in depth, but in large areas of the typical soil there usually is less difference in color between surface soil and subsoil than in the case of the gravelly sandy loam. Moderate to large quantities of rounded stones, varying in size from that of an egg to 1 foot or more in diameter, generally are present on the surface and throughout the soil section. They increase in quantity and size toward the higher and steeper parts of the extensive alluvial

fans, and frequently large bowlders weighing many tons are encountered. It is necessary to remove most of the stones before crops can be planted, and this involves considerable labor and expense. After the stones are removed the type usually is very gravelly, resembling the Hanford gravelly sandy loam. The stones gathered are used for fencing or building purposes, for paving drainage ways, or are piled in the least valuable part of the field. It usually is necessary to gather the stones after each plowing for a few years, until all those within plow depth are removed.

The Hanford stony sandy loam is almost as extensive as the gravelly sandy loam. It occurs along the foothills and in a number of large bodies from Upland east to Lytle Creek, with a few small areas along the foothills north of San Bernardino. (Pl. II, fig. 1.) The areas of this type constitute the steepest and roughest parts of the large fans projecting from the mountains and gradually merge into more gently sloping and less stony areas valleyward. The type ranges from about 1,500 to 2,750 feet in elevation. The slope usually is very favorable for frost protection, but in the more exposed places winds are somewhat damaging at times. Protection, however, is afforded by the use of windbreaks where necessary. The surface generally is smooth on the lower extensions of the fans, but frequently is quite rough and broken by shallow abandoned stream ways.

Agricultural development on this type has been retarded by its stony, rough surface and the expense required for clearing. In the last few years, however, large areas have been cleared and planted to lemons and oranges. The trees are in excellent condition, and the type seems especially well adapted to the growing of these fruits. In planting it is the custom to dig quite large holes for the trees and to remove all the large stones near them.

The type is not quite so well located with respect to towns and roads as is the Hanford gravelly sandy loam, but the roads usually are good, and shipping points are generally convenient. Land of this type usually is much cheaper than that of the gravelly sandy loam, and this frequently compensates for the difference in cost of clearing and preparation.

In agricultural practice, crops grown, fertilizer requirements, crop adaptations, and irrigation the Hanford stony sandy loam is comparable with the gravelly sandy loam.

HANFORD GRAVELLY SAND.

The Hanford gravelly sand, to a depth of 6 feet or more, consists of a brown, uniform-textured sand containing varying quantities of small to medium-sized, rounded gravel. The type contains a small

percentage of mica, which usually is finely divided. It carries considerable fine material, and in many places closely approaches a loamy sand to light-textured gravelly sandy loam. No distinctive subsoil is present, but the material below a depth of 2 feet generally is somewhat lighter in color and frequently contains more fine material than the surface soil.

South of Etiwanda, around Wineville, and near areas of old valley-filling material, the type occurs as a recent-alluvial covering, several feet deep, overlying a much older subsoil and substratum. The underlying material in such places generally is much heavier than the surface soil and consists of a light-brown to brown or slightly reddish or yellowish brown sandy loam or loam, somewhat compact when dry. Irregular areas of sand or sandy loam, an acre or two in extent, occur at intervals in slight depressions or on flat surfaces. The type grades into the Hanford sand and the Tujunga soils through indefinite boundaries. In a few local areas small cobbles are present, but they affect the type only in a small way. Where the gravel content is fairly high tillage is hindered, but as a rule little difficulty is encountered from this source, because of the open texture of the soil. The soil and subsoil contain varying quantities of fine material, often giving them a loamy appearance. A slightly compact layer quite frequently occurs at a depth of 10 to 12 inches below the surface, resulting from a filtering down of fine material and from tillage. The type is low in organic matter but is quite retentive of moisture.

The Hanford gravelly sand is an extensive soil. It occurs most typically in a large area between Rialto and Etiwanda. Other prominent areas are encountered south of Etiwanda and around Wineville. Smaller areas occur just southeast of Upland and of Ontario, northeast of Redlands, north of Lewis, and north and northwest of San Bernardino.

The type occupies gently sloping alluvial fans, and the topography is uniform. In places it occurs in long, narrow areas which become fan shaped in their valleyward extensions. The surface is modified somewhat in places by wind action, and low ridges or slight undulations occur. Occasional small, shallow, intermittent, spreading stream ways occur, which contribute fresh material in periods of heavy rains. These new accretions are nearly always grayer in color than the average for the type, and in places approach the color of the Tujunga sand. The water table is deep, and the porous, open nature of the soil and subsoil gives good to excessive drainage. No alkali is present.

Granitic and schistose igneous, quartz-bearing rocks are the principal sources of the materials giving rise to this type.

About one-third of this type is devoted to general farm crops, mainly grain and grain hay, about one-tenth to grapes, and the remainder to citrus fruits, peaches, apricots, and nurseries, and alfalfa and eucalyptus plantings. Lemons are the principal citrus crop and appear to do well with good care where the slope is sufficient for good air drainage. Grain usually produces light yields and requires alternate summer fallowing to give best results. Grapes become very deep rooted and produce good yields without fertilization in most years. Apricots and peaches produce well, especially where the subsoil consists of sandy loam or heavier material. Nursery stock is produced successfully, and there are some fair plantings of eucalyptus, to which the soil seems well suited. Alfalfa requires irrigation, but where properly irrigated gives good yields. The type appears to be better adapted to lemons than to oranges. The greatest citrus development on this type is west and southwest of Rialto, and the most extensive plantings of grapes are about 5 miles west of Rialto and around Wineville. The relatively high development of the type is due principally to its favorable location with reference to good roads and shipping points, and to the ease of handling the soil and its general productiveness.

The price of land varies widely, depending upon the location, the degree of development, and the range of crops possible.

The adding of organic matter greatly increases the productiveness of this soil.

HANFORD GRAVELLY SANDY LOAM.

The Hanford gravelly sandy loam is indicated on the soil map by gravel symbols in the color used for the Hanford sandy loam. The soil is typically brown to grayish brown, with variations to light brown, light reddish brown, or even dark brown or dark grayish brown. The type is friable, well granulated, and of open texture to a depth of 10 feet or more, but tillage is difficult where the gravel content is high. The material below the depth of 18 inches is lighter brown than the surface soil, and when moist occasionally has a reddish cast. Occasionally the material is very uniform in color to a depth of 6 feet or more, but local deposits of gravel or gravelly sand frequently are encountered. The type is generally light in texture and in places closely approaches a gravelly sand. The subsoil generally contains a little more fine material than the surface soil, and in places it closely approaches a loam or gravelly loam. Wherever the type is bordered by the Hanford loam or by soils of the Placentia series, as north and northeast of Upland, the soil becomes heavier and approaches in color the adjoining types. Small areas of sand, sandy loam, or loam, too small to be mapped separately, are included with this type. Local washes of fresh material occur in places, the

soil here being grayish in appearance and usually coarse and gritty. The type along Lytle Creek Wash is occasionally coarse and gritty, in places closely approaching a coarse sandy loam in texture.

In some places gravel almost covers the surface after several cultivations, and in others only a moderate to small quantity is present. The gravel varies in size from coarse grit to fragments about 2 inches in diameter. It is mainly granitic in character. Small quantities of cobbles are present locally, and these make tillage operations difficult.

The Hanford gravelly sandy loam is an extensive type. It occurs mainly in the vicinity of Ontario and Upland, with prominent areas along the foothills from Upland eastward to San Bernardino. Other important areas are mapped in the vicinity of Rialto. Only a small total area occurs south of the Santa Ana River.

The type occurs on gently sloping to steeply sloping alluvial fans, in low terracelike areas along some of the main drainage ways, and in nearly level areas subject to overflow along the larger stream courses. The surface usually is smooth and uniform, and practically no preparation is necessary for planting or irrigating. The water table is low over all the type, and it has good drainage. The soil is free from alkali.

The material giving rise to this soil has been derived from disintegrated granitic and schistose igneous rocks. It is composed of both recent and old valley-filling deposits. The older material, although slightly browner from oxidation, has not undergone sufficient translocation of the particles to necessitate its being classed with the soils of old valley-filling origin.

Agriculturally, this type is one of the most important in the area surveyed. It is devoted to the production of oranges, lemons, grapes, peaches, bush fruits, alfalfa, grain, and grain hay. The fruits grown on this type are generally of high quality and flavor, and good yields are obtained. Grapes are long-lived and thrifty and are produced successfully without irrigation. (Pl. II, fig. 2.) Grain and grain hay are still important crops, but usually are grown as fillers until irrigation is developed. Oranges are the most important crop, although lemons are gaining in favor and the type has proved especially adapted to their production. (Pl. III, fig. 1.) Many new plantings have recently been made of both oranges and lemons, and all the trees are in good condition. Citrus fruits on this type require large quantities of water. Commercial fertilizers are used extensively, and very satisfactory results are obtained where liberal quantities of organic matter are applied. Both barnyard manure and cover crops are used. The cover crops consist principally of legumes, although some grain is sown for this purpose. They are seeded at the time of the first rains in the fall and are plowed under the fol-

lowing spring. Fertilizer is applied at various times, but mainly in the spring and midsummer.

The type is well located with reference to shipping points and transportation facilities. A good system of roads reaches nearly all the areas.

Land prices vary widely, but are usually high, because of the favorable location of most of the type and its adaptation to citrus fruits. Prices range from $150 an acre for the poorest and most unfavorably located areas to $500 or more an acre for the more favorable areas not planted to trees.

HANFORD GRAVELLY LOAM.

The Hanford gravelly loam is indicated on the soil map by gravel symbols in the color used for the Hanford loam. In this survey the soil is prevailingly light grayish brown to brown. It contains a small percentage of mica and is friable and easily tilled. The soil is uniform in texture to a depth of 6 feet or more where typically developed. Below 18 inches the subsoil is light brown to slightly reddish brown. Both soil and subsoil contain moderate quantities of gravel, which interferes somewhat with tillage. Local areas subjected to vigorous stream action contain larger quantities of gravel and some cobbles and sand. Pockets and lenses of gravel or stony sand occur locally in the subsoil and where present tend to make the type somewhat droughty.

As mapped, this type includes a stony variation in which the soil, subsoil, and substratum contain gravel and cobbles in quantities which vary from place to place but are sufficient to interfere seriously with tillage. The stony areas are retentive of moisture under cultivation and respond with materially increased yields where organic matter and irrigation water are applied. In preparing this land for tree fruits it is customary to remove the stones to a depth of several feet. This involves considerable labor and expense. It leaves the soil a gravelly loam.

The largest area of the typical Hanford gravelly loam is in the northwestern corner of the area surveyed, around San Antonio. Two small areas occur near the foothills where Lytle Creek emerges from the mountains, and another northwest of San Bernardino. The stony variation of the type is of very small extent. It occurs in several small areas, mainly along the foothills just west of Lytle Creek. One small body lies in the extreme northwestern part of the area, west of San Antonio.

The type has a gently to moderately sloping topography. The surface usually is smooth and uniform except locally, where shallow

channels traverse the type. The soil is well drained and is free from alkali.

Granite and schistose igneous quartz-bearing rocks have supplied the greater part of the material giving rise to the type. The stone and gravel content is mainly granitic in character.

The Hanford gravelly loam is of small extent and of minor importance agriculturally. The area around San Antonio is highly developed to oranges, to which the type has proved well adapted. Some lemons also are grown with success. Both fruits are of high quality, and heavy yields are obtained. The other areas of the type are mainly devoted to grain, which gives moderate yields. The stony areas are utilized principally for grain production, but are adapted to the same range of crops as the typical Hanford gravelly loam.

Good roads supply a ready outlet for the products grown. Land prices vary widely, but are somewhat lower than on the Hanford loam.

The Hanford gravelly loam responds well to the addition of organic matter and to good tillage.

HANFORD SAND.

The Hanford sand typically consists of a light-brown, buff, or grayish-brown, friable, micaceous, loose-textured sand, continuing to a depth of 6 feet or more. It is easily tilled, usually low in organic matter, and readily permeable to roots and water. Most of the type closely approaches a loamy sand or light sandy loam in texture.

The subsoil and substratum to depths of many feet vary little in texture from the surface soil, although they are slightly more compact. The subsoil usually is browner than the surface material and frequently becomes yellowish brown or light reddish brown toward the lower extensions of the large alluvial fans. In such places the underlying material frequently is heavier, and passes into a light sandy loam or, rarely, a light loam or silt loam. A layer of variable compactness frequently occurs at a depth of 8 to 12 inches below the surface, due to a filtering down of finer material and to tillage. Washes occurring in this type usually have perpendicular banks, largely due to the binding qualities of the relatively large quantities of fine particles in the soil mass.

Small quantities of fine gravel and coarse, gritty material occur locally over the type, marking the location of shallow stream ways which carry water during periods of prolonged heavy rains. The gravelly and coarse material do not interfere with cultivation. Slight depressions occupied by a sandy loam soil occur locally, and

small undifferentiated areas of the Tujunga sand are included with the type.

The Hanford sand occurs extensively between Ontario and Wineville, and smaller areas are mapped in the vicinity of Etiwanda, Declez, and San Bernardino. It occupies gently sloping alluvial fans or nearly level areas. Wind action has had an important influence in modifying the surface into slightly ridged or gently undulating areas. Marked drifting occurs during high winds where there is little or no vegetation, and sand drifts several feet high are not uncommon along fences and roads. The moving sand frequently injures young crops by cutting the leaves, by covering them up, or by exposing the tender roots.

The type is well drained and is free from alkali. It is retentive of moisture, owing to low capillarity. Crops frequently show a healthy, vigorous growth on this soil while those on heavier soils suffer for water.

The material giving rise to this type has been derived from granitic and schistose igneous rocks and laid down over the more nearly level parts of the large sloping alluvial fans.

The type is intensely developed. It is utilized for the production of grapes, peaches, apricots, alfalfa, grain, and grain hay, and to some extent for milo and truck crops. Alfalfa is irrigated from wells and thrives for five to seven years. Six and sometimes seven cuttings of three-fourths ton to 1½ tons per acre are obtained in a year. Little or no irrigation is practiced except for alfalfa, and very little fertilizer is used. Manure is used wherever available, usually being spread as a surface dressing around the trees. Moderate to good crop yields are the rule. Fresh erosion by streams and trenches excavated for irrigation pipe lines indicates a deep rooting of fruit trees on this type. Success has been obtained with sweet potatoes, but they are grown only in a very small way. Good tillage and the maintenance of a good surface mulch are inexpensive and very effective, and crop rotations have proved highly beneficial.

Land of this type ranges in price from $75 to $300 an acre, depending on the location.

As mapped in this area, the type includes a coarse phase and a wind-blown phase, which are indicated on the soil map by cross lines.

Hanford sand, coarse phase.—Typically, the Hanford sand, coarse phase, consists of a light-brown to light grayish brown, coarse, gritty, micaceous sand, containing a moderate quantity of small angular fragments of granite. It is loose and porous and uniform in texture and structure to a depth of 6 feet or more. The soil is easily tilled. It is low in organic matter and of low water-holding capacity. In places the soil is somewhat darker than typical because of the accu-

mulation of black mica, hornblende, and other dark-colored minerals. No distinct subsoil is present, but the material below the depth of about 2 feet is darker brown and more micaceous than the surface soil.

Only a small total area of this phase is mapped. Two small areas occur to the north of San Bernardino, and another extends southeast from Corona along the Temescal Wash. The material of the latter area has been transported farther and is less micaceous. The phase has a relatively smooth surface, but may be slightly ridged by stream action. It occupies small alluvial fans and abandoned stream bottoms, and each year receives fresh contributions of material. The soil consists of only slightly assorted granitic detritus which occurs as outwash from the near-by granitic hills and mountains.

The phase is of very little value agriculturally and remains in its virgin condition. It supports a scant growth of scrubby brush and grass and is used only for grazing.

Hanford sand, wind-blown phase.—The wind-blown phase of the Hanford sand consists of material which has been heaped into rolling ridges by wind action. The mass usually is unstable and subject to noticeable modifications by high winds. It consists of a light-brown or light grayish brown sand, with a slightly variable degree of fineness in the cross section, due to differences in wind velocity. It is incoherent, but contains a moderate quantity of fine material, giving it a slightly loamy texture in places. No important variation occurs within the depth of 6 feet except in low areas between dunes, where the wind-blown material rests on alluvial deposits at depths of less than 6 feet. The soil is low in organic matter, but very retentive of moisture. Most of the dunes are barren of vegetation and present a white, glistening surface.

This phase is confined to three small areas southwest of Wineville. Other small drifts occur in places, as along roads, but these are too small to differentiate upon the map and are included with the Oakley series.

The material forming the dunes has been blown from sandy areas of Hanford and Tujunga soils. It is slightly micaceous and principally granitic in origin. It usually is nonagricultural, but the more gently undulating and the outer marginal areas are sometimes planted to corn and milo, which give fair yields. Borings made about two months after the winter rains had ceased showed considerable moisture in the soil. Furrows are sometimes plowed over the surface to check drifting and encroachment on near-by lands. It is difficult to irrigate on account of the elevation and the uneven surfaces, and in many cases crops are destroyed by the drifting of the sand at the time of the frequent spring winds.

HANFORD COARSE SANDY LOAM.

The Hanford coarse sandy loam is brown where typically developed, but in places where fresh accumulations have been added it frequently is grayish brown. Near areas of old deposits the type may have a reddish cast, and frequently it is dark brown in the lower and more nearly level areas where there is a more extensive growth of vegetation. The type is coarse, gritty, and slightly micaceous, and frequently small quantities of waterworn gravel are scattered through the soil and subsoil. The material usually is uniform in texture to a depth of more than 6 feet, but near stream courses and where the depositing streams have been very irregular in volume and velocity the soil and subsoil contain lenses or pockets of coarse sand or gravel. Below the depth of about 18 inches the material becomes lighter in color and may be either light brown, light reddish brown, or light grayish brown.

The type is porous and incoherent. Its leachy nature permits water to percolate rapidly beyond the reach of plant roots. The organic-matter content is variable, but usually deficient, and the soil responds readily to applications of barnyard manure and the plowing under of cover crops. It is easily tilled but is generally droughty, requiring the addition of large quantities of water for best results with crops. Occasionally heavier material occurs at depths of 5 to 6 feet below the surface, materially improving the water-holding capacity and furnishing a favorable medium for the development of deep-rooted plants. In the higher areas near canyons or ravines and where the soil contains more coarse material, it is more droughty than usual and frequently is underlain at a depth of a few feet below the surface by coarse, gravelly sand and cobbles. The area slightly northwest of Colton contains considerable fine material and closely approaches a sandy loam in texture.

The Hanford coarse sandy loam is of minor importance agriculturally. It occurs principally in a number of irregularly shaped areas on the large, gently sloping fan formed by the Cajon Canyon drainage. (Pl. III, fig. 2.) Other areas occur on minor fans along the base of the San Bernardino Mountains from Arrowhead Station southeastward. Two areas occur near Colton, along Lytle Creek, and one along Temescal Wash. A small area lies on the south bank of the Santa Ana River northwest of Corona, and several bodies occur in other places, mainly in the eastern third of the area.

The type has a gently sloping to nearly level topography where it occurs on the valley floor, but it becomes much steeper near the foothills. The surface usually is smooth and is easily prepared for crops and irrigation except in a few places where it has been eroded

by streams. Usually the type is excessively drained, and it is free from alkali accumulations.

The Hanford coarse sandy loam has originated principally from granites and schistose igneous quartz-bearing rocks. Much less sorting of the material has occurred near the foothills, and the type in such places lacks uniformity.

The area east of Highlands and that northwest of Colton are devoted to orange growing. The first-named area is very well adapted to this crop, and excellent results have been obtained. In favorable years fair results have been obtained elsewhere on the type, but frost has done much damage to fruit in the lower lying areas, and in places serious injury to the trees has resulted. Grain and grain hay are important crops, but the yields are not high. Some deciduous fruits are grown, with fair results where good care is given the trees and ample water for irrigation is available. Grapes give fair yields without irrigation.

The type is accessible over good roads, and near-by shipping points offer a ready outlet for the products grown. Land prices are high where the soil is well located and is suited to citrus fruits. For general farm crops, the value is about equal to, or slightly less than, that of the Hanford sandy loam. The methods of soil treatment and irrigation and the crop yields are similar to those on that type.

HANFORD SANDY LOAM.

The Hanford sandy loam, to a depth of 6 feet or more, consists of a micaceous, smooth-textured, friable sandy loam. It is typically brown to grayish brown in color, but in places where influenced by older and more highly oxidized soils or where the material itself is considerably aged it frequently has a reddish-brown cast. Near areas of the Chino soils and the heavier members of the Hanford series the color frequently is darker brown. The texture is generally that of a light sandy loam, and in places the type approaches a loamy sand.

As in the other members of this series, no distinct subsoil is developed. The material below a depth of about 20 inches, however, is generally lighter brown and usually contains more fine material than the surface soil. The soil section on the large fans near the foothills is often quite uniform, but farther out in the valley the color becomes somewhat lighter, and the subsoil and substratum material grade into a loam, silt loam, or, in slightly depressed or flat areas, a silty clay loam or clay loam. The underlying material is permeable to roots and water, but often has a compact structure when dry. Seams of gravel or sand are not uncommon. Small quantities of gravel are present over a large part of the type, but they do not

affect tillage operations. Local, low, rounded gravelly ridges, marking former stream beds, are present. These areas and the more nearly level areas over which fresh wash has been spread usually have a quite gray soil, but are generally too small to differentiate in mapping. Near the larger streams and on the steeper parts of the fans the type frequently contains moderate quantities of coarse, gritty sand and may in many places include small undifferentiated areas of coarse sandy loam or coarse sand. These conditions exist in the large area of the type north of Redlands.

The entire type is open, friable, and easily tilled. It contains sufficient fine material to give it a good water-holding capacity, and the material is uniform to a sufficient depth to permit good root development. The soil contains more organic matter than the lighter textured types of this series. Applications of organic matter, however, are highly beneficial.

The type is prominently developed just north of Redlands, southwest of Colton, around San Bernardino, and in smaller areas east and south of Ontario and Upland. Important areas occur near Declez, and small areas are mapped in various other parts of the survey.

The topography is variable, but usually the surface is smooth, gently sloping, or nearly level. Minor surface irregularities, such as occasional shallow stream washes or slight undulations, occur. There is no great range in elevation, but the slope is nearly everywhere favorable for irrigation and good drainage. The water table is generally deep, except in the lower areas around San Bernardino, where drainage is necessary and injurious quantities of alkali are present.

The material forming this type has been derived from granitic and schistose igneous rocks, with minor quantities of material from other formations. Some material has been contributed from old, highly oxidized valley-filling deposits occurring as scattered remnants throughout the area.

This type is agriculturally one of the most important of the Hanford soils. It is highly developed to intensive crops and is well adapted to orange culture where the drainage is good and the slope favorable for frost protection. Many successful orange groves are located on this soil near Rialto, with smaller plantings in other places where soil and climatic conditions are favorable. A considerable acreage is still sowed to grain and grain hay. The land is summer fallowed each alternate year, and fair yields are obtained, but land values are usually too high for the profitable production of these crops. Grapes, peaches, apricots, and other deciduous fruits, and walnuts and truck crops are grown successfully in a small way.

Alfalfa gives satisfactory returns where irrigation is possible at low cost, where the crop is properly managed, and where it is grown as feed for dairy cattle and hogs or to be sold at a good price for hay.

Land prices are generally high, ranging from $200 an acre upward.

Hanford sandy loam, reddish-brown phase.—A reddish-brown phase of the Hanford sandy loam occurs in the vicinity of Casa Blanca and Arlington. The soil and subsoil are noticeably reddish brown and have a higher mica content than typical. When wet they closely approach a red color in the field. Generally the material below the depth of about 12 inches is somewhat heavier than the surface soil, and in places this slightly heavier subsoil may extend to depths of 2 or 3 feet, grading into smooth, friable, open-textured material. Except in color and mica content, this phase is similar to the typical soil as it occurs south and southeast of San Bernardino. Its regular occurrence and lack of uniformity are due to overflows and poor drainage. In places it is water-logged a large part of the year. In such places iron stains of red, yellow, and brown are present in the subsoil, and drainage water flowing from such areas is dark brown in color.

HANFORD FINE SANDY LOAM.

The Hanford fine sandy loam typically consists of a brown to light grayish brown, fine-textured, smooth, micaceous fine sandy loam, uniform to a depth of 6 feet or more. The soil is friable and open and easily penetrated by roots and permeated by water. The cost of tillage and cultivation is low, owing to the light texture and favorable granulation of the soil. Below a depth of 20 inches the material becomes slightly lighter in color and somewhat heavier, and in small depressions or unusually flat areas sometimes approaches a silt loam or silty clay loam. In low places of restricted drainage south and southeast of San Bernardino red, yellow, or brown spots occur in the subsoil, and the drainage water from such places is dark brown.

In recent stream bottoms and on the lower extension of the large alluvial fans, where the type is subjected to occasional overflows or the addition of fresh accumulations, it frequently is light grayish brown, with a higher mica content. Where drainage is somewhat restricted and a high water table is present the decay of plants has given the type a dark-brown color, approaching that of the Chino series. In well-drained areas the soil frequently is uniform to depths of 15 feet or more, and in all cases it is very retentive of moisture. It is low in organic matter.

Occasionally small accumulations of gravel occur. In places where it has recently been affected by alluvial action the type includes small areas of sand or fine sand. Prevailingly the type is light in texture, and it sometimes approaches a loamy fine sand, but near areas of

loam soil it is more silty and heavier than usual. A slightly compact layer, about 1 foot thick, frequently occurs at a depth of 8 to 10 inches below the surface. This is locally called "plowsole." It slightly impedes aeration and the downward movement of water, but can easily be loosened by subsoiling.

The type does not occur in large areas. It is most prominently developed north and northeast of San Bernardino, east of Colton, north of Ontario, several miles northwest and north of Corona, and northwest of Riverside. Areas of smaller extent occur in practically all other parts of the survey, except on the high, steep fans along the mountains from Upland eastward. The surface is gently sloping to nearly level. Slight ridges and undulations occur locally, due to recent stream action. The soil is easily prepared for irrigation and is well drained except locally in stream bottoms, where alkali salts tend to accumulate. The areas thus affected range in extent up to an acre or more. Water for pumping in the areas located on the large fans is relatively deep, but in stream bottoms water is readily available and the land can be irrigated at low cost.

This type is composed of material originating principally from granitic and schistose igneous, quartz-bearing rocks. It is slightly influenced locally by projecting areas of old valley-filling material and sedimentary rocks. The type in places receives fresh material in periods of heavy rainfall and overflows.

The Hanford fine sandy loam is highly developed to agriculture where well drained and ranks among the important soils of the area. Grapes, alfalfa, and fruit trees root deeply. Deciduous fruits usually produce well in normal years without irrigation where proper tillage is practiced. Citrus fruits, truck crops, walnuts, and alfalfa give very uncertain returns without irrigation. Considerable grain and grain hay are produced, but these crops usually are unprofitable in areas suitable for fruit production because of the relatively high land values. Of the citrus fruits, oranges are the most important. Alfalfa yields from 3 to 10 tons per acre, depending upon the care given the crop and the age of the stand. It lasts longer on this type than on the more sandy soils, but frequently becomes unprofitable 6 to 8 years after planting. In favorable locations walnuts yield heavily. The type seems particularly well suited to truck crops.

The price of land of this type ranges from $100 an acre in the less favorable situations to $350 or more an acre in the better areas.

The incorporation of organic matter and the development of irrigation are the chief requirements in successful crop production on this type.

Hanford fine sandy loam, reddish-brown phase.—A reddish-brown phase of the Hanford fine sandy loam occurs near and southwest of Arlington, in which the soil and subsoil are brown to reddish brown

when dry, but have a distinct reddish cast when wet. This soil is much higher in mica than the typical, but is similar to it in other respects.

HANFORD LOAM.

The Hanford loam, to a depth of 6 feet or more, consists of a friable, micaceous, smooth-textured loam. The surface soil to a depth of about 20 inches is generally brown, but variations of dark brown, reddish brown, or grayish brown are common. The subsoil frequently is somewhat heavier than the surface soil, and in places it approaches a silt loam, silty clay loam, fine sandy loam, or gravelly loam. It is typically lighter brown than the surface soil, but may vary from grayish brown to reddish brown.

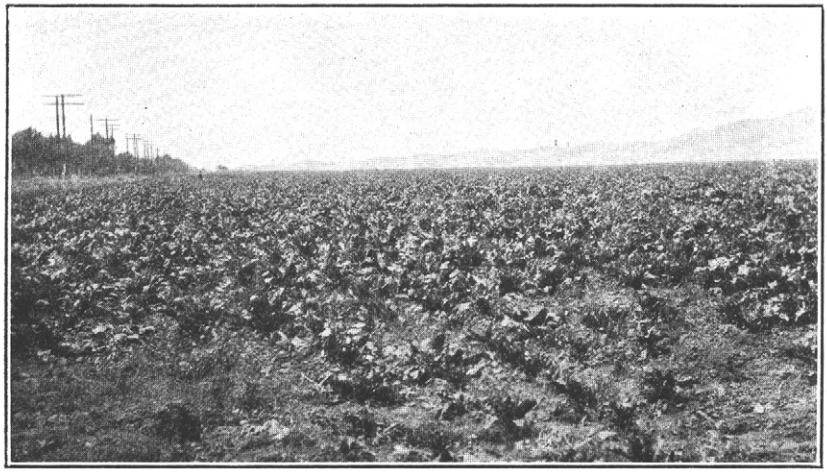
The type is open and easily tilled, but constant flooding in irrigation frequently causes the soil to puddle and become cloddy, especially where it is heavy. The type is usually light textured and contains moderate quantities of fine sand and silt. Near areas of fresh alluvial wash and near gravelly soils the type contains varying quantities of gravel. The physical character of the subsoil and substratum is in most places favorable to deep root development.

The Hanford loam is not extensive, but it is very important agriculturally. Important areas occur north of Upland, around Cucamonga, east of Colton, and northwest of San Bernardino. Several small areas are encountered west and southwest of Redlands, in the San Timoteo Canyon, and a number of others are scattered along the valley margin in the eastern part of the survey.

The topography is favorable for growing citrus fruits, except in a few places along stream bottoms. The type largely has a smooth, gently sloping surface. On the large alluvial fans it occurs on wide, gently rounded ridges. Practically no labor is necessary to prepare the type for planting or irrigation. Good drainage prevails, and no alkali is present.

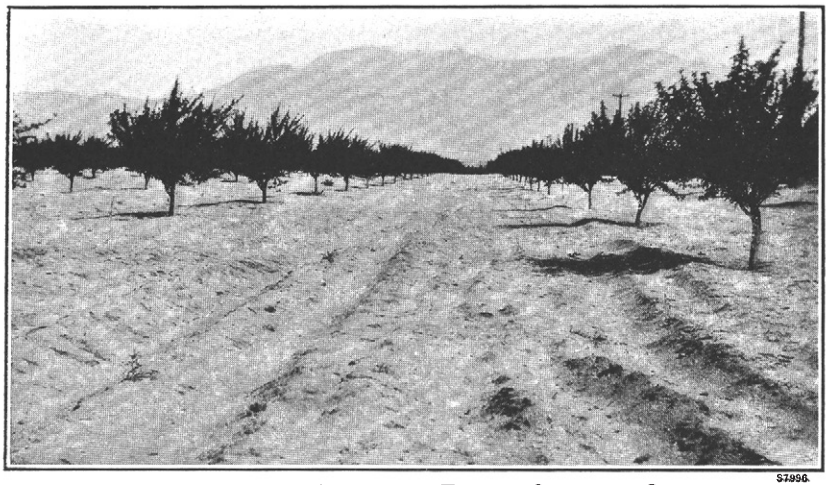
The material giving rise to this type is granitic in character. The gravel and cobbles present are also granitic and plainly indicate an origin similar to that of the other members of the Hanford series.

This type ranks among the leading soils of the area for citrus fruits. It is intensely developed to citrus crops and is one of the highest priced types in the area surveyed. The greater part of the type is devoted to oranges, which constitute about 90 per cent of the fruit grown. The trees do especially well; they are thrifty and long-lived, bear heavily, and produce fruit of good flavor and quality. Some lemons are grown; this fruit does well and bears heavily, but appears to be better suited to the slightly lighter and more gravelly soils than to the Hanford loam. Grapes and other deciduous fruits are produced successfully in a small way. The lower and flatter



S7979

FIG. 1.—SUGAR BEETS ON HANFORD SILTY CLAY LOAM, REDDISH-BROWN PHASE, NEAR ARLINGTON.



S7996

FIG. 2.—YOUNG PEACH ORCHARD ON TUJUNGA SAND NEAR ONTARIO.

Note slightly wind-blown cultivated surface.

areas of the type are more susceptible to frost and are devoted to alfalfa, grain, and sugar beets.

The use of liberal quantities of manure and the growing of cover crops greatly lessen the need of commercial fertilizer on this type and increase the productiveness. Varying quantities of mineral fertilizer are used, however, with widely varying results. Irrigation is necessary for citrus fruits and alfalfa and increases the yields and vigor of deciduous fruit trees. Grapes do well without irrigation.

The type is very well located with reference to roads, towns, and shipping points. It was one of the earliest soils to be developed for citrus fruits in the region of Upland and Cucamonga, and the citrus industry of the area has been centered mainly on or near this type.

The areas used for general farm crops and areas unfavorably located, with reference to air drainage, for citrus crops range in price from $150 to $300 an acre. Those areas suited to intensive fruit production sell for more than $300 an acre, and in very favorable locations are held at as much as $1,000 an acre even where not planted to orchards.

Hanford loam, reddish-brown phase.—A reddish-brown variation of the Hanford loam occurs in the vicinity of Casa Blanca and of Arlington. It contains more mica and frequently has a slightly heavier subsoil than the typical soil. The subsoil is usually lighter reddish brown or more pronounced reddish brown in color and is somewhat compact when dry. Below a depth of about 4 feet the subsoil is similar to the surface soil, and it usually continues uniform to depths of many feet. In other respects the reddish-brown variation resembles the typical Hanford loam.

HANFORD SILTY CLAY LOAM.

In the surface 18 to 30 inches the Hanford silty clay loam is brown to slightly reddish brown, and in places grayish brown or even dark brown. The surface material is smooth, friable, and quite well granulated, and its silt content lessens the difficulty of cultivation. The subsoil resembles the surface material in color and texture and usually continues uniform to a depth of more than 6 feet. No compact layers are present, as in the Placentia and Ramona clay loams, except in rare instances near areas of old valley filling. Generally, the subsoil has a slightly browner cast than the surface soil. Small seams of sandy material occasionally occur at various depths. The type contains a moderate quantity of organic matter. It is very retentive of moisture and readily permeable to roots.

This type is of small extent. It is confined to an area on the bluff of the Santa Ana River just northeast of Corona. The surface

is smooth and requires little or no leveling for crops or irrigation. It usually has sufficient slope for good drainage.

Granitic rocks have contributed most of the material forming this type. Its mineral components have undergone little change since deposition.

The Hanford silty clay loam is small in extent. It is not used for fruit culture. Sugar beets constitute the principal crop. Yields of 12 to 18 tons per acre are obtained with good care. Alfalfa does well and yields heavily on the well-drained areas where water is available. Some grain and grain hay are produced as dry-farm crops and give moderate yields. The poorly drained areas are utilized for pasture.

The type is well located with respect to roads and shipping points and ranges in value from about $100 an acre for the least desirable land to about $300 an acre in the best areas.

Irrigation, the addition of organic matter, good tillage, and in places drainage, are the leading factors which control yields and the range of crops possible on the type.

Hanford silty clay loam, reddish-brown phase.—The Hanford silty clay loam, reddish-brown phase, is mapped in two areas of moderate size west and north of Arlington. (Pl. IV, fig. 1.) When wet, the soil in these areas is nearly reddish brown in color. The content of mica is somewhat higher than in the typical soil.

This phase usually has sufficient slope for good drainage, but part of the area west of Arlington is quite level and is poorly drained. A tendency to puddle exists in slightly depressed places here, where water stands for a short time during rainy periods. Alkali has accumulated in spots or in patchy areas where drainage is restricted, but is not present in large quantities and usually is controllable by drainage and flooding.

TUJUNGA STONY SAND.

The Tujunga stony sand, which is shown on the map by stone symbols on the color used for the Tujunga sand, range in color from light gray to light brownish gray, and consists of a coarse, gritty, loose-textured gravelly sand, extending to a depth of more than 6 feet. The soil, subsoil, and substratum contain varying quantities of cobbles and stones, which vary in diameter from about 2 inches to 1½ feet on the lower slopes of the large alluvial fans and range upward to several feet in diameter on the steeper parts near the foothills. The stone content becomes much lower valleyward, the type grading into a gravelly sand. The finer soil material usually is brownish.

The soil section is very irregular and variable. In places on the more gentle slopes considerable fine material may be present in

undisturbed areas, but the surface is occasionally dissected by long, narrow, shallow, abandoned drainage ways, giving a ridged appearance, and in such places stone and gravel with coarse sand as interstitial material may extend to depths of many feet. Varying quantities of mica are present in the fine material. Narrow areas of fresh wash of sand and cobbles, too small to differentiate, are included with the type. Tillage in most places is practically impossible unless the larger stones are removed. The type is very deficient in organic matter and has a very low water-holding capacity.

The Tujunga stony sand is an extensive soil. It occurs in large, sloping areas along the foothills northeastward from Upland nearly to Lytle Creek. Several small areas are encountered in the Lytle Creek Wash northwest of San Bernardino, and a prominent area occurs in the Santa Ana Wash north of Redlands, and another northeast of Crafton. The last is really a stony phase of the Tujunga gravelly sand. Along the foothills of the Sierra Madre Mountains the type is moderately to steeply sloping, with a fall in places of 100 to 300 feet per mile. The area in the Santa Ana Wash is only gently sloping, but is rough and dissected. In detail the surface of the type is very irregular and broken, and there are a large number of abandoned washes a few feet deep, with very rocky, winding courses. Owing to the steep slope and coarse, porous nature of the soil, the drainage is excessive.

Granite, gneiss, and schistose quartz-bearing rocks constitute the parent material of this type. Some of the granite bowlders weather rapidly into soil material, but most of the cobbles are dense, indurated, and very resistant to weathering. Prolonged heavy rains in the mountains give rise to rapidly flowing streams which carry and roll the coarse material of this type from the canyons and deposit it on the large, steeply sloping fans. The channels are not well defined or permanent, and they soon become clogged with coarse detritus. Deposition has continued until the material is several hundred feet deep in places.

The Tujunga stony sand is of little value agriculturally, both because of its droughty nature and deficiency in organic matter and available plant food, and because of the great expense of preparing it for crops. Except for a very few patches the type has never been tilled. It is used for grazing. The land usually supports a moderate to heavy growth of ceanothus and other brush, except in the lower and more gently sloping areas.

The type reaches an elevation of over 2,500 feet on the large fans and extends down to about the 1,100-foot level in the more gently sloping areas. Few roads reach it, and land values usually are quite low. The type is adapted to only a very limited range of crops.

TUJUNGA GRAVELLY SAND.

The Tujunga gravelly sand is indicated on the soil map by gravel symbols in the color used for the Tujunga sand. The soil typically consists of a medium to gritty sand extending to a depth of 6 feet or more. It varies in color from light grayish brown to light brownish gray. Southwest of Etiwanda the soil and subsoil are slightly browner and of finer texture than in the areas along the Santa Ana Wash south of Highlands. The color becomes more intensely brown as the fine material increases in amount. Along the Santa Ana Wash the type is gritty and frequently approaches a coarse sand. Coarse gravel, sand, and cobbles frequently occur in the subsoil and substratum near stream channels, and occasionally some large stones are present in the surface soil.

The type as a whole is variable, owing to the influence of stream action. Intermittent streams frequently spread out considerably and lose themselves in the type on the large fans. This gives rise to streaks of very gravelly or sandy material, which frequently give the surface a spotted, irregular appearance.

The type contains moderate to small quantities of mica. Tillage is somewhat difficult on account of the gravel present. The soil is low in organic matter. The areas in which the soil section is uniform are quite retentive of moisture, but where the subsoil is coarse and porous the water is soon lost and crops suffer from drought.

The largest and most typical area of this type lies southwest of Etiwanda. Two small areas occur a short distance east of Ontario; one is mapped northwest of San Bernardino; and several prominent areas are situated south and east of Highlands.

The material giving rise to this type is principally derived from granite and schistose igneous quartz-bearing rocks, with minor contributions from sedimentary sources.

The surface is generally quite uniform, but near streams is more or less dissected by old channels.

The Tujunga gravelly sand is utilized principally for the production of grain and grain hay, which give moderate to low yields. Some grapes are grown on the area southwest of Etiwanda. This crop produces well, and the fruit compares favorably with that grown on the Tujunga sand. Peaches, almonds, and apricots are grown on a small scale in favorable situations and do fairly well. Along the Santa Ana Wash the type is utilized as pasture. As a whole, the areas in the eastern part of the survey have a low agricultural value, and elsewhere the type ranks somewhat below the Tujunga sand in producing power.

Land prices vary widely, depending largely on the location and the uniformity of soil and subsoil. In general, the type sells for considerably lower prices than the Tujunga sand.

TUJUNGA SAND.

The Tujunga sand varies considerably in color and texture. Typically it consists of a light grayish brown to light brownish gray, medium-textured sand. When dry, the surface material is light gray in the field, but the underlying material is browner. The light color of the surface apparently is due to the reflection of light or to surface concentrations of light-colored quartz particles. When moist, the soil and subsoil are light brown in color. There is very little change in the structure of the material to a depth of 6 feet or more. The underlying material is generally a fine sand and contains a little more silt than the surface soil. It is somewhat compact in places and usually is browner in color.

A slightly compact layer frequently occurs at a depth of 10 to 12 inches. This layer usually is less than 12 inches thick and appears to be due mainly to a filtering down of fine material. It is present in both tilled and untilled areas, and also where the land has not been irrigated.

The surface soil contains a moderate quantity of fine sand and in most places closely approaches a loamy sand in texture. Wind action has had a marked influence on the type and has modified the surface noticeably in many places. Locally, a light silt loam layer may occur in the subsoil at a depth of about 18 inches. Small areas of sandy loam, fine sand, or gravelly sand occur throughout the type. Occasional low gravelly ridges occur, marking filled or choked stream channels, and small quantities of cobbles are present in shallow washes and along the upper margin of the type where it approaches the stony soils of the Tujunga or Hanford series. Some gravel frequently is present in the soil and subsoil, but the quantity is not sufficient to interfere with tillage.

The type is easily tilled, and its weak capillarity and loamy nature make it very retentive of moisture. It is low in organic matter and seldom requires irrigation for the crops commonly grown.

The Tujunga sand is an extensive type, prominently developed east, northeast and southeast of Guasti. An important area occurs south of Harlem Springs, and several smaller areas lie along Lytle Creek northwest of San Bernardino.

The type has a gently sloping to nearly level topography, with minor surface undulations and irregularities due mainly to wind action. Sand drifts several feet high frequently occur along roads and fences. In some areas sand has blown into small dunes. Wind is still an active agent of modification in exposed locations and frequently causes clouds of drifting material. Drifting is prevented in many places by growing alfalfa, by irrigating, and by setting out wind breaks. Drainage over the type is good, and no alkali is present.

The material giving rise to the Tujunga sand is confined almost entirely to granitic and related schistose igneous rocks.

The Tujunga sand is a very important agricultural soil, utilized for the production of grapes, peaches, apricots, alfalfa, and grain. More than one-third of the type is devoted to the growing of wine grapes, one vineyard alone containing 4,000 acres. This crop does especially well on this soil, and yields of 3 to 5 tons per acre are obtained. Irrigation is not practiced for this or the other deciduous fruits, and fertilizers are not applied. The grapevines root very deeply; in a number of places where streams have cut fresh banks the roots may be seen to extend to depths of 10 feet or more. The vines are thrifty and long-lived and produce well. Muscats, Thompson Seedless, and Sultanas are grown in a small way for raisin making and table use and generally do well.

Next to grapes, peaches are the most valuable crop. (Pl. IV, fig. 2.) They receive much the same treatment as grapes. Where possible, barnyard manure is used, largely as a surface dressing around the trees. The product is consumed by local canneries. The Muir, Lovell, Tuscan, and Phillips Cling varieties are most extensively grown. Yields of 3 to 5 tons per acre are generally obtained, and in very favorable years as much as 8 to 10 tons from the best trees in the most favorable areas. The selling price at the cannery varies from about $18 to $25 a ton. Bearing begins at 3 years of age, and the trees live for 12 to 20 years, depending on the care given the trees, the soil, and the variety grown. Practically no cover crops are grown, on account of the strong wind action. Egyptian corn is quite frequently grown among the trees until they come into bearing. The hauling of fruit to the cannery usually is expensive, on account of the sandy roads.

Large areas are devoted to apricot culture. This fruit gives good returns. The same methods of culture are used as in peach growing, but the crop is marketed mainly as fresh fruit.

Some sweet potatoes are produced on the type, and with good care and proper rotation this crop should prove profitable if grown on a large scale. Grain is grown extensively. Yields are moderate to small. In growing grain the fields are fallowed every other year. Most of the grain is cut for hay, and small yields are obtained. Alfalfa is grown successfully, giving fair yields for 5 to 8 years after planting. Irrigation is necessary for this crop. One application of water is generally given each cutting except the first.

Tujunga sand, low phase.—The Tujunga sand, low phase, typically consists of a micaceous, smooth-textured, friable, silty fine sand, extending to a depth of 6 feet. It is light grayish brown to light brownish gray when dry and light brown when moist. The subsoil below a depth of about 12 inches is slightly heavier than the surface

soil. A somewhat compact layer frequently occurs at 8 to 12 inches below the surface. The type contains sufficient fine material to stand in perpendicular banks in eroded exposures. In places the subsoil is a fine sandy loam or light silt loam, and along stream bottoms the material is more or less stratified. Small undifferentiated areas of fine sandy loam, medium sand, and sandy loam are included with the phase as mapped.

The phase is not extensive. It occurs principally in long, narrow areas along stream courses. Its chief occurrence is along the Santa Ana River from Colton to Rincon. Small bodies are encountered along Lytle Creek northwest of San Bernardino. The type generally has a uniform, nearly level to gently sloping surface. It is slightly dissected by stream action in places, but not to a sufficient extent to affect tillage. Owing to its low-lying position, the water table is high, but excess water drains away readily because of the open structure of the material. Periodic flooding prevents the accumulation of alkali.

Granitic and other quartz-bearing schistose igneous rocks are the source of most of the material, but sedimentary and metamorphic rocks have supplied part, and there have been smaller contributions from old valley-filling deposits. Most of the phase is subject to overflows each year, and considerable fresh material is added.

The phase usually supports a moderate to dense growth of willow and cottonwood, vines, and other vegetation common to the stream bottoms. It is of very little value for crop production on account of the periodic overflows and the cost of clearing and is utilized principally for pasture and locally for truck crops. It is low in organic content. The soil is very easily tilled.

TUJUNGA FINE SANDY LOAM.

Where typically developed the Tujunga fine sandy loam consists of a light brownish gray to light-gray fine sandy loam. Variations of light grayish brown or light brown occur, sometimes within short distances. Where the type occurs in stream bottoms the color usually continues uniform to a depth of 6 feet or more, but on the large alluvial fans the subsoil below the depth of 10 inches generally is browner than the surface soil, approaching the color of the Hanford types. The soil is micaceous and typically smooth textured to a depth of 6 feet or more. The subsoil below the depth of about 12 inches frequently contains a slightly higher percentage of fine sand and silt than the surface material, but the 6-foot soil section in places is uniform throughout. A tendency toward stratification of the material occurs along the stream courses, but seems to be absent elsewhere on the fans. Occasionally seams of fine sand, silt loam, or sand occur in the subsoil, and small areas of the same materials are occa-

sionally present at the surface. The soil is generally light in texture and frequently approaches a fine sand. In exposed areas slight drifting occurs in periods of high winds. The soil usually is low in organic matter. It is retentive of moisture, friable and easily tilled, and favorable to deep root development.

A number of quite well defined areas of sandy loam texture are included with the type as mapped. This soil usually contains a large quantity of fine material and closely approaches a fine sandy loam in many places. Locally, however, it is very coarse, and in places it resembles a sand. The soil is porous, open textured, and slightly micaceous. Small quantities of gravel occasionally are present in the soil section, but they do not interfere with tillage. The substratum closely resembles the subsoil, but it may contain seams of sand or gravel, making the soil somewhat droughty in places.

The Tujunga fine sandy loam is fairly extensive. Several small areas occur east and northeast of Ontario, north of Wineville, and along Lytle Creek northwest of San Bernardino. An extensive area occurs northwest of Redlands, and long, narrow areas lie along both sides of the Santa Ana River from Rincon northeast to a point several miles beyond Colton. The sandy loam variation occurs mainly in two small areas northeast of Ontario, in several elongated areas along Lytle Creek, and in a well-developed area southwest of Harlem Springs.

The surface ranges from very gently sloping on the large fan deposits to nearly level along stream bottoms. The land is smooth and uniform. Parts of the low river-bottom areas are overflowed during periods of high water. The areas more elevated above the stream courses have a deep water table, are well drained, and are free from alkali. The water table usually is less than 10 feet below the surface along stream bottoms. Occasionally it is less than 1 foot deep, and in such places the surface is swampy and meadowlike. Small quantities of alkali are occasionally present in spots a few yards in diameter. These accumulations are not serious, however, and are easily removed by draining.

Granitic rocks have supplied most of the material of this type. Part of the material is derived from sedimentary and metamorphic-sedimentary and metamorphic-igneous rocks, and small quantities from old valley-filling deposits. Fresh contributions are added locally each year by overflows.

The typical areas of the Tujunga fine sandy loam have a high agricultural value and are devoted to fruits and truck crops. About two-thirds of the large area northwest of Redlands is planted to oranges. The trees are in very good condition, are thrifty and moderately uniform, and produce well. Grain and grain hay are grown in the less favorable areas and in some places in areas suitable for

more extensive crops. Fair yields are obtained, but the income from grain crops generally is too low to warrant their production on land having so high a value. Some alfalfa is grown, and good yields are obtained where the water table is deep. A large part of the type along the Santa Ana River is highly developed to truck crops, which give excellent yields of products of high quality. Water for irrigation is readily available at low cost by pumping. Peaches, apricots, grapes, sugar beets, and a few other crops are grown in a small way and with good results where soil and climatic conditions are favorable.

The sandy loam variation of the type is of little importance agriculturally. It is devoted chiefly to the growing of grain, grain hay, alfalfa, and grapes. Yields vary widely, depending on the care given the soil, the water supply, and the crop rotations followed.

The Tujunga fine sandy loam is well located with respect to roads and shipping points. Land capable of producing citrus fruits and truck crops sells for $250 an acre and upward. The poorly drained areas sell for less, but usually require considerable expenditure to be prepared for crop production.

CHINO SILT LOAM.

To a depth of about 18 inches the Chino silt loam typically consists of a dark-gray to black micaceous, friable, smooth-textured silt loam. Variations in the surface material to dark brownish gray and very dark grayish brown occur. When dry, the surface soil in places is grayish. The surface material usually is quite light in texture and easily tilled. It is high in organic matter and very retentive of moisture. Owing to the high silt content, the soil does not crack, and an effective surface mulch is easily maintained.

The subsoil is a gray to grayish-brown, or in places dark-gray, heavy silt loam to silty clay loam, containing moderate to large quantities of lime. In places small calcareous concretions are encountered at a depth of 4 to 5 feet. These become more numerous and occasionally are several inches in diameter toward the southern and southwestern boundaries of that part of the type north of Rincon.

In the region about San Bernardino the type is variable. The subsoil is less calcareous than typical, and may be somewhat mottled with red, yellow, and brown iron stains. In places a light-gray porous sand is encountered at about 1 foot below the surface.

This type is not extensive, but usually it is more clearly defined than the other soils of the area. Important bodies occur about 5 miles north of Rincon, and several small areas near San Bernardino. The type has a smooth, nearly level surface except where it occurs along the slopes and bottoms of small, winding drainage ways. In

places the surface is somewhat depressed; elsewhere variations a foot or two in elevation are about the only irregularities present. The color of the material in the higher areas is slightly browner than typical, and in some places it closely approaches the brown of the Hanford soils.

The type is poorly drained in most places, and accumulations of both white and black alkali occur. Areas affected with alkali usually are spotted in appearance, the concentrations being widely variable. East and southeast of San Bernardino continuous areas, several acres in extent, of moderate to high concentrations are encountered. The alkali is very patchy in the large areas of the type north of Rincon, but it prevents crop growth in only a few places. In areas affected by moderate to high concentrations of alkali the soil has a tendency to puddle quite badly and becomes clodded and hard when dry. Some of the areas of this character have been drained successfully. The water table is high over all the type, and in slight depressions near San Bernardino it occurs at or very near the surface. The high organic-matter content of the type apparently is due to its low-lying, semiswampy condition.

Granite, gneiss, and related schistose igneous rocks are the chief sources of the material giving rise to this type.

The Chino silt loam is a very important agricultural soil. The areas north of Rincon are devoted almost entirely to sugar-beet culture, and good yields are obtained. Some grain and grain hay are grown. Near San Bernardino the type is used for the production of grain and grain hay and for pasture. Some alfalfa is grown successfully in the better drained areas, and truck crops have proved successful wherever grown. The water table usually is too near the surface for successful fruit culture, but all shallow-rooted crops thrive. Irrigation is seldom necessary.

Land prices vary widely, depending upon the location, uniformity of soil, and degree of improvement. The type is well supplied with good roads.

Chino silt loam, sandy phase.—The sandy phase of the Chino silt loam has a lighter fine sandy loam texture than the typical soil and if of greater extent would be mapped as the Chino fine sandy loam. The soil to a depth of 18 to 24 inches consists of a dark-gray to black, micaceous, smooth-textured, friable, silty fine sandy loam. Variations of dark brownish gray to very dark grayish brown occur. The subsoil to a depth of 6 feet or more is usually a gray to grayish-brown, calcareous silt loam, but in places the material is uniform in texture throughout the 6-foot section. The soil is high in organic matter and works up into a fine, floury seed bed.

The phase is very inextensive. It occurs in two small areas, one about 6 miles north of Rincon and the other about 1 mile east of San Bernardino. It has a smooth, uniform surface and is moderately well drained. No alkali concentrations of importance are present. The areas of this phase are not well defined. They occur mainly between the typical Chino silt loam and the lighter colored Hanford soils. The phase is composed of recent-alluvial material derived mainly from granitic rocks and deposited by streams of relatively uniform volume and current.

This phase is of little importance agriculturally, owing to its small extent and its somewhat limited range of crops. It is largely devoted to sugar beets, which give very satisfactory returns. Deciduous fruits are grown in a small way, but give good results. Grain and alfalfa also are grown to a moderate extent and give fair yields. Owing to its low position the phase is not well suited to citrus fruits, but truck crops do well. The phase is generally well located with respect to roads and towns. It varies widely in price.

CHINO SILTY CLAY LOAM.

Typically, the Chino silty clay loam is dark gray to black, smooth textured, friable, and micaceous to about 18 inches in depth. Variations of dark brownish gray and very dark grayish brown occur. When wet, the surface layer usually is very dark colored, and when dry, it frequently becomes gray or dark grayish brown. The soil is light in texture, and frequently it closely approaches a heavy silt loam. It contains a high percentage of organic matter and works up into a loamy mass which readily forms an effective surface mulch.

The subsoil to a depth of 6 feet or more is typically a gray, dark-gray, or dark grayish brown, highly calcareous, friable silty clay loam to silty clay. Where this type adjoins the lighter soils of this series and near the Hanford soils the subsoil may be a silt loam. In low, wet areas the subsoil occasionally is somewhat mottled with yellow, brown, and gray stains. Small to moderate quantities of calcareous concretions are sometimes encountered in the lower subsoil. These usually are very small, but in rare instances they are 3 or 4 inches in diameter. The areas along the Santa Ana River and near San Bernardino are less calcareous than typical in the subsoil. There are no obstructions to root development in the soil or subsoil.

The Chino silty clay loam is not extensive, but it is distinct from the adjoining soils in color and in other important features. The most important areas occur north and northwest of Rincon. A few smaller areas are mapped along the Santa Ana River bottoms from Rincon northeastward to a point slightly beyond San Bernardino.

The surface of the type is generally smooth, but variations in elevation of 1 foot to 2 feet are common, and on slopes and in the bottoms of local drainage ways the surface may be somewhat irregular and undulating.

The type is poorly drained. The water table is encountered at 1 foot to 10 feet below the surface. Some alkali is present, usually in spots a few yards in diameter, although sometimes areas an acre or more in extent are affected. In places the concentration is sufficient to destroy crops, but usually it only discolors and stunts the plants. Both white alkali and black alkali are present. Where the alkali occurs in moderate to high quantities the soil has a marked tendency to puddle, and bakes and becomes cloddy when tilled. The largest affected area north of Rincon has been drained successfully, and the water table sufficiently lowered for crops to make a good growth and produce heavy yields.

The Chino silty clay loam is composed of material derived mainly from granitic rocks.

The more nearly level and better drained areas north of Rincon are utilized for the production of grain and grain hay, and heavy yields are obtained. Without drainage a large acreage is too low and wet for any use except pasture. The water table usually is too high for tree fruits, but truck crops do well.

Land of this type varies widely in price, depending on the location, drainage, and development. It is well located with reference to shipping points and is well supplied with good roads.

YOLO GRAVELLY LOAM.

The Yolo gravelly loam is indicated on the soil map by gravel symbols on the color used for the Yolo loam. It consists of a brown to grayish-brown, medium-textured gravelly loam. Below a depth of about 15 inches the subsoil frequently is somewhat heavier than the surface material and ranges in color from light brown to slightly reddish brown. Both soil and subsoil are quite compact when dry. Varying quantities of gravel are present throughout the 6-foot section. The particles are subangular and of small to medium size. The gravel content increases toward the upper part of the slopes. In places it is very high, seriously interfering with tillage operations, while in some small areas very little gravel is present. The gravel is derived principally from metamorphosed sedimentary rocks.

When moist, the type is much less compact, and with tillage it becomes more open and absorptive of water. It contains moderate to small quantities of organic matter. In places where the type is affected by recent stream action it is often gritty and closely approaches a gritty loam; in the lower and more gently sloping areas it

sometimes approaches a light clay loam. The subsoil is uniform to a depth of 10 feet or more in most places and is not too compact for deep root development. Small quantities of cobbles are sometimes present near streams, and in such places local deposits of gravel and cobbles occur in the subsoil and substratum. The type averages a light loam in texture and is friable and mealy when tilled.

As mapped in this survey the Yolo gravelly loam includes areas of gravelly sandy loam texture, which, if of greater extent and importance, would have been differentiated as a distinct type of the Yolo series. In these areas the soil is nonmicaceous, open textured, rather incoherent, and variable to a depth of about 12 inches. Varying quantities of small to medium gravel are present, and local areas of gravelly sand and coarse, gritty sand occur. The subsoil is variable, ranging from a loose, porous gravelly fine sand to a light gravelly sandy loam of brown to light-brown color. Pockets or local deposits of coarse sand and gravelly sand are common, and occasionally there is a slight tendency toward stratification. The material is deepest near the foothills and gradually becomes shallower valleyward. In places cobbles occur in sufficient quantity to interfere with tillage. Both soil and subsoil have a structure favorable to root development.

The Yolo gravelly loam occurs in a number of irregular, long, narrow areas in the southwestern part of the survey. The largest and most typical area lies just west of Corona. The included gravelly sandy loam variation is of small extent and occurs in several long, narrow, irregular areas in small valleys extending out from the foothills from Rincon southeastward to Temescal Wash.

South of Corona the Yolo gravelly loam has a moderate slope. In the higher situations the grade is nearly 200 feet to the mile. In the lower parts and on the small fans farther west the slope is gentle and uniform. The surface is smooth in most places, but locally it is somewhat undulating and slightly dissected by stream action. Practically no leveling is necessary to prepare the type for crops or irrigation, and there is little or no brush in the untilled areas. The type is well drained, and no indications of alkali are present.

The surface of the gravelly sandy loam areas is variable and usually more or less broken and dissected by shallow, intermittent stream channels. The areas near the foothills are more uneven and unfavorable for tillage, owing to the steeper grade and to more active stream erosion and deposition. Drainage frequently is excessive, especially where the soil and subsoil are coarse and incoherent. Water usually disappears quickly by run-off or percolation, and there is no opportunity for the accumulation of alkali.

The Yolo gravelly loam is principally derived from sedimentary and metamorphic-sedimentary rocks, with minor additions from

igneous rocks. Fresh silt, sand, and gravel are added each year by the shallow, spreading streams.

Some oranges and lemons are grown successfully on the type southwest of Corona, and with an adequate water supply and good care most of this large area should prove valuable for such crops. Grain and grain hay, however, are the principal crops, giving moderate yields. The land usually is summer fallowed in alternate years, and irrigation is not practiced except where citrus fruits are grown. Land prices vary widely on this type and are usually high, because of its suitability to intensive fruit culture.

The included areas of gravelly sandy loam are of little value agriculturally, on account of their droughty nature, the expense necessary to prepare the soil for crops, and the possibility of injury by erosion or overflow during heavy rains in the mountains. The most favorable areas are utilized for the production of grain and grain hay, which give moderate to low yields. The remainder is virgin land and is covered with brush and used as pasture.

Yolo gravelly loam, high-fan phase.—The Yolo gravelly loam as mapped in this area includes a high-fan phase, consisting of elevated, dissected areas of alluvial material of greater age than the typical soil and topographically comparable with old valley-filling material. In physical character of the soil and subsoil, however, this phase is more closely related to the Yolo series than to the old valley filling. The phase is shown on the soil map by cross lines and gravel symbols over the color used for the Yolo loam. The surface 18 to 24 inches is brown, light brown, or grayish brown in color. It is nonmicaceous or nearly so, friable and smooth textured, and tilled without difficulty. The subsoil is somewhat lighter in color and slightly heavier in texture in most places than the surface soil. It is quite compact locally and occasionally is a light reddish brown or light-brown gravelly loam or loam. Varying quantities of angular gravel are present in the soil and subsoil, but the gravel is distributed throughout the soil mass and in most places shows no tendency toward stratification. A gravel substratum is observable in places in the banks of drainageways, and comparatively large quantities of gritty material sometimes occur in the subsoil, but these conditions appear to be local and have only a slight influence on the phase as a whole. The gravel content decreases toward the lower parts of the phase, and in local areas no gravel is present. The soil is retentive of moisture and to depths of many feet is permeable to roots, air, and water.

This phase occurs in several areas south and southeast of Corona and in one area several miles northeast of Crafton. It occupies a steeply sloping alluvial fan and in most places has a fall of 100 to 200 feet to the mile. The surface is generally smooth, but locally it is slightly undulating, and this feature, together with the deeply

intrenched streams, gives the phase a comparatively old topography. No leveling is necessary in preparing the land for irrigation, and the soil is well drained and free from alkali.

The material has been derived principally from sedimentary formations, with minor additions from igneous rocks. It was deposited as an extensive alluvial fan by intermittent streams issuing from the mountains to the south. Erosion is not active except along intermittent streams, where some reworking occurs in places. The phase apparently is intermediate in age between the oldest and youngest alluvial deposits of the area and possesses features similar to both.

The Yolo gravelly loam, high-fan phase, is not extensive, but is very important agriculturally. Nearly all of it is devoted to the growing of oranges and lemons. Oranges do well where given proper care, and the soil seems especially well adapted to lemons. These fruits are grown in about equal proportion. A small acreage is devoted to grain and grain hay, but these crops do not give good returns on the basis of the high value of this land. The phase is well supplied with good roads and is favorably located with respect to shipping points and railroads. It constitutes the most highly developed areas in the southwestern part of the survey. Land prices are very high, and water for irrigation is costly. Irrigation, the adding of organic matter, and good tillage are the most important soil requirements.

YOLO LOAM.

The Yolo loam, to a depth of 18 to 24 inches, consists of a brown or grayish-brown, nonmicaceous silty loam. The subsoil usually is heavier in texture and slightly lighter in color than the surface soil, although in places it is similar to the surface material to a depth of 6 feet or more. Occasionally the subsoil has a reddish-brown cast, and in places it is brown to dark brown. It is frequently a clay loam or silty clay loam in texture and contains a small percentage of gravel near streams. Small quantities of gravel are sometimes present at the surface, and undifferentiated patches of gravelly sandy loam or gritty sandy loam occasionally are encountered. The type is deep and friable and of smooth texture and is tilled without difficulty. It is retentive of moisture when properly handled, permits deep root development, and contains small to moderate quantities of organic matter. A dark-brown variation occurs locally northwest of Rincon. It resembles the type in all respects except color.

The Yolo loam is of little importance agriculturally, because of its small extent. It occurs in several small, irregular areas in the bottoms of small stream valleys crossing the large fans and on minor fans and footslopes. The areas lie along the foothills from Temescal Wash northwestward to the boundary of the survey.

The type has a gently sloping topography and a smooth, uniform surface except near drainage ways and in the very narrow valleys. No leveling is necessary for planting or for irrigation. The type is well drained, and no alkali is present. Along its lower boundaries, where the type adjoins the valley soils, the water table is within 10 feet of the surface in places.

This soil is derived from sedimentary shales, sandstones, and conglomerates, with small additions of material from igneous rocks. Some parts of the surface are reworked annually by local streams, and new accretions of small extent are added in rainy periods.

The Yolo loam is highly developed agriculturally. It is utilized largely for sugar-beet production, and heavy yields of beets of good quality are obtained. A part of the type is used for grain and grain hay, which give moderate to good yields. The areas generally lie too low topographically for citrus fruits, but deciduous fruits thrive. The small area on the high alluvial fan southwest of Corona is planted to lemons and oranges, and the trees do well. A small acreage is devoted to alfalfa, which gives good yields. Fruits, alfalfa, and sugar beets require irrigation. The type is well located with reference to roads and shipping points. Land prices vary widely, depending mainly on the kind of crops that can be grown.

YOLO SILTY CLAY LOAM.

The Yolo silty clay loam, to a depth of 12 to 18 inches, is a brown, grayish-brown, or light-brown, nonmicaceous silty clay loam, but small areas of dark-brown soil are included with the type as mapped. The subsoil usually is heavier than the surface soil and consists of a brown to light-brown clay loam, silty clay loam, or clay. Occasionally it has a reddish-brown cast, especially near areas of older material, and in places it resembles the surface soil in color and texture. The soil is friable and retentive of moisture where properly handled and works up into a mealy seed bed. When wet, the soil is sticky, but when dry, it is hard and compact. No obstructions to root development are present in the soil or subsoil. The content of organic matter is generally moderate. The color of the soil is darker where the organic content is higher. In places the subsoil plainly shows the presence of lime. No alkali is present.

The type occurs in one small area of irregular outline, extending from Corona to Rincon along the lower margin of the large alluvial fan on which Corona is located. It has a smooth, gently sloping surface and is well drained.

This type consists of recent-alluvial material derived mainly from sedimentary and metamorphic-sedimentary rocks. Some of the soil

is derived from igneous rocks, streams from the higher slopes and fans having carried part of the material down to its present position. Fresh material in small quantities is added annually by small intermittent streams which spread out and disappear on the type.

Grain, corn, sugar beets, and alfalfa are the principal crops grown, and good yields are obtained. Irrigation is necessary for all crops except grain and corn. The type is too low in topographic position for the safe production of citrus fruits, because of the occurrence of frost, but deciduous fruits do fairly well. Land prices usually range above $200 an acre.

Yolo silty clay loam, high-fan phase.—The Yolo silty clay loam, high-fan phase, to a depth of 18 to 22 inches consists of a brown or dark-brown, nonmicaceous, heavy soil, predominantly of clay loam texture. The subsoil is a brown to light-brown clay loam or clay, continuing uniform to depths of more than 6 feet. It is, in nearly all cases, somewhat lighter in color and slightly heavier in texture than the surface material. Small quantities of gravel occur locally, but there is very little or no tendency toward stratification. In the older parts of the type the subsoil approaches reddish brown in color, and in all places it is more or less compact. The soil is much more difficult to till than the gravelly loam of this series and tends to become very cloddy when plowed. Both soil and subsoil have an unfavorable structure and tend to puddle if handled while wet. Granulation is rather poor, and considerable working is required to effect a good tilth. The incorporation of organic matter makes the soil more friable, checks evaporation, and increases crop yields. Occasionally small strips of gravelly loam or loam are included with the type as mapped. The structure of the soil is generally unfavorable to root development and the movement of moisture.

This phase is inextensive. It occurs in one small area just west of Corona. It has a smooth surface and sufficient slope to insure good drainage and freedom from alkali. Sedimentary and metamorphic-sedimentary rocks have contributed most of the material. In age the soil resembles the Yolo gravelly loam, high-fan phase. Except for a small amount of alluvial reworking locally in rainy periods, it is receiving no fresh accumulations.

The phase is highly developed to oranges and lemons, with some grain, grain hay, and sugar beets. Deep-furrow irrigation apparently gives good results. Greater care is generally required in handling the soil than in the case of the high-fan phase of the Yolo gravelly loam, to obtain equal returns. The price of land is about the same as for the high-fan phase of the Yolo loam. Proper irrigation and the application of organic matter are the principal factors in successful crop production.

OAKLEY SAND.

The Oakley sand, to a depth of 6 feet or more, consists of a brown to grayish-brown, medium-textured, loose, slightly micaceous loamy sand. Slightly variable layers of somewhat compact material occur at different depths, the differences in textures being indicative of the variable velocity of the winds which deposited the material. In cuts the type maintains a moderately steep bank. It is low in organic matter, very easily tilled, and retentive of moisture. Areas of Hanford sand, too small to map separately, are included with the type, and in places the wind-blown material rests on Hanford soil, which occurs in the more nearly level areas at about 1 foot below the surface.

The Oakley sand is inextensive. It occurs in two areas west and northwest of Colton. The topography is undulating with some low, rounded hills or ridges. The surface is smooth, and where exposed to wind action the soil drifts considerably. Drifting is largely counteracted by maintaining windbreaks. The type has good drainage, and its loose, open texture makes it absorptive of moisture. Capillarity is poor, and the subsoil is moist even in midsummer in areas free from vegetation. Little moisture is lost by evaporation.

The material giving rise to this type consists chiefly of wind-blown Hanford sand, originally derived mainly from granitic rocks.

The greater part of the type supports a sparse growth of brush and grass and is used for grazing. Some deciduous and citrus fruits and grain are grown along the eastern margin of the areas where the land is not too hilly. With leveling and irrigation the type is suited to alfalfa, which does well for a few years and aids greatly in packing the soil. Adding organic matter materially increases crop yields and tends to prevent the soil from drifting. The price of land of this type of soil is usually low.

RIVERWASH.

Practically all the streams in the area are intermittent. After the rainy period their channels are dry and barren of vegetation. These nonagricultural stream beds and bottoms of fresh washes are mapped as Riverwash. The areas are subject to inundation in prolonged rainy periods. The material ranges from coarse, rounded cobbles and bowlders to gravel and sand. It resembles the material of the Tujunga stony sand, which at one time existed under the same conditions. A large part of the soil of the steep alluvial fans leading out from the mountains was of this character at one time. The areas of Riverwash on the large fans are subject to change in flood periods, as the streams quickly clog their channels and shift to new ones. The soil mass is loose, coarse, leachy, and low in available plant food.

The coarser material greatly predominates, but farther out in the valley the material becomes finer, and in places there is a moderate growth of willow and vines.

The most prominent areas of Riverwash occur along the Santa Ana River, east of Colton, and along Lytle Creek and Cajon Canyon northwest of San Bernardino, with a long, narrow strip near the Santa Ana Canyon southwest of Harlem Springs and several small, irregular areas from Lytle Creek westward along the base of the Sierra Madre Mountains.

Riverwash occupies steep fans to gently sloping stream-bottom areas. The material is derived principally from granite and schist rocks. In a few places the production of crops is possible, but only annuals can be grown with safety, on account of the overflows.

ROUGH BROKEN LAND.

Rough broken land consists of hilly, mountainous, and badly dissected areas too uneven and precipitous for agriculture, but not containing sufficient stone and rock outcrop to be classed as Rough stony land. Small areas of moderate slope capable of tillage and local occurrences of rock outcrop are included. The Rough broken land marks the lower slopes of the larger mountains bounding the area, and may consist of severely dissected remnants of old valley-filling material or of sedimentary formations along the foothills, or it may occur as very steep residual slopes with only a shallow covering of soil. It includes steep bluffs marking a sudden change in topography from the old, fragmentary valley-filling deposits to the more recent soils below. The material is variable and ranges in texture from very gravelly or stony soil on steep contours to sandy loams and fine, friable deposits of old valley filling many feet deep. In places it consists of a coarse, gritty covering 1 foot or less in depth over the steeper and more mountainous areas.

Rough broken land usually marks the upper limit of the agricultural land and grades on its upper boundary into Rough stony land. It extends as a marginal belt along the north and east sides of the area and from a point in the mountains south of Arlington to the southwestern boundary of the survey. A body of moderate size lies about 3 miles northeast of Corona, and several small areas occur south of Glenavon and northeast of Wineville.

Granite, gneiss, and schists are the main sources of the soil material, with small contributions from sedimentary rocks. The material is principally residual in origin, but large quantities of unconsolidated old-alluvial deposits occur. A few acres here and there are capable of tillage, but the greater part of the type can not be used agriculturally except for pasture. The areas usually support a dense growth of chamisal.

ROUGH STONY LAND.

Rough stony land consists of steep, broken, dissected areas which contain considerable rock outcrop and small patches of Rough broken land and are too rough for tillage. The surface is rocky, and in most places there is only a thin veneer of coarse soil material. Very small patches of tillable soil are included. Rough, clifflike areas and deeply eroded ravines occur. The heavy rains of the winter months have a tendency to remove the soil covering over the greater part of the surface as rapidly as it is formed.

Rough stony land occurs mainly to the south and southwest of Colton. Granite, gneiss, and schist, with some conglomerate and sandstone, are the principal rocks giving rise to the thin soil covering.

Few trees of any kind are found on the areas of Rough stony land, but there is usually a moderate growth of chamisal. Most of this land is included in a National Forest and used only to a small extent for pasture.

IRRIGATION.

The climate and the distribution of rainfall in the Riverside area are such that irrigation is necessary for the best results with nearly all the highly specialized crops. It is only on certain soils and for particular crops that sufficient water can be stored within the soil during the rainy period to produce satisfactory yields without irrigation. Fruit, alfalfa, sugar beets, and truck are the principal irrigated crops. Extensive development, high specialization, and a limited water supply, with favorable temperatures and a large area of suitable soils, have resulted in an unusually efficient and economical use of water.

The supply of water for irrigation is mainly limited to that provided by the rainfall in the valley and in the watershed to the north and east, only a small amount being derived by drainage from the hills and mountains to the south. All the surface stream flow was appropriated many years ago, and underground supplies have been drawn upon since 1870. Hundreds of wells have been sunk in different parts of the area to considerable depths. Large quantities of water are obtained from these wells by pumping, and the quantity is somewhat augmented by artesian supplies at San Bernardino and in the region several miles south of Ontario. A number of tunnels have been dug into the water-bearing gravels along the north and east sides of the area, and flood waters have been diverted and spread over the large, coarse-textured alluvial fans during rainy periods, noticeably increasing the underground supply available for irrigation. The supply is maintained during the summer months to some extent by melting snow, which covers the higher mountains to considerable depths nearly every winter. The numerous wells sunk in the "ciena-

gas," or low, moist natural valley basins, have noticeably reduced the artesian supply, and many wells that once flowed now have to be pumped. Many small concrete reservoirs are used in connection with pumping plants. They act mainly as regulators in the distribution of water.

The conservation of water made necessary by its relative scarcity has resulted in distributing systems which reduce to a minimum the losses through percolation and evaporation. Underground pipe lines and cemented canals are used, the former being preferred, and the only water visible over most of the area is that applied to the surface of the fields and orchards. Movable galvanized-iron pipes are used quite extensively in the irrigation of alfalfa. Where these are employed the land does not require so much leveling or checking as where irrigated by gravity from permanent ditches. In most cases an effort is made to prevent loss from evaporation and percolation by measuring the amount of water applied, by using the furrow system where possible, and by cultivating the surface as soon after each application as the soil will permit.

A large number of cooperative water companies and associations of all kinds control the various systems in use. In some instances individual growers have their own pumping plants.

The quantity of water applied varies widely, depending upon the crop grown, the character of the soil and subsoil, and the supply available. Under the gravity system, water frequently is cheaper and more extravagantly used. A miner's inch is considered sufficient to water from 5 to 8 acres of citrus orchard. For deciduous fruits a much smaller amount is required, about 7 to 10 acres being supplied with 1 miner's inch.[1] From 2 to 3 acre-feet are required for alfalfa.

The check and border methods are used in the irrigation of alfalfa, and the furrow method as a rule for fruit. The irrigation water from all sources is of good quality and practically free from alkali. Irrigation costs from $3.50 to $20 or more an acre per year, the higher cost being on lands less favorably located. The length of the irrigation season depends upon the date of the last rainfall in the spring and the first in autumn. It generally covers the period from May 1 to November 1. Electricity obtained at a fixed rate per kilowatt-hour or per horsepower per month is mainly used for pumping.

The extensive citrus plantings have necessitated the fullest utilization of the present available water supply. A considerable area will be used for general-farm crops until the large quantities of water

[1] For a full discussion of water supply and irrigation in the Riverside area see "Hydrology of San Bernardino Valley, California," by Walter G. Mendenhall; "The Surface Water Supply of California, 1906," by W. D. Clapp; and the Report of the Conservation Commission of California for 1913.

now lost as surface run-off each year can be more fully stored in reservoirs constructed in the canyons and mountain valleys. There are still large areas of valuable land which can be utilized for intensive crops as soon as a water supply is assured.

ALKALI AND DRAINAGE.

Alkali in injurious quantities is not of extensive occurrence in the Riverside area. It occurs in small quantities in a number of places, but is mainly confined to the surface 12 to 24 inches of soil. The areas affected are patchy, and in only a few local places is the salt concentration of sufficient strength seriously to affect crop growth. Such areas are indicated on the soil map by symbols and inclosing lines, printed in red, by means of which two grades of concentration are expressed, one in which the alkali occurs only in spots and the other in which the area is more uniformly affected by an injurious concentration of salts. In the region several miles south of Ontario, on the Chino and Antioch soils, alkali occurs locally over an area of several square miles. Much of this land has been effectively drained, and it is said that much of the alkali has been removed. Many spots are still affected, however, and their presence is indicated by a scant growth of yellow-leaved sugar beets, in places the crop being entirely destroyed. The damaging effect of the alkali is materially influenced by weather conditions during the time of planting and early growth of the crop. If there is a high percentage of sunshine the salts quickly become concentrated in the surface soil, and a puddling tendency occurs which seriously interferes with germination and early growth. If, however, cloudy or foggy weather prevails during this period, the crop is able to get a good start before the salts appear in sufficient quantities to be harmful. Both white and black alkali are present in most places. The latter adds greatly to the difficulty of reclamation.

Small affected areas occur locally along the bottoms of the Santa Ana River. In these places the water table frequently is within a foot or two of the surface, and the excess salts are almost entirely confined to the top foot of soil. This is also the case in the affected areas west and north of Arlington and south and southeast of San Bernardino. In these places the alkali affects crops, and there is almost invariably a growth of salt grass.

In several places concentrations of 1 per cent of alkali, or 1,000 parts per 100,000 of dry soil, occur in the surface foot, frequently decreasing to one-tenth per cent, or 100 parts per 100,000, in the second foot and to a still smaller percentage at greater depths. Where alkali shows plainly at the surface and the water table occurs at or below a depth of 6 feet, the concentrations are nearly always

higher and frequently average one-half per cent, or 500 parts per 100,000 parts of dry soil, for the 6-foot soil section. Heavy subsoils in alkali-affected areas are nearly always associated with higher concentrations of salts than light-textured subsoils. In most places in the area an average concentration of one-tenth per cent for the surface 6 feet results in serious injury to crops, since almost the entire amount occurs in the surface foot. The harmfulness is also augmented by the presence of black alkali, which has a corrosive effect upon vegetation and develops a puddling tendency in the soil. The boundaries of affected areas do not change greatly, except where overirrigation is practiced on the higher surrounding land, and in such places stagnated drainage noticeably increases their extent. Climatic conditions usually are favorable for increased concentrations in affected areas where a high water table is present.

A high water table is accompanied by the presence of alkali in the Riverside area, and any method which tends to remove surplus water and lower the water table also tends to reduce the injury from this source. Some draining has been done in places and has proved very effective. In most places alkali is present in such small quantities that lowering of the water table with occasional heavy flooding and ordinary irrigation usually suffices so to distribute the salts not removed at once by the drainage waters that they will not be seriously harmful. The economical use of irrigation water has very effectively kept down injury from seepage and alkali accumulation, and it is only where water has been plentiful and wastefully used that harm has resulted. Low-lying areas are the first to be affected. Preventive measures which will keep the water table down and forestall the accumulation of alkali are well worth the attention of all the farmers.

SUMMARY.

The Riverside area, Cal., comprises 606 square miles, or 387,840 acres. It lies about 35 miles east of Los Angeles and includes the western parts of San Bernardino and Riverside Counties. Topographically, it consists mainly of a series of large alluvial fans extending from the surrounding mountains and merging into an extensive, gently sloping plain, which is most prominently developed east and southeast of Ontario. Several low mountains occur within the area in the region west and northwest of Riverside. The general slope is south and southwest.

The Santa Ana River is the main drainage way. A large number of creeks enter the area from the surrounding mountains. These carry large volumes of water during periods of heavy rainfall, but spread out and lose their water in the gravels and sands of the broad, sloping fans.

Many cities, towns, and suburban communities are situated in the area, ranging in population from a few hundred to 15,000 or more. They are well supplied with excellent roads, schools, churches, libraries, and other public improvements. Riverside, San Bernardino, Redlands, Colton, Ontario, Corona, Upland, and Rialto are the leading cities.

Three transcontinental railroads, a number of electric lines, and an excellent system of highways afford good transportation facilities.

The climate is semiarid, the rainfall ranging from about 10 to 20 inches per year. The precipitation occurs mainly during the winter months, and the quantity varies widely from year to year. The summers are dry and warm, but the temperature seldom is oppressive for a long period. The climate is very favorable for a wide range of intensively cultivated fruits, and only occasionally and in unfavorable locations is serious damage done by frosts. The healthful climate has been an important feature in attracting population. Snow, hail, and thunderstorms are rare, and the average wind velocity is relatively low.

A wide range of fruits, truck crops, and other agricultural products are grown, chief among which are oranges, lemons, walnuts, olives, grapes, peaches, apricots, alfalfa, sugar beets, grain, and grain hay. Dairying is a profitable and thriving industry. Citrus fruits rank first in value and are grown on more than 50,000 acres.

Irrigation is necessary for most of the crops grown and is extensively practiced. The water is distributed mainly by underground pipe lines. Streams, wells, and tunnels are the sources of water, and owing to the limited amount available it is carefully and economically used. There are two artesian districts in the area, one south and west of San Bernardino and one several miles south of Ontario.

The soils vary widely in color, but their range in texture and origin is narrow. They are prevailingly light; 90 per cent of the soil is of loam or lighter texture. Granite, gneiss, and schists are the principal rocks giving rise to the soils, and most of the material has been spread over the area as extensive alluvial-fan deposits. The soils are well drained as a rule, but local low-lying areas have a high water table and are affected with alkali. Such areas are easily reclaimed. The soils are generally deficient in organic matter.

A total of 35 soil types, representing 13 soil series, are mapped, in addition to 3 classes of miscellaneous material. Many of the soil types are closely related, but in general there are important physical or chemical differences. Extensive areas of soil are still undeveloped because of limited water supply, large holdings, or unfavorable texture.

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[PUBLIC RESOLUTION—No. 9.]

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

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

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

Approved, March 14, 1904.

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

Areas surveyed in California.

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