U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

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

RECONNOISSANCE SOIL SURVEY OF THE UPPER SAN JOAQUIN VALLEY, CALIFORNIA.

BY

J. W. NELSON, IN CHARGE, AND WALTER C. DEAN, OF THE UNIVERSITY OF CALIFORNIA, AND E. C. ECKMANN, OF THE U. S. DEPARTMENT OF AGRICULTURE.

MACY H. LAPHAM, INSPECTOR, WESTERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1917.]

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., July 15, 1920.

SIR: I have the honor to transmit herewith the manuscript report and map covering the survey of the Upper San Joaquin Valley area, California, and to recommend that they be published as advance sheets of Field Operations of the Bureau of Soils, 1917, as authorized by law. This work was done in cooperation with the University of California Agricultural Experiment Station, Thomas F. Hunt, Director.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. E. T. MEREDITH,
Secretary of Agriculture.

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Soil map, Upper San Joaquin Valley sheet, California.

RECONNOISSANCE SOIL SURVEY OF THE UPPER SAN JOAQUIN VALLEY, CALIFORNIA.

By J. W. NELSON, In Charge, and WALTER C. DEAN, of the University of California, and E. C. ECKMANN, of the United States Department of Agriculture.—Area Inspected by MACY H. LAPHAM.

DESCRIPTION OF THE AREA.

The area covered by the reconnoissance soil survey of the Upper San Joaquin Valley is located a short distance south of the geographical center of the State. It covers the upper or southern part of the Great Interior Valley of California and on the west and southwest includes most of the Temblor Mountains and the Carrizo Plain, in addition to the southeastern extension of the Caliente Range and a small part of the Cuyama Valley. Its center is almost 200 miles from Los Angeles and about 300 miles from San Francisco. Its western boundary lies about 50 miles inland from the Pacific Ocean and its eastern boundary about 100 miles from the California-Nevada State line. The area is bounded on the east by the foothills and lower ridges of the Sierra Nevada and the Greenhorn Mountains, and on the south by the Tehachapi and San Emigdio Mountains. Its western boundary is formed by the Coast Range Mountains and its northern boundary by parallel 36° north latitude.

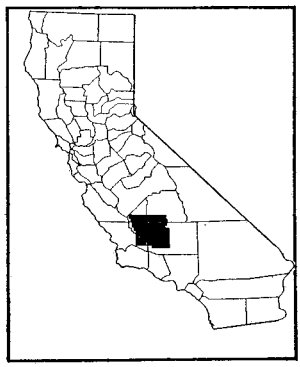

FIG. 1.—Sketch map showing location of the Upper San Joaquin Valley area, California.

The general trend of the main valley and the lesser ones with the included mountain spurs and ridges is northwest-southeast. The main valley resembles the letter U in shape with its open end northward, including all the area between the arms of the letter. Its north and south length within the area is about 75 miles, and the greatest width is about the same. About three-fourths of the area is included in Kern County and the remainder is about equally divided between Tulare, Kings, and San Luis Obispo Counties, with a few square miles extending into Santa Barbara County. The area covers 5,130 square miles or about 3,283,200 acres.

United States Geological Survey topographic sheets were used as a base upon which to plot the soils, except in the parts lying in Tulare and Kings Counties and in the northern and northeastern part of Kern County, the base map of which was prepared partly from county maps and by original traverse work. Slight revision in the culture was made where necessary in the published county and topographic maps used.

Physiography and topography.—The main part of the area, occupying the south end of the San Joaquin Valley, consists of an almost level plain, terminated rather abruptly by the surrounding hills. The valley is separated from the adjoining mountains along its east and west margins by a rolling foothill belt several miles wide, consisting of a series of rolling ridges and slopes, badly broken and dissected in many places. These hills usually merge into the valley plain through moderately to steeply sloping alluvial fans. While the valley presents the appearance of an extensive nearly level plain, closer inspection shows it to consist of alluvial fans which increase in gradient as the foothills are approached. The fans are most extensive, and more gently sloping on the east side of the valley than elsewhere, owing to the occurrence there of heavier precipitation and larger streams, which have carried their sediments far out into the plains, the accumulating deposits having forced the valley trough westward until it lies close to the base of some of the hills of sedimentary formations projecting into the main valley from the west. The elevation of the floor of the valley ranges from about 200 to 400 feet and the higher parts of the fans up to 1,800 feet above sea level.

The greatest variation in the surface features of the main valley occurs around its margin. The west side is most marked in this respect, a number of pronounced elevations extending into the valley from the bordering mountains. Most prominent among these are the Elk, the Buena Vista, the Kettleman, and the Lost Hills. Under the arid climate conditions of this part of the area the hills have preserved much of their original structural features. Drainageways are in most places sharply defined and the uplands are generally marked by steep slopes, which with their shallow soil covering and exposed strata plainly show the folding which has taken place in the rocks.

The portion of the main valley within the area has no definite drainage outlet, but contains two minor depressions in which practically all the flood waters collect. These are the Buena Vista Lake depression, lying wholly within the area, and the Tulare Lake depression, only part of which lies within the survey. The former covers an area of about 31 square miles and the included part of the latter about 142 square miles. In unusually wet periods water had been known to pass from Buena Vista Lake to Tulare Lake, and

thence through Fresno Slough and the San Joaquin River to the ocean, but this has been made practically impossible now by the irrigation systems and by the storage of flood waters and their diversion on pasture lands. These depressions occupy the lowest parts of broad flats on the valley floor. Formerly the extent of the lake beds fluctuated greatly, but at present the lakes are confined by levees. Their existence is due to the coalescing of the Kings River and Los Gatos Creek fans, which have formed a low ridge across the San Joaquin Valley north of Tulare Lake. The region for a number of miles south and east of these lakes has a fall of only 1 or 2 feet per mile, while that of the extensive alluvial fans entering the valley from the east averages from 5 to 7 feet to the mile. The fans entering the area from the south end of the valley are much steeper and have a gradient of about 75 feet per mile, while that of the west side fans ranges from 25 to 40 feet to the mile.

Part of the San Joaquin Valley has for ages received deposits brought into it by the streams issuing from the surrounding mountains. These deposits are several thousand feet deep in places and contributions are annually being made during flood periods, which are locally considerable. The deposits are derived mainly from igneous and sedimentary rocks. The major streams from the east side have their source in the high Sierras and are eroding mainly areas of granitic rocks, while those from the Coast Range traverse sedimentary formations.

Kern River, the largest stream of the area, enters the valley east of Bakersfield. On passing into the plains it divides into a number of diverging channels which spread out and disappear in the alluvial soils farther west. Some of the flood waters reach Buena Vista Lake and are there stored for use in irrigation. White River, and Deer, Poso, Caliente, and Tejon Creeks are the other main streams entering the area from the east. They are small and intermittent and their waters soon disappear in the soils of the valley slopes. Grapevine and San Emigdio Creeks rise in the mountains forming the southern border of the area. Their waters also seldom reach far out on the valley floor, but they have built large, steeply sloping fans. A number of other small intermittent streams lie in the western part of the area, chief among which are Avenal and Buena Vista Creeks. Water from these seldom reaches the valley trough, but the streams have built quite extensive gently to moderately sloping fans. The spreading of the streams by means of branching distributaries over the valley floor has raised the water table in places, and the stagnated drainage has caused the accumulation of alkali over extensive areas. The marginal slopes of the area in most places lie well above the streamways and have good drainage.

The Carrizo Plain and the part of the Cuyama Valley included in the survey with the surrounding hills and mountains, belong to a different physiographic division, although climatically they resemble the main valley quite closely. The Carrizo Plain covers about 150 square miles. It is separated from the San Joaquin Valley by the Temblor Mountains, which reach a maximum elevation of about 4,000 feet above sea level. The Carrizo Plain is about 7 miles wide in its central part and narrows to less than a mile near the southern end. The Temblor and Caliente Mountains form its eastern and western boundaries, respectively, and the converging of these two ranges incloses the valley at its southern end. The plain, formed as is the main valley, of alluvial fans, slopes from the mountains along each side of the valley toward the trough. (Pl. I, fig. 1.) The western slopes of the Temblor Mountains have been greatly distorted by faulting, and a series of distinct scarp faces is developed where the range breaks to the valley floor. The elevation of the plain averages about 2,000 feet above sea level, and about 1,500 feet above the general level of the part of the San Joaquin Valley, included in this survey. This valley has no outlet and its drainage waters collect in Soda Lake, a slightly depressed alkali flat, which usually dries up in summer, leaving a thin covering of glistening sodium salts.[1]

East and north of the Temblor Mountains there are a number of other essentially similar structural valley basins. Most of these, however, open out into the main San Joaquin Valley and are not so conspicuous or so well defined as the Carrizo Plain. These include the Midway Valley, Buena Vista Valley, and Santa Maria Valley lying between the Temblor Mountains and the Buena Vista and Elk Hills; and the Antelope Valley, McLure Valley, Antelope Plain, and Kettleman Plain, lying between the Coast Range and the Kettleman and Lost Hills.

In the extreme southwestern part of the survey a small part of the Cuyama Valley is included. It is traversed by the Cuyama River, which finds its way to the ocean through the Santa Maria River farther west. The elevation of the part of this valley included in the area is a little more than 1,500 feet above sea level. The valley has a pronounced gradient and the streams are deeply intrenched, giving it good drainage. It resembles the other valleys in general features and climatic conditions.

The early history of the region covered by this survey is that of other parts of the Great Interior Valley. In the early settlement the most desirable of the agricultural lands were portioned out as large Spanish grants. Some time after American occupation the various

[1] Considerable quantities of sodium sulphate were gathered and shipped to market from this lake bed in 1917.

counties were formed, and a steady growth in population began. The earliest development was along agricultural lines, but in comparatively recent years the discovery and exploitation of oil deposits has added materially to the growth of these counties. The oil industry now ranks among the greatest industries of the State. Oil has had a marked influence on the development of the southwestern part of the San Joaquin Valley, in the Taft, Maricopa, and McKittrick districts, and also in the Kern River region, a few miles northeast of Bakersfield. Thousands of people are engaged in the industry and the income from this source has added greatly to the wealth of the area. The oil industry is now by far the greatest source of income for the area, there being about four and one-quarter millions of barrels produced each month within the limits of the survey, or about 80 per cent of the entire output of the State.[2]

The population of Kern County increased from 5,601 in 1880 to 54,843 in 1920. Most of this population is in the part of Kern County covered by this survey. Less than 4,000 people live in those parts of Kings County and Tulare County included in the area, and only a few hundred live in the included parts of San Luis Obispo and Santa Barbara Counties. Nearly all of the people live east of the valley trough except those engaged in the oil or in the cattle-raising industries. Most of the people live in the rural districts, and this tendency is increasing in those places where crops are becoming more diversified. Americans from various parts of the United States form by far the greater part of the population. In addition there are some Chinese, Japanese, and other foreigners.

Bakersfield is the county seat of Kern County and is the largest city in the area. Its population in 1920 was 18,638. It is a thriving city and is the center of both the oil and the agricultural interests. Taft is the second city of importance. It is situated in the oil region about 25 miles southwest of Bakersfield in an air line, and depends upon that industry entirely. There are a number of other oil towns and agricultural communities in the area, each of which has a population of a few hundred.

The area is well supplied with railroads, being traversed from north to south by the main lines of the Southern Pacific and Atchison, Topeka & Santa Fe Railroads. A branch line leaves the Southern Pacific at Famoso and traverses the northeastern part of the survey, passing through Porterville and other towns to Fresno. Two branch lines also connect Bakersfield with the McKittrick, Taft, and Maricopa oil districts. These connect all important points in the

[2] For a fuller discussion of the oil resources of this region see Bulletin 406, U. S. Geological Survey, Preliminary Report on the McKittrick-Sunset oil region, Kern and San Luis Obispo Counties, California, by Ralph Arnold and Harry R. Johnson. See also Bul. 471–A–5, Advance Chapter from Contributions to Economic Geology, 1910. Part II, Mineral Fuels—Petroleum and Natural Gas in California, by Robert Anderson.

area and furnish outlets for its products. The remotely situated minor valleys, chief among which is the Carrizo Plain, have no rail connection. These are mainly concerned with cattle raising, and have small prospect of agricultural development, owing to the low rainfall, as well as to inaccessibility. In addition to the rail connections, an excellent system of State and county highways connects most of the important points in the area. Besides the main State highway, which traverses the area from north to south, there are branch county highways connecting Delano with Porterville, Wasco with Lost Hills, and Bakersfield with McKittrick and Taft, and with Maricopa and Tehachapi. A branch of the State highway connecting Lost Hills with the coast highway in San Luis Obispo County is now under construction. Telephone communication reaches all developed parts of the area and nearly all localities are served with daily mail. Electricity for lighting and power is available over most of the area. Excellent schools are located in all but the most sparsely settled parts of the area. Local markets are supplied with products grown in the area and considerable quantities are shipped to outside points. Manufacturing has not been developed to any great extent. Some oil refineries are in operation, but large quantities of crude petroleum are piped directly to the San Francisco Bay region, and much of the natural gas is piped to Los Angeles.

CLIMATE.

The climate of the area is arid and, except for a lower rainfall, resembles that of the rest of the San Joaquin Valley to the north. It is largely the controlling factor in the agricultural practice and limits the range of crops grown without irrigation. The year is divided into a wet and a dry season corresponding with winter and summer, respectively. The rainy period extends from November to April, inclusive, with most of the precipitation falling during the three winter months. The rains are for the most part gentle, and little or no injury to crops or soils results from surface run-off. The amount of precipitation varies from year to year, but the variation is less than in most other parts of the State. The rainfall decreases in amount from the northern toward the southern boundary and also from the bordering foothills toward the middle of the valley plains. The three summer months are frequently devoid of rainfall, and at Bakersfield, from April to November, inclusive, less than one-half inch falls during any one month. The average for the eight months is 0.22 inch.

Besides their scanty rainfall the summer and early fall months are characterized by high temperatures and low atmospheric humidity, which are very favorable to the drying and curing of fruits out

of doors. The uniform temperatures and high relative atmospheric humidity of winter with accompanying foggy weather greatly reduce evaporation during this period and aid in conserving the rainfall, so that dry-farmed crops utilize the limited supply to the full extent. On the steeper slopes part of the rainfall is lost as run-off, and the parts most exposed to the sun's rays soon lose their moisture and become dry and barren early in summer. The northern and eastern slopes hold moisture longer, as is indicated by a heavier growth of grass and in places of oak and juniper. Run-off is sufficiently active on some of the steeper slopes to dissect the surface and to remove much of the soil covering, but damage of this nature is comparatively rare.

The following tables give the rainfall and temperature records for several Weather Bureau stations well distributed over the area. Records for the Porterville and Coalinga stations, located in the extreme eastern and western sides of the San Joaquin Valley just north of the area, are also included for comparison.

Normal monthly, seasonal, and annual temperature and precipitation.

Month.	Bakersfield.						Delano, 1876–1909.		
	Temperature.			Precipitation.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1898).	Total amount for the wettest year (1909).	Mean.	Total amount for the driest year.	Total amount for the wettest year.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
December	47.5	80	13	0.69	0.10	1.36	0.80	1.16	2.16
January	47.4	78	22	1.71	1.36	2.12	.97	.18	1.61
February	52.3	88	20	.77	.28	2.05	1.13	.10	2.38
Winter	49.1	88	13	3.17	1.64	5.53	2.90	1.44	6.15
March	56.7	94	21	.99	.26	1.50	1.05	.07	1.98
April	63.5	100	30	.32	.05	.00	.68	.93	2.31
May	71.4	110	34	.38	.20	.00	.52	.06	2.27
Spring	63.9	110	21	1.69	.51	1.50	2.25	1.06	6.56
June	78.8	112	38	.03	.00	.00	.08	.00	.22
July	85.3	118	46	.01	.00	.00	.01	.00	.00
August	80.0	113	44	.01	.00	.00	T.	.00	.00
Summer	81.4	118	38	.05	.00	.00	.09	.00	.22
September	74.7	111	30	.19	.65	.00	.22	.00	.00
October	65.5	100	31	.36	.00	.00	.34	.43	.00
November	55.6	90	24	.46	.26	2.26	.59	.74	.16
Fall	65.3	111	24	1.01	.91	2.26	1.15	1.17	.16
Year	65.0	118	13	5.92	3.16	9.29	6.39	3.67	13.09

Normal monthly, seasonal, and annual temperature and precipitation—Contd.

Month.	Angiola.					
	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1903).	Total amount for the wettest year (1915).
	°F.	°F.	°F.	Inches.	Inches.	Inches.
December	43.1	76	14	0.79	0.00	1.43
January	46.4	75	15	1.50	.75	1.86
February	49.9	85	18	.85	.11	3.40
Winter	46.5	85	14	3.14	.86	6.69
March	53.6	88	23	1.42	.90	.15
April	58.6	98	27	.50	.22	1.61
May	65.1	112	26	.30	.00	2.03
Spring	59.1	112	23	2.22	1.12	3.79
June	72.4	112	35	.00	.00	.00
July	78.8	115	38	.00	.00	.00
August	77.7	115	39	.00	.00	.00
Summer	76.3	115	35	.00	.00	.00
September	71.8	109	37	.35	.00	.00
October	62.7	102	26	.26	.00	.00
November	52.0	91	20	.68	T.	.06
Fall	62.2	109	20	1.29	T.	.06
Year	61.0	115	14	6.65	1.98	10.54

Normal monthly, seasonal, and annual temperature and precipitation—Contd.

Month.	Maricopa (3-year record).						
	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	1914	1915	1916
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December	46.0	80	20	1.32	.....	.....	.....
January	46.1	72	22	2.13	.....	.....	.....
February	51.9	78	23	1.38	.....	.....	.....
Winter	48.0	80	20	4.83	.....	.....	.....
March	58.3	96	30	.93	.....	.....	.....
April	62.7	96	40	.86	.....	.....	.....
May	68.2	105	38	.40	.....	.....	.....
Spring	63.1	105	30	2.19	.....	.....	.....
June	76.5	108	47	.00	.....	.....	.....
July	83.2	111	54	.00	.....	.....	.....
August	82.9	114	57	T.	.....	.....	.....
Summer	80.9	114	47	T.	.....	.....	.....
September	74.4	105	46	.33	.....	.....	.....
October	65.2	96	41	.61	.....	.....	.....
November	55.1	88	28	.08	.....	.....	.....
Fall	64.9	105	28	1.02	.....	.....	.....
Year	64.2	114	20	8.04	8.02	8.91	7.19

Month.	Porterville.						Coalinga (3-year record.)			
	Temperature.			Precipitation.			Temperature.			Precipitation—mean.
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Mean.	Absolute maximum.	Absolute minimum.	
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*	°F.	°F.	°F.	*Inches.*
December	47.8	85	22	1.49	0.35	3.80	46.2	76	20	1.74
January	48.0	76	24	1.85	.75	2.54	46.7	67	25	4.39
February	51.8	85	25	1.62	1.55	1.35	50.2	72	28	1.77
Winter	49.2	85	22	4.96	2.65	7.69	47.7	76	20	7.90
March	56.2	89	31	1.84	.08	6.59	54.9	84	29	.51
April	62.9	101	32	.79	T.	2.20	59.1	95	34	.61
May	70.3	109	38	.71	.55	3.29	63.2	103	29	.43
Spring	63.1	109	31	3.34	.63	12.08	59.1	103	29	1.55
June	78.8	111	40	.11	.00	.02	72.9	109	35	.00
July	84.8	114	44	.03	.00	.00	79.6	114	50	.00
August	82.6	114	49	.01	.00	.00	78.5	112	40	.00
Summer	82.1	114	40	.15	.00	.02	77.0	114	35	.00
September	75.1	110	41	.29	2.10	.00	70.7	105	35	.10
October	64.9	102	35	.52	T.	.00	56.7	96	30	.47
November	54.9	95	26	.76	.27	.30	52.8	84	26	.08
Fall	65.0	110	26	1.57	2.37	.30	63.1	105	26	.65
Year	64.8	114	22	10.02	5.65	20.09	61.0	114	20	10.10

Rainfall is well distributed over the area in general, but varies locally with the elevation, the position, mountain barriers, and the direction of air currents. It is greatest in the mountainous margins of the area and increases with elevation. Snow sometimes falls on the lower mountain slopes adjoining the area, but its occurrence in the valley is very rare. Hail and thunder storms seldom occur.

Temperatures vary greatly in different parts of the area and are noticeably influenced by topography, wind movement, exposure, and fogs. The lower and flatter parts of the valley floor are the coldest and most frequently visited by frosts, while the foothill slopes have better air drainage and are free from frost, thus being more favorable for the growing of citrus fruits and tender winter truck crops. The difference in temperature between the sloping positions and the valley floor ranges from about 5° to 8°, which is ordinarily sufficient to make tender crops in the former localities safe during the periods of critical

temperatures. The hardy vegetables thrive during the winter months in all parts of the area, and the more tender crops have an 8 or 9 months' growing period even in the lower positions. The warmest part of the year is from June 15 to September 30, and the greatest danger from frosts is during the three winter months. The highest and lowest official temperatures, 118° and 13° F., respectively, are shown by the records at Bakersfield. Temperatures range above 32° F. during most of the days in winter. The diurnal range is greatest in summer, often amounting to 40° or more. The low humidity of the atmosphere during summer greatly increases evaporation and necessitates careful cultivation to conserve moisture for the use of crops. Heat prostrations are rare, but temperatures are usually too high in summer for comfort. The growth of grain and grass is not materially checked by the cold of winter. Fog is common during the winter months and is ordinarily densest in the lower lying parts of the valley. At times it is continuous for several days, but in most cases it disappears before noon. The following table gives frost data for the area:

Station.	Average date of last killing frost in spring.	Average date of first killing frost in autumn.	Latest killing frost in spring.	Earliest killing frost in fall.
Bakersfield	.....	.....	Feb. 6	Nov. 12
Maricopa	.....	.....	Mar. 24	Do.
Angiola	.....	.....	Mar. 26	Nov. 1
Coalinga	.....	.....	May 2	Oct. 20
Porterville	Feb. 7	Dec. 10	Apr. 13	Nov. 11

Wind movement in the area is usually light, and damage to crops from this source is very rare. Winds are prevailingly from the north and the northwest in spring and summer, and commonly blow from the southeast and south for two or three days preceding stormy periods in winter. The north winds usually diminish in intensity toward the south end of the valley and strong breezes farther north frequently give only gentle air movement here. Wind is generally strongest toward the trough of the valley and on the west side, there being little tree growth in the latter region to check air movement. Wind is very light in summer and fall.

Atmospheric conditions are favorable for irrigated crops in the area, but the rainfall is near the lower limit for success with dry-farmed crops. Extensive areas of excellent land on the west and south sides of the valley are utilized for pasture only, because of a scarcity of irrigation water and because of their inability to produce dry-farmed crops, except in years of unusual rainfall. Except

for the occurrence of malaria in the lowlands forming the Kern River bottoms and along the trough of the valley, the climate is healthful.

AGRICULTURE.

General conditions.—The early history of agriculture in the area is similar to that of other parts of the San Joaquin Valley. For several decades following the first settlement stock raising was the chief pursuit of the people, and little attention was given to production of farm crops until after 1870. For the 10-year period following this date wheat, barley, and corn, in the order named, and hay became important crops. These were used principally as feed for cattle. During this period land was held in large tracts, there being in 1880 less than 300 farms covering Kern County. Subsequently to this year agriculture developed quite rapidly and many new crops were introduced. Cheap land and favorable crop yields attracted many people to the area during this stage of its development. In addition the building of the Southern Pacific and the Atchison, Topeka & Santa Fe Railroads into the area, the development of the petroleum industry in Kern County, and the extension of irrigation have been important factors in the more recent progress of agriculture. Production in the area is, however, limited by the amount of water available for irrigation, except in case of barley and wheat and a few other crops, which give moderate returns in the more favorable parts of the area under dry farming. The suitability of the soils of the area to alfalfa and to the many fruits that are grown here has resulted in full utilization of the readily available supplies of water for irrigation, and future extension of the area under cultivation will depend largely upon the development of additional water, either by storage or by pumping from underground sources. Scanty rainfall is the limiting factor in successful crop production in the nonirrigated parts of the area, and, because of this, those types of soil which best absorb and retain moisture within the root zone give best results with dry-farmed crops. The influence of rainfall on soil types and crop production is plainly shown in that part of the area west of the main valley trough. Here the rainfall is usually too low for the maturing of crops on the gray soils of the Panoche and Kettleman series of the alluvial slopes and lower foothills, but the amount of precipitation increases with elevation, and wherever it is sufficient to give rise to the darker colored soils of the Altamont and Diablo series the maturing of crops is much more certain. This fact is substantiated by the distribution of the cropped areas in this section. The influence of elevation has a similar effect on the soils and crops along the eastern margin of the survey, though it is less marked than on the west side of the valley.

The present tendency of agriculture in the area is toward a system of highly specialized crops grown largely for shipment to outside points. Chief among these are raisin grapes, peaches, apricots, and oranges. In addition to these special crops dairying, hog raising, and poultry raising are important. At the present time the production of these crops and the extension of these animal industries are showing marked progress in those parts of the area best suited to them, and new settlers are gradually occupying the most favorable lands in sections where water for irrigation is available. The experience of farmers along the various agricultural lines followed has tended to centralize the several industries in those parts of the area in which the soils and climate are most favorable.

Comparatively little commercial fertilizer is used in the area, applications being confined to the orange groves and to the land occupied by a few others of the more intensively cultivated crops. The use of fertilizer is not considered profitable in the case of most crops. The soils, however, are deficient in organic matter, and respond readily to applications of manure and the turning under of green crops, provided sufficient moisture is present to enable them to decompose properly.

In normal times the supply of labor is ample for the needs of the farmers. The different periods at which the crops mature tends to keep labor employed and enables the farmers to distribute the expense over most of the year.

The average number of acres of improved land per farm in the counties making up the larger part of this area was in 1910 for Kern 270 acres, for Tulare 126 acres, and for Kings County 107 acres. In Kern County this represents about 22 per cent of the average-sized farm, which at the same date was 1,202.5 acres. All the intensively farmed part of the county lies east of the main valley trough and includes many moderate to small sized farms, while much of that under ownership in large tracts comprises either areas affected with alkali or areas where the rainfall is normally insufficient for the successful growing of dry-farmed crops. In 1910 nearly 75 per cent of the farms in Kern County were operated by owners and about 23 per cent by tenants. In Kings County the percentages were about the same at this date, while in Tulare County about 82 per cent of the farms were operated by the owners, about 12 per cent by tenants, and 5.5 per cent by managers.

Farming operations are carried on both by the use of horses and by tractors. The latter are becoming more popular and are displacing much work stock. Weather conditions are usually favorable for farm work during the entire year, and by proper management labor and equipment can be kept busy nearly all the time.

Land values vary greatly in the area. Land of good quality near the State highway ranges in price from $100 to $250 an acre, while similar soils more remotely located may bring only half this amount. Land only suited to dry farming ranges in price from $25 to $100 an acre, while that only fit for grazing brings from $10 to $25 per acre.

In the pages following the principal crops of the area are discussed briefly. Further information regarding them is available in bulletins and circulars published by the experiment station of the University of California, by the United States Department of Agriculture, and by the California State Commission of Horticulture and the California State Board of Agriculture.[3] The statistical data given in the discussion of crops were obtained from the monthly bulletin No. 7 and others of the California State Commission of Horticulture,[3] from the records of the commissioner of horticulture for Kern County, and from the census of 1910.

Alfalfa.—Alfalfa is an important crop in the area and the acreage is being rapidly extended. It is grown almost entirely on the valley floor and on the alluvial lands along the streams east of the valley trough. Small plantings also occur in the narrow canyon valleys in the eastern and southern parts of the area. The crop is generally confined to localities in which an ample supply of water for irrigation is available. Twenty-three thousand six hundred acres were producing alfalfa in Kern County in 1910, and small acreages were grown in those parts of Tulare and Kings Counties included in the survey. It is the principal forage and hay crop, although grains cut green for hay are very important.

Alfalfa is produced on a variety of soils, ranging in texture from sand to clay loam, but the best yields are obtained on deep, well-drained, friable soils of medium or slightly lighter texture, such as the sandy loams, fine sandy loams, and loams. The recent alluvial soils (Hanford and Foster series) occurring in the large deltas of the east side streams are preferred and most used in the production of this crop. Large quantities of alfalfa are also produced on the better drained, alkali-free soils of the Tulare and Merced series in the valley trough. The more elevated old valley-filling soils in which topography, subsoil, and water conditions are favorable are here and there brought into use in growing this crop.

Alfalfa is a deep-rooted crop, and soils having hardpan or other subsoil features that limit root development are usually avoided. The soils on the lower levels of the deltas or alluvial fans and in the valley trough and in old lake beds having a high water table, which also restricts root growth, are not commonly used for this

[3] These organizations have been consolidated since the survey of this area was made and are now included in the California State Department of Agriculture.

crop. Small quantities of alkali or occasional alkali spots do not inhibit its growth, but so reduce the yields that lands so affected are to be avoided, owing to the possible increase of salts from seepage when water is applied to adjacent higher lands. Soils well supplied with lime are favorable to and give best results with this crop, other things being equal.

Irrigation is necessary for profitable alfalfa production in this area. Water is supplied by gravity canals or by pumping from underground sources. Where possible, the crop is irrigated once for each cutting, but some fields receive only the flood waters in spring and early summer. In this case the number of cuttings is reduced. On the average five irrigations per season are given on the better drained lands, while only two irrigations may be enough on the lower moist or subirrigated lands. Alfalfa requires about 3 acre-feet of water per season for maximum yields, and it is usually applied by flooding in checks and borders. Alfalfa culture is extensive and is not favored where a lift of over 40 feet is necessary in obtaining water by pumping.

The average yield of alfalfa in Kern County in 1910 was 3.1 tons per acre. Fields properly handled and irrigated often produce 8 to 10 tons per acre per season, but the practice of pasturing after removing one or two cuttings, and frequent neglect in irrigation and care of the crop greatly reduce the average yield. From two to seven cuttings are obtained, depending upon the water supply, care, and purpose for which the crop is grown.

Much alfalfa is fed on the ranches to horses, dairy stock, and fat cattle as hay or pasture. The average price in the stack has in past years ranged from $6 to $8 per ton. It is sometimes planted as a cover crop in orchards or grown to improve the soil before setting the land in fruit. Where alfalfa is grown commercially the stands last for 8 or 10 years. Little seed is produced in the area, chiefly on account of its poor quality. Bakersfield, Buttonwillow, Weed Patch, Shafter, Wasco, Delano, and McFarland are the principal centers of alfalfa production in Kern County.

Grain and hay crops.—Dry-farmed grain is produced extensively in the area and will continue to be until extension of irrigation makes a wider range of crops possible on the grain lands. Barley and wheat, named in order of importance, are the chief cereal crops, and both are grown on a wide range of soils and under variable moisture conditions. The acreage of wheat decreased markedly from 1900 to 1910, largely as the result of unfavorable seasons. A small acreage is irrigated and the yields here are large and certain. Under dry-farmed conditions, however, the grain crops are usually cut for hay, because the supply of moisture is insufficient to mature them properly. Much of the area devoted to wheat in earlier times

has either reverted to pasture or has been given over to barley production. Barley appears to be better adapted to the soil and climatic conditions than wheat. During the period in which wheat declined so noticeably barley increased in acreage by about 500 per cent. This crop is more certain to mature than wheat and gives about twice the yield per acre. In parts of the area, as, for instance, the northern part of the Temblor Mountains (Pl. I, fig. 2), where the annual rainfall is 10 inches or more, good yields of both crops are obtained, but elsewhere the returns are variable and in proportion to the amount of rainfall and its distribution. The heavier and more favorable soils to some extent are cropped continuously, but as a rule the grain land is summer fallowed in alternate years.

Potatoes.—Potato culture is an industry of considerable importance in the vicinities of Bakersfield, Arvin, Shafter, and Wasco. In 1910 the area planted in Kern County was 339 acres. The high prices prevailing for several seasons has stimulated the industry greatly. Some potatoes are produced in the area outside of Kern County, but the commercial acreage is small.

Potatoes are grown upon the friable, deep, alluvial soils of medium texture, and commercial plantings are confined largely to the soils of the Hanford and Foster series. The crop is irrigated once every 40 days, or at sufficient intervals to keep the soil moist. Proper cultivation and handling is essential to success. Few pests or diseases attack potatoes in the area. Two crops can be produced on the land in a single year, the spring crop being planted about the middle of February and harvested in June, and the fall crop about the middle of August and harvested in November. If planted during extremely hot periods or if insufficiently irrigated, failure is likely to result from baking or burning.

The American Wonder is the most popular variety for both plantings. In 1910 the average yield of potatoes in Kern County was 150 bushels per acre. In 1916, 50,000 bushels of potatoes were marketed in Kern County at an average price of $2 per hundredweight.

Nonsaccharine sorghums.—Nonsaccharine sorghums are of importance in the area, owing to their ability to thrive with a moderate moisture supply. In the past sorghum has been grown in many cases for feed on land from which some other crop has been harvested. It is also planted to utilize land not adapted to fruit culture or other of the more important crops, its quick maturity making it a good crop for this purpose. With the prevailing high prices, the sorghums have become more popular as a cash crop. Where formerly only scattered plantings were made, many large fields are annually put in this crop. The 1910 census reports 2,183 acres in nonsaccharine sorghums in Kern County.

Many varieties have been grown in the area. Among the more popular ones are the red and the white dwarf milos and Egyptian corn, or white durra. Feterita is grown to some extent, but does not meet the market requirements so well as the varieties first named.

Little attention has been paid to adaptation of this crop to soils, it being grown on types of all textures and of many different series. Many areas which are affected by alkali, or have a water supply insufficient for alfalfa, or are too cold for fruit, have been planted with these sorghum crops. They also are grown on bottom lands when floods destroy the crops first planted. Deep alluvial soils of medium texture give excellent results with sorghums when properly handled. They are not so well adapted to the extremely light or heavy soils, but fair yields can be obtained under favorable conditions on soils of widely differing textures.

Much of the area in sorghum is irrigated at least once, but, to insure the maximum yields, three irrigations are necessary on the drier or better drained land. Small plantings are made on subirrigated land that receives but little or no surface irrigation. In localities supplied with canals that carry flood waters the land receives one irrigation in the late spring. Considerable acreages are also irrigated by pumping from wells.

The crop is planted in the early summer, and often follows a crop of early potatoes or of winter grain. A second crop may be grown for forage or ensilage. The sorghums are easily grown and little trouble is caused by disease or insect pests. Birds cause some loss by eating the grain. A rotation with other crops, such as beans, sugar beets, or grain, is necessary to maintain yields. Harvesting is usually done on small fields by hand and on larger plantings with a binder. Owing to the high prices now prevailing, the haphazard methods formerly adopted are giving way to better cultural methods.

Yields vary greatly. The average yield in 1910 was less than three-fourths ton per acre. A yield of more than 1½ or 2 tons per acre is not unusual where proper care is given and the crop is planted on a favorable soil. The average value of the crop prior to present war-price increases was between $20 and $30 a ton. The grain is an excellent feed for all kinds of stock and may be fed whole, ground, or cooked.

Indian corn.—Less than 500 acres of Indian corn were grown in Kern County in 1910, and the crop will probably never assume much importance in this area. It is confined almost entirely to the more humid bottoms. Climatic conditions, such as the low relative humidity, extreme heat, and cool nights are unfavorable. Corn grown under semiarid conditions is of inferior quality and yield, the average yield in 1910 being less than 16 bushels per acre. Both yellow and white dent varieties are planted. Irrigation is necessary. The crop

does best on deep alluvial soils of medium texture that are well supplied with organic matter and free from alkali. It is attacked somewhat by smut and by corn-ear worm. Most of the crop is fed to stock.

Rice.—Rice has been recently introduced but is not yet very extensively grown in the area, 1,500 acres representing the acreage in that part of Kern County included within the survey. A small acreage occurs also in that part of the survey lying in Kings and Tulare Counties. The rice fields are small and for the most part isolated. Success with the crop has been variable, the results depending mainly upon soil, alkali, and supply of water. It is doubtful if the industry will develop as rapidly as in the area to the north where there are more extensive areas of heavy textured, compact hardpan soils favorable to production of this crop.

Rice is grown in the valley trough, chiefly upon soils having a high water table and containing more or less alkali. Soils of many different textures are used, but the range is not as great as in the Middle San Joaquin Valley area. The heavy loams, clay loams, or silty clay loams of the Fresno, Pond, or Merced series are preferred. The best results are obtained on heavy soils which possess impervious subsoils, or hardpans that prevent the rapid percolation of water. With proper handling and favorable soils moderate amounts of alkali are tolerated by this crop, but the presence of large quantities reduces the yields.

Rice requires large supplies of water for irrigation, and after germination the fields must be kept flooded till a short time before harvest. In this area most of the land is irrigated by pumping from underground sources, the lift generally being small. Rice land must be carefully leveled and uniformly checked to insure an even distribution and stand of water or the yield will be materially lessened. Where land is excessively high in alkali, it must be flooded and drained before planting, as the germinating plants are frequently killed by amounts of alkali that would not be injurious later.

Seventeen thousand sacks of rice were produced in Kern County in 1916. Under favorable conditions 25 to 40 sacks can be grown per acre, but the average yield is probably not more than 10 or 12. Many attempts to grow rice have resulted in failure because of the lack of foresight in selecting soil, in choosing land too high in alkali salts, and in not providing sufficient water. The popular idea that rice could be grown on land regardless of alkali concentrations, and without proper preparation, flooding, and drainage has been disastrous. It is ordinarily unprofitable to produce rice where water is expensive, or where the soils are of such texture that water can not readily be retained on the surface. Many of the lands of the valley trough which have a high water table, and consequent low lift for irrigation by pumping, may become important for this crop.

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FIG. 1.—VIEW ON THE CARRIZO PLAIN.

Smooth alluvial fan soils of the Panoche series in foreground, with western slopes of the Temblor Mountains in distance occupied by Rough broken land.

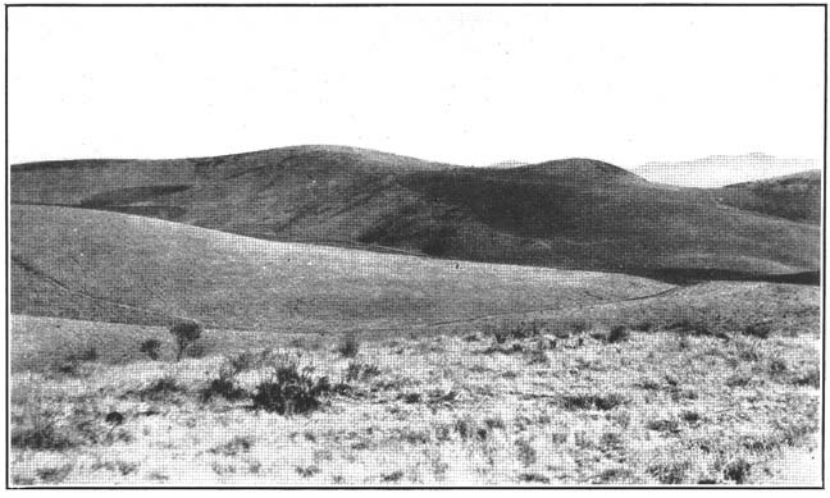

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FIG. 2.—VIEW OVERLOOKING PART OF THE TEMBLOR MOUNTAINS, OCCUPIED BY SOILS OF THE ALTAMONT SERIES.

Note the characteristic topography. The dark-colored areas on the hillsides have been recently plowed for seeding to grain.

Rice is frequently grown to reclaim alkali lands, which are subsequently seeded to alfalfa or some other crop. Much of the salt is removed after several seasons of rice culture, but where drainage is poor and a high water table exists, alkali will probably accumulate again in injurious quantities.

Sugar beets.—The sugar-beet industry has been of little importance until recent years. No records for the crop are given in the census of 1910, but according to State authorities about 6,000 tons were produced in 1916. The acreage in beets in 1917 is estimated at about 6,500 acres. High prices for sugar are stimulating the industry and a further increase in acreage will probably result. Most of the crop is grown in the vicinities of Buena Vista Lake, Kern Island, Conner, Buttonwillow, Alpaugh, and Tulare Lake.

Beets are raised on soils varying in texture from sandy loam to silty clay loam, but the most satisfactory yields are obtained on fine sandy loam, loam, or silt loam types. The crop is almost entirely confined to soils with a large content of organic matter, a high water table, and subject to overflow. The Merced, Foster, and the more poorly drained parts of the Hanford series are most extensively used for this crop. Alkali is present in varying quantities in most of the beet lands and great care is required in handling the soil and crop where it occurs.

Thorough preparation of the seed bed is essential. The crop is thinned after it is well up and much hand labor is necessary throughout the growing season. All the fields are irrigated from gravity canals, the number of applications depending largely upon soil conditions. Harvesting begins about July and continues for several months. A rotation with grain is practiced by some growers.

Sugar beets are grown in the valley trough and lake basins where restricted drainage or accumulations of alkali make many other farm crops unprofitable. The average yield is somewhat more than 3 tons per acre, though much higher yields are obtained under the best methods, where water and alkali conditions are favorable. The crop tolerates moderate amounts of alkali, but large concentrations are injurious.

Beets are shipped to the sugar factories at Visalia and Corcoran. In 1916, $39,941 or about $6 per ton was obtained by the growers.

Beans.—The growing of beans has not been important in the area in the past, but high prices have awakened interest in this crop. In 1916 small acreages about Shafter and Bakersfield were the only ones producing beans commercially, 155 acres being planted. It is doubtful if the crop will ever become important in this area.

The most popular variety is the Tepary, while Black Eye and Pink beans are also grown. Practically the entire crop is planted on deep, well drained, alluvial soils. The crop is irrigated two or three times

a season. The bean crop is favored by a long dry growing season, with little danger of damage from rains and frosts. The average yield is 10 to 15 sacks, of 85 pounds each, per acre. Care is necessary to prevent destruction by rabbits. The crop is beneficial to the land and is sometimes grown to make one step in a rotation. The market price in 1916 was about $6.50 per hundred pounds.

Citrus fruits.—The citrus industry is being steadily extended southward from the Porterville district lying northeast of the survey and is becoming important in this area. The horticultural commission reports 1,500 acres in Kern County in 1916. Of these, 450 acres were in bearing, and 920 acres in nonbearing orange trees and 150 acres in nonbearing lemon trees. There is also an important acreage in the Tulare County section of the survey, but no statistics are at hand showing the exact extent of the industry there. Most of the plantings in Kern County and many in Tulare County are comparatively recent.

The principal center of the citrus industry in this area lies just south of Deer Creek in Tulare County, around Terra Bella and Ducor and thence toward the eastern foothills. This thermal belt continues along the foothills southward, and includes a center of orange culture in the vicinity of Edison in Kern County. Orchards of 3 to 40 acres occur at Jasmine, in the vicinity of Bakersfield, near the mouths of the canyons of San Emigdio and Tejon Creeks, and in a few other places.

The Washington Navel is the leading variety of orange, there being only small plantings of Valencia. Lemons and grapefruit are also produced, but as yet they have not attained much importance.

Citrus fruits are produced on soils ranging in texture from sandy loam to the heaviest clay adobe. The old valley-filling soils of the Ducor, Porterville, San Joaquin, Madera, and Delano series are the principal ones utilized. The Olympic and Hanford soils are used locally.

Many of the difficulties arising from unfavorable subsoil conditions in the areas of hardpan soils have been overcome by shattering the impervious layers by means of explosives and thus providing drainage and permitting deeper root development. The soils usually selected lie relatively high and possess a sloping or rolling to hummocky topography with good surface and air drainage. Excessive concentrations of lime within the 6-foot profile are not considered desirable. Soils with bed rock close to the surface, and those of recent alluvial origin subject to frosts or in which there is a high water table or that have an open structure are avoided. Some growers prefer the heavier soils; others select those of lighter texture.

The Porterville and Ducor series are devoted most extensively to citrus fruits in the vicinities of Terra Bella and Ducor. (Pl. II, fig. 1.) The San Joaquin and Madera series are important for this crop near Jasmine, and the Delano sandy loam is the type mainly used in the vicinity of Edison.

A large amount of capital is invested in the industry, and lands are carefully selected and prepared for these plantings. Much attention is given the groves, leguminous cover crops are grown and plowed under in spring, and clean cultivation is practiced during the rest of the season. Both commercial fertilizers and barnyard manure are applied annually, the latter being much sought after and often transported long distances. The citrus industry is young in Kern County and diseases and pests are not troublesome as yet, but precautions are being taken to keep them out by careful inspection.

Irrigation is essential to success and water must be available during the entire growing season. Water is obtained from deep wells often at great expense, drawn from irrigation systems getting their supply from streams, or obtained by pumping from wells in the lowlands and piping the water to the groves. Income from citrus crops will usually warrant a high water cost, but where water is easily obtained a great saving is effected. Groves are irrigated once in 30 or 40 days during the rainless period.

Groves yield from a few to over 200 boxes per acre. The average yield for the county in 1916 was 59 boxes per acre, but it is estimated that frost reduced the yield nearly 10 per cent that year. The June drop is also serious and greatly reduces yields in most seasons. The present low yield is, however, mainly due to the youngness of the trees.

The 1916 orange crop returned the grower a little less than $1.25 per box at the grove.

Grapes.—The grape industry has not assumed extensive proportions as yet, but it promises to become very important. About 1,200 acres, practically all in small plantings, constitutes the vineyard area in Kern County. The chief centers of grape growing are at Wasco, Shafter, Bakersfield, and Weed Patch. A few small plantings are grown in that part of the area lying in Tulare and Kings Counties.

Grapes are grown on soils ranging in texture from a loamy sand to a loam or silt loam. The fine sandy loam, sandy loam, and light loam of the Hanford, Pond, and Delano series are the preferred soils. The principal vineyards are situated on the deep, well aerated, and drained alluvial soils. Small plantings occur on the Mohave series. The Madera and San Joaquin series, which are used for grape growing in other parts of the San Joaquin Valley, are not so desirable because of their hardpan, which, unless deep, requires shattering.

Alkali is present in harmful quantities in some of the vineyard soils on the lower levels of the alluvial fans.

Practically all of the vineyards are irrigated once or more during the season. Most of the water is obtained from wells, though a small acreage is under gravity canals. Ordinarily the latter receives but one irrigation, which is insufficient for the best results. The crop requires much less water than alfalfa, and will warrant higher irrigation costs. On the alluvial delta soils the lift of water is usually not great, while a much higher lift is necessary in the old valley-filling soils, except where these occur in the valley trough.

About 90 per cent of the vineyards are planted with raisin grapes. These are chiefly Alexandria (*Muscat of Alexandria*) and Sultanina (*Thompson Seedless*). The latter seems well adapted to local conditions. There are also a few plantings of wine and table grapes, chiefly Zinfandel and Flame Tokay. It is doubtful if Tokay grapes reach the perfection of development and coloring that is attained in the lower parts of the San Joaquin Valley. The grape industry is still in its infancy and many vines have not yet reached full bearing. Accurate data on yields are not obtainable, but in 1916 900 acres of raisin grapes in Kern County produced less than one ton per acre. When properly handled and irrigated a yield of more than two tons per acre is possible.

No fertilizers and only local applications of manure are used in growing grapes. Clean cultivation is practiced. The climate favors early maturity and satisfactory drying of raisins. The grapes are practically free from diseases or pests in Kern County, and precautions are being taken to prevent their introduction.

The raisin crop is marketed very largely through an association, which has obtained good prices during the past several years.

Apricots and prunes.—In 1915 there were less than 500 acres of apricots in Kern County. About half the orchards had not then reached bearing age. The prune acreage is about the same, the statistics of the horticultural commissioner for 1916 indicating 200 acres of bearing and 270 acres of nonbearing trees. Both crops are grown in small, scattered plantings, the principal orchards being situated near Famoso. Others lie near Wasco, in the vicinity of Bakersfield, and near Weed Patch. Climatic conditions are generally not considered as favorable for apricot or prune culture as are those of the more moist and cooler coast region.

The soil requirements of both crops are much the same. They thrive on well-drained recent alluvial soils of medium or moderately heavy texture, and are better adapted than the peach to heavy soils. Various types of the Hanford, Foster, Delano, and Pond series are preferred. Alkali areas are usually avoided.

Apricot and prune orchards are given clean cultivation and irrigated. No fertilizers are used. The orchards in this area are but little affected by diseases or insect pests. The apricot blooms early and the yield is sometimes cut short by frost. It varies greatly in yield from year to year, but the irregularity of bearing may be overcome to some extent by good care. Most of the apricot crop is shipped to canneries in southern California and a part is dried locally. The prune crop is less subject to failure than the apricot.

Peaches.—In 1916 there were about 660 acres of bearing and 450 acres of nonbearing peach trees in Kern County, and a few orchards in the included parts of Tulare and Kings Counties. The 1910 census reports a total of less than 400 acres of peaches and nectarines in Kern County. The industry has not expanded as rapidly as conditions of soil and climate seem to warrant, but it is doubtful if more extended plantings will be made during the time of prevailing high prices for other farm crops.

The leading varieties grown are Phillips for canning and Heath for drying.

The peach industry is centered very largely in the region about Bakersfield, Weed Patch, Wasco, and Famoso, with small scattered plantings east of Delano and in a few other parts of the area. Most of the orchards are situated on deep friable soils of light or medium texture, the well drained, recent alluvial soils, the sands, sandy loams, and light loams of the Hanford and the Delano series being preferred. On soils with a high organic matter content the trees have a tendency to produce wood and foliage at the expense of fruit. Yields are materially reduced on soils containing alkali or having a high water table. Some orchards are located on subirrigated land and require very little additional water, but there is always danger from a fluctuating water table and alkali accumulation in such places.

Peach orchards are ordinarily irrigated once or more during the growing season. Under the gravity canals water can in many cases be obtained but once in a season. Those irrigated from wells receive several applications each year. Clean cultivation is practiced by careful growers. No commercial fertilizers are used. In some instances small applications of barnyard manure are made. The peach is not seriously affected by diseases in this part of the valley. When grown on apricot roots, the nematode is sometimes troublesome and rootknot may affect the older trees. Spraying and thinning of the fruit are essential for the best results.

Reliable data showing the yields of the bearing orchards are not available. The census of 1910 indicates an average of less than 2½ tons per acre, but this is far below the yield of the bearing orchards that receive good attention.

The product is marketed either fresh or dried, or is sold to the canneries. In 1916 the production of dried fruit amounted to 150 tons, the fruit marketed fresh to 150 tons, and the product sent to canneries to 500 tons.

The average price paid by the cannery ranges from $8 to $12 a ton. The price paid for the dried fruit in the past several years was not encouraging, but the selling of the product through an organization has stabilized the market and produced more satisfactory returns.

Live stock.—Live stock is the most important industry in the area, producing in Kern County over 60 per cent of the total agricultural income in 1916. The total value of all classes of live stock in Kern County in 1910 was $4,509,038. Considerable live stock is also produced in the parts of Tulare, Kings, San Luis Obispo, and Santa Barbara Counties within the survey.

Cattle.—The cattle industry is the most extensive and important agricultural interest in Kern County. In 1916, $2,700,000 worth of beef and $217,200 worth of by-products were marketed. It has expanded considerably since 1910, at which time the census reported 118,320 animals of all ages in the county, with a total value of $3,051,957. Much of the stock is run on the range or hills, receiving no other food than the ordinary pastures afford. Where alfalfa is available it is sometimes pastured or fed as hay to fatten cattle, and occasionally some grain, hay, or roughage forms part of the ration. Large areas of salt grass on the alkali lands furnish good pasture, but in many places cattle must range over considerable land to secure sufficient food.

Most of the cattle in the area are grade animals. The introduction of many purebred bulls of the important beef breeds, especially the Hereford, has greatly improved the quality of range cattle. Plate II, figure 2, shows a herd on grazing lands in the west side of the San Joaquin Valley.

Sheep and goats.—The sheep industry is of next importance to the cattle industry in Kern County. In 1910 there were 31,247 sheep of all ages, with a total value of $117,442. The sale of lambs, mutton, and wool in 1916 amounted to $510,000. Sheep are grazed in large bands on the range. They are not common where intensive farming is carried on, although many of the agricultural sections are grazed over after harvest. Beet tops, grain stubble, and corn stalks supply much feed during part of the year.

Hogs.—Hog raising is becoming more important, especially as more intensive agriculture develops. In 1910 there were 20,513 hogs in Kern County, of a total value of $167,439. In 1916, $245,000 worth of pork was sold. Purebred stock of the standard breeds, such as Duroc-Jersey, Berkshire, and Poland-China, are being introduced and are doing much to put the industry on a firmer basis.

Hogs are raised chiefly in the general localities where the alfalfa and dairy industries have developed. The principal shipping centers are Bakersfield, McFarland, and Buttonwillow. Alfalfa, sorghums, grain, and the by-products of the dairy industry are used for feed, the first probably being the chief food for the growing hogs and sows. Auction sales, under the direction of the Farm Bureau, are doing much to secure fair prices for the small producers.

Horses and mules.—In 1910 there were 10,347 horses and 1,248 mules in Kern County, valued at $1,159,657. In 1916, $80,000 worth were sold, prices ranging between $90 and $100 a head. Horses and mules are bred largely for local use. Many of the younger animals are pastured or ranged till sold or used for farming operations. Tractors are rapidly displacing horses on many farms and ranches.

Dairying.—In 1910 there were 6,917 dairy cows in Kern County and dairy products, exclusive of home use, had a total value of $245,601. In 1916 the value of all dairy products was $450,000. The dairy industry is usually associated with alfalfa production. Alfalfa hay or pasture constitutes the greater part of the feed for dairy cows, other feeds such as the sorghums and small grains being used locally. In some parts of the survey salt grass pastures, composed of lands spotted with alkali, supplement alfalfa and other feeds or are used to carry the young stock.

There are a number of creameries in the principal dairy centers, where most of the milk goes for the manufacture of butter. Some sweet cream and milk is shipped to Los Angeles, which, with the many oil towns, furnishes a good market for large quantities of dairy products. On many of the dairy farms herds of purebred Holsteins are kept; on others herds of good grades occur. The standard is being raised by the use of purebred males.

Poultry.—The raising of poultry is in most cases carried on in connection with other lines of agriculture, but in a few instances it is the principal interest. In 1910 the total value of poultry and eggs sold in Kern County was $84,931. The recent high price of grain has tended to restrict poultry raising. A good market for all poultry products is near at hand in the cities and towns of the area.

Bees.—In 1910 there were 4,501 colonies of bees in Kern County, and the income from the sale of honey and wax amounted to $12,159. It is estimated that there were 8,000 colonies in the county in 1916. Many colonies of bees are moved into the large pastures during the honey season, where they work on the blooms of grasses, weeds, and other native vegetation.

SOILS.[4]

In character of soil, so far as that is determined by the climatic conditions under which development took place, the soils of the Upper San Joaquin Valley vary widely. Part of the region is humid, part arid, and part semiarid. In climatic variations the region, although small in area, is rich, and as much variation in rainfall can be found within the area as may be found in passing from the mouth of the Arkansas to Pueblo, Colo. Corresponding differences in soils are present.

In the mountains of the eastern part of the area, where the rainfall amounts to as much as 30 inches or more, the soils are typical humid soils, with light color, brown or reddish, thoroughly oxidized subsoils with complete absence of carbonates in both soil and subsoil with local exception of small amounts of residual lime carbonate. The subsoils are usually heavier than the soil, and in flat areas with poor surface drainage the subsoil may have the varied coloration due to the presence of excessive moisture. This group of soils is represented by the members of the Holland series, by the lighter textured members of the Altamont series, and probably also by those of the Placentia series. Some of these soils occur also in the higher parts of the mountains on the west side of the valley.

The Hanford soils, consisting of recent alluvial deposits, have not yet attained a stage of development that will show the effects of the climatic conditions prevailing in the areas in which they now occur, and since the soil material comes mainly from areas of humid soil, is light in color, and leached of its carbonates, the soils should be grouped with the humid soils.

The rainfall throughout the valley is low. It is lowest on the west side, where it does not amount to more than 10 inches per annum, and increases eastward. The soils developed to maturity on the valley floor have true desert characteristics, such as very light gray color of soil and gray to reddish highly calcareous subsoils, often with well-developed hardpans. Concentrations of alkali are present in places, both those old enough to have caused the development of a characteristic soil profile and those not yet old enough to have

[4] Upon the north the area surveyed joins with that covered by a previous survey of the middle portion of the San Joaquin Valley. In certain cases the maps of these two surveys do not appear to agree in classification of the soils along the boundary. This is due to gradual transition between the soils of certain series represented in the two surveys, and to changes in correlation in the later survey resulting from wider study of certain of these soils in areas of their more complete development. The brown soils of the Pleasanton series as occurring along the southern boundary of the Middle San Joaquin Valley survey were recognized as representing a light colored and calcareous variation of this series. In the present survey these characteristics become more pronounced, and they are now recognized as constituting a new series of soils designated as the Cuyama series. The material of the Sacramento soils of the middle San Joaquin Valley survey were recognized as being more closely identified with lake conditions and as being somewhat lighter in color and more calcareous than is typical of this series. In the later and present survey these characteristics become more marked and the soils are now recognized under the Tulare series.

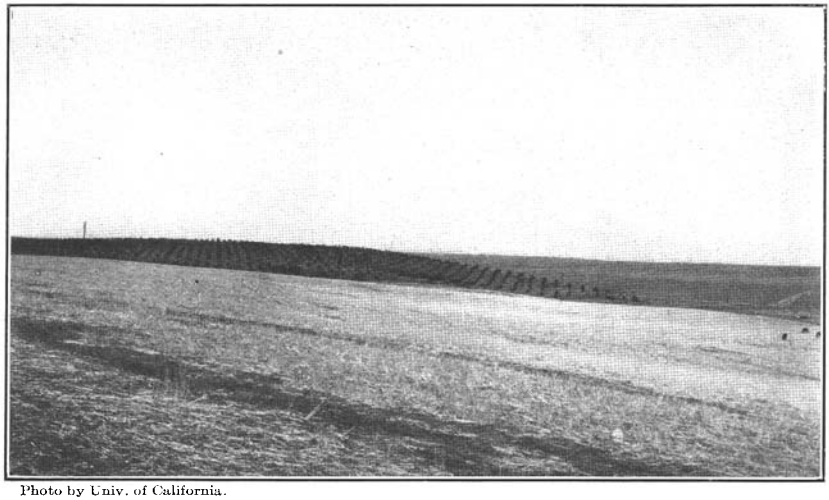

Photo by Univ. of California.

FIG. 1.—VIEW IN AREA OF THE DUCOR LOAM.

Dry farmed grain stubble in foreground and irrigated citrus orchards in the distance.

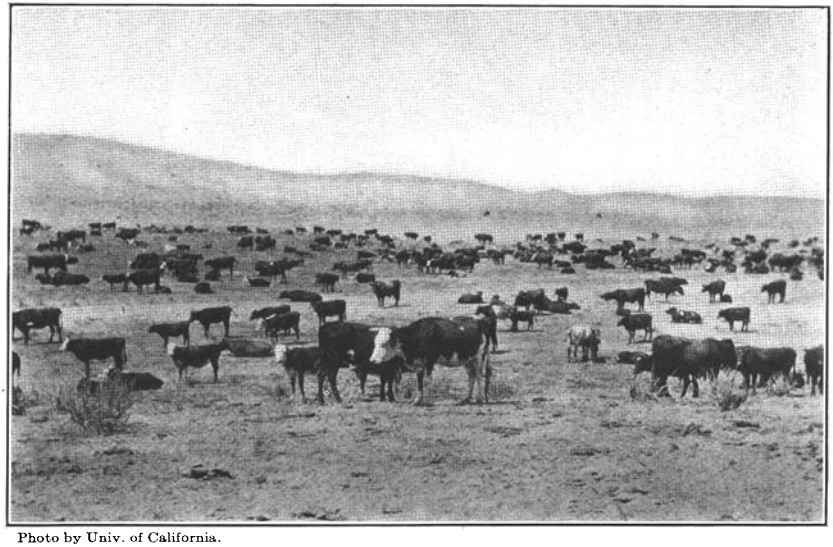

Photo by Univ. of California.

FIG. 2.—CATTLE ON WEST SIDE OF SAN JOAQUIN VALLEY.

The soils in this region consist mainly of types of the Kettleman and the Panoche series.

produced any profound effect in the soil profile. The soils of this group include the members of the Kettleman, San Joaquin, Mojave, Cuyama, Madera, Delano, and Fresno and Panoche series, the latter consisting of alluvial accumulations originating in arid areas.

On the east side of the valley lies a belt of country that is neither arid nor humid. It lies far enough toward the eastern mountain belt to receive more moisture than the arid valley floor and less than the humid mountain slopes. The soils are semiarid, or in some cases may be designated as subhumid. They are dark in surface color, with brown or reddish-brown upper subsoils and grayish lower subsoils in all excepting the heavier members, whose deep subsoils and substrata vary greatly according to the character of the parent rock. The surface and, in most cases, the greater part of the subsoil has been leached of its carbonates, but the deep subsoils and substrata contain concentrations of these substances. They have been developed under conditions of rainfall comparable to those obtaining in central Kansas and west central Oklahoma. To this group of soils belong the several members of the Porterville, Ducor, Olympic, Pond, and the heavier members of the Altamont series. The members of the Diablo series may be placed in this group, but in reality these soils have no true relative within the area, the lime carbonate occurring in their subsoils being apparently due to the nature of the parent rock rather than to the action of climatic forces. The soils of the Merced series could probably be included in this group.

The Foster, Chino, and Tulare soils are alluvial accumulations with high percentages of carbonates throughout the soil profile, and in the case of the Chino with a low concentration of other salts. They consist of material accumulated mainly from arid areas. The following descriptions of the soils of the area and the discussion of their capabilities are arranged according to the sources of the soil material and the processes by which it was accumulated in the localities where it is now found and where it has been developed by the prevailing climate into the soils of the region in the case of the older deposits, or is still but little changed from its original character as an accumulation of material by geological processes, as is the case with the recent alluvial deposits.

The soils of the Upper San Joaquin Valley area are grouped into five general classes or provinces, viz: (*a*) Residual soils, or those derived from the weathering of consolidated rocks in place; (*b*) old valley-filling soils, which are derived from old weathered and otherwise modified unconsolidated, water-laid deposits; (*c*) recent alluvial soils, or those derived from recent stream deposits that have undergone little, if any, change by weathering since they were laid down; (*d*) lake-laid soils; and (*e*) wind-laid soils, or those owing their accumulation to wind action.

The first three provinces include by far the greater part of the soils of the area. The residual soils predominate in the hilly and mountainous regions; the old valley-filling soils prevail along the valley margins in the form of extensive fans and foot slopes or elevated stream or marine terraces; and the recent alluvial soils form the lower parts of the valley floors or lie on the valley slopes influenced by recent stream deposits. The lake-laid soils are confined to the flat shallow basin of Tulare Lake, and the wind-laid soils, which cover but a small area, are developed in the southern part of the survey. By far the greater part of the area is composed of soils of the old valley-filling and recent alluvial group.

In addition to the five major groups described there are two miscellaneous groups: (*a*) Rough broken land and (*b*) Rough stony land. These are nonagricultural land and are extensively developed in the hilly and mountainous parts of the survey.

The soils of the several provinces are subdivided into smaller groups or series, each of which consists of types similar in origin, mode of formation, color, structure, and important mineralogical features, that distinguish them from the soils of all other series. The types of each series are distinguished by the one feature of texture or the proportions of particles of different sizes.

In detailed surveys the type is the unit of mapping, but in the more general reconnoissance work, of which the present survey is an example, it is not practicable to draw as fine distinctions, and in many cases a number of types are mapped together and shown in one color on the map. Usually these groups are made up of the soils in a single series, but in some instances it has been necessary to group the soils of different series.

There are in the area according to this classification, 22 series of soils including 42 types and groups of types, 1 subordinate phase, and 2 miscellaneous types of nonagricultural land.

Residual soils.—The residual soils of the area are identified with hilly or mountainous regions and are formed from the weathering in place of consolidated rocks. They usually have uneven and more or less dissected surfaces with bedrock frequently occurring at depths less than 6 feet and are typically well drained. They are generally associated with Rough broken land or Rough stony land and include some areas of rock outcrop. The soils which vary greatly in composition are derived in this survey from both sedimentary and igneous rocks.

The sedimentary rocks consist principally of calcareous shale with smaller areas of sandstone and conglomerate. They are very feebly consolidated in many places and some difficulty was experienced in distinguishing such areas from old valley-filling deposits. These rocks give rise to the residual soils in the western part of the survey and also those of the foothills flanking the lower margin of the

mountains forming the southern and eastern boundaries of the area. Three series—the Altamont, Diablo, and Kettleman—are derived from these sedimentary formations. Of these the Kettleman series is the most extensive. (Pl. III, fig. 1.)

The igneous rocks cover a much smaller area than those of sedimentary origin. The former occur on the lower slopes of the Sierras and the Tehachapi and San Emigdio Mountains. Granitic formations comprise more than 90 per cent of the igneous area. These rocks give rise to soils of the Holland series. The rocks break down mainly by exfoliation, and are in many places partly decomposed to considerable depths. Different degrees of resistance, however, cause them to weather irregularly, and there is present in the types more or less outcrop and fragmental rock. The contours of the hills are rounded and much like those formed of sedimentary rocks, except that the latter show less rock outcrop and have a more choppy topography in their rougher places.

Basic igneous rocks occur in the northeastern part of the area only. They also weather into rounded hills. Mainly heavy textured and adobe structured soils come from these rocks. They are classed with the Olympic series.

Old valley-filling soils.—The old valley-filling soils are derived from unconsolidated water-laid deposits that have suffered marked changes since their deposition through weathering, leaching, and the translocation of materials, resulting in more or less zonation, since their deposition. The deposits vary greatly in color, mineral composition, and other features, and they give rise to a number of different soil series. These soils, which are very extensive in the present survey, have been grouped in the San Joaquin, Placentia, Mohave, Cuyama, Madera, Delano, Porterville, Ducor, Fresno, Pond, and Merced series. The complexity of the old valley-filling materials is greater in this area than in any other area of equal size in the State.

Recent alluvial soils.—The recent alluvial soils, while representing the youngest soils of the area, vary considerably in age, ranging from the conditions existing in some of the less aged old valley-filling deposits to the conditions found in fresh accumulations still in process of accretion. The soils of this division are extensive, and members of four series have been identified and mapped. The recent alluvial soils are extensively developed on the broad plains on both sides of the valley trough, where they occupy broad, gently sloping alluvial fans and stream bottoms. The materials forming them are mainly sedimentary or mainly granitic, depending upon the character of the rock formations in the drainage basin of the streams that have transported and deposited them. The soils have been classed in the Panoche, Hanford, Foster, and Chino series.

Lake-laid soils.—The soils of the lake-laid province in the area consist of deposits, mainly of fine texture, that have been laid down in lakes of fluctuating volume, and recently exposed either by natural recession of the waters or through reclamation works. They are most closely associated with the recent alluvial soils with which they merge gradually. They occupy low, flat basins of poorly developed drainage. The soils are classed in the Tulare series.

Wind-laid soils.—The soils of the wind-laid group occupy low, undulating ridges and hummocks which in places closely resemble sand dunes. The material, which has been accumulated through the action of the wind, has come from the adjacent light-textured alluvial soils. It consists mainly of sand. The soil has been classified with the Oakley series.

Miscellaneous materials.—The types Rough broken land and Rough stony land, which are nonagricultural, consist of soils of the various residual and old valley-filling materials, no attempt being made at classification owing to their lack of value for farming. This will be discussed in sufficient detail under their individual heads.

The following table gives the name and actual and relative extent of the several types or type groups of soil in the Upper San Joaquin Valley:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Panoche loams	437,056	13.3	Ducor loam	32,256	1.0
Rough broken land	384,512	11.7	Chino and Foster loams, undifferentiated	29,312	.9
Hanford sandy loams	313,088	9.5	Hanford and Foster sandy loams, undifferentiated	23,744	.7
Panoche sandy loams	254,272	8.7	Fresno clay loam	23,232	.7
High phase	28,864		Ducor adobe soils	20,352	.6
Delano sands and sandy loams	219,072	6.7	San Joaquin loam	18,048	.6
Kettleman sandy loams	165,504	5.0	San Joaquin sandy loams	17,536	.5
Altamont loam and clay loam	148,480	4.5	Madera sandy loams	17,408	.5
Pond loams	145,920	4.5	Oakley sands	15,872	.5
Merced clay loams	102,784	3.1	Mohave sandy loams	15,232	.5
Rough stony land	72,704	2.2	Foster sandy loams	14,912	.5
Tulare sandy loams and sands	66,560	2.0	Hanford loams	14,336	.4
Kettleman loam and clay loam	62,400	1.9	San Joaquin and Madera sandy loams, undifferentiated	11,904	.4
Holland sandy loams	59,968	1.8	Porterville adobe soils	10,880	.3
Panoche loam and clay loam, high phase	58,368	1.8	Altamont and Diablo loams and clay loams, undifferentiated	10,496	.3
Pond sandy loams	56,192	1.7	Panoche clay loam	10,048	.3
Pond clay loam	50,304	1.5	Tulare clay	8,128	.3
Tulare clay loam	50,112	1.5	Placentia loam and sandy loam	7,808	.2
Altamont sandy loams	47,296	1.5	Olympic adobe soils	7,168	.2
Hanford sands	46,656	1.4	Madera loam	6,400	.2
Delano loam	44,288	1.4			
Tulare loam	43,904	1.3	Total	3,283,200	.....
Merced loams	38,528	1.2			
Cuyama sandy loams and loam	36,864	1.1			
Fresno loam	34,432	1.1			

Description of Soil Series and Types.

RESIDUAL SOILS.

Altamont Series.

The surface soils of the Altamont series are brown in color, ranging from light brown to dark brown. They contain a moderate amount of organic matter, but seldom show the presence of free lime. The subsoils are brown to reddish brown and are normally of lighter color and somewhat more compact and heavier in texture than the surface soils. Concentrations of lime are frequently present in the subsoil but not as generally as in the subsoils of the Diablo series. The soils of this series are derived from the weathering in place of interbedded sandstones, shales, and conglomerates. Bedrock is usually encountered at depths of less than 6 feet. The series occupies gentle slopes, rolling areas, and mountainous positions. The surface is usually smooth and rock outcrop is not common. Drainage is good to excessive and no alkali is present. The soils differ from those of the Diablo series in their lighter color and lower lime content, and from the Kettleman series in their darker color and in distribution of lime in the soil profile. The series is represented in this survey by a group of sandy loams, and by one of loam and clay loam.

ALTAMONT SANDY LOAMS.

The Altamont sandy loams group includes the fine sandy loam and the sandy loam members of the series the former covering 75 per cent or more of the group area. The total area of the group is between 60 and 70 square miles.

Description.—The surface soil of the Altamont fine sandy loam consists of light-brown, brown, grayish-brown and in places rather dark brown friable sandy loam, varying in depth from 12 to 18 inches. The soil is low in organic matter. It is ordinarily easy to till and retentive of moisture when well handled. The subsoil ranges from a light-brown to a grayish-brown or slightly reddish brown, somewhat compact fine sandy loam or light loam. Generally there is no great difference in texture between surface soil and subsoil, but locally the latter is slightly heavier. Gravel and small shale fragments are present locally in small amounts, but they seldom interfere with tillage. Shale and sandstone bedrock is generally encountered within the 6-foot profile where the soil is typically developed, but in this area it lies somewhat deeper, in many places 8 to 10 feet below the surface. In places where the bedrock consists of rather feebly cemented material it has weathered deeply, but where it is indurated it may occur within a few inches of the surface. A small amount of lime is present in the subsoil in places, but it is not indicated by tests with dilute acid over much of the group.

The sandy loam differs but little from the fine sandy loam except in texture. The two types merge and are so intimately mixed in their occurrence that differentiation was not practicable in this survey. The fine sandy loam sometimes contains a little more organic matter and is considered a little more desirable in places for dry farming than the sandy loam, owing largely to its slightly greater power to hold moisture.

The soils of this group resemble the grayish soils of the Kettleman series, and in places include small areas of the latter. It also contains small remnants of old unconsolidated water-laid deposits properly referred to the old valley-filling soils. The soils vary in texture considerably and include local spots of sand and loam. In many places where they merge with old valley-filling soils the boundary is indistinct. Areas of Rough stony land too small to warrant separation are also mapped with this group.

Location.—The group is extensively developed in the hills several miles north of Bakersfield and occurs in two smaller areas in the foothills of the Caliente Mountains southeast of Soda Lake.

Topography and drainage.—The group has a rolling or hilly topography, the hills being rounded and smooth, with very little irregularity due to rock outcrop or erosion. The surface is moderately to steeply sloping and the rougher parts merge with Rough broken land. The soils are well drained, and on the steepest slopes, on the shallow areas of the hilltops, and on western and southern exposures are inclined to be somewhat droughty.

Utilization.—These soils are of little value for farming on account of the low rainfall. They are utilized almost entirely for pasture and support a fair growth of grass in favorable seasons. A small acreage of dry-farmed grain is grown, but the yields are normally low because of insufficient moisture. Water for irrigation is not available, and pasturage will likely remain their chief use for some time to come.

ALTAMONT LOAM AND CLAY LOAM.

The Altamont loam and clay loam group includes the loam and clay loam types of the series. It is one of the more important groups of residual soils, covering an area of about 250 square miles, 85 per cent of which consists of the loam.

Description.—The surface soil of the Altamont loam consists of a brown, grayish-brown, or dark-brown, rather friable loam ranging in depth from about 12 to 20 inches. The darker shades of brown occur on the more gentle slopes and on the north and east sides of hills, which are less exposed to the direct rays of the sun, while the lighter shades prevail where the soils are shallow, which condition is most prevalent on steep hills and ridge crests. The dark-colored

parts contain a moderate supply of organic matter, while the others are usually low in this constituent. The texture varies greatly within short distances and is usually lightest where the soil is shallow. Varying amounts of gravel and small shale fragments are present in places, but seldom in sufficient quantities seriously to interfere with tillage. No distinctive subsoil occurs in some of the shallowest phases, the material remaining uniform to the underlying bedrock. Elsewhere it consists of a light-brown, grayish-brown, or slightly reddish brown somewhat compact loam or clay loam containing locally small concentrations of lime. The subsoil is readily permeable by roots, and where it is deep forms a very favorable zone for their development. Bedrock is usually encountered at depths of less than 6 feet, but it may occur a few inches below the surface or may lie at a depth of 8 or 10 feet. In the areas of shallow soils the rock is harder and more resistant to weathering and occasional outcrops give rise to very stony or gravelly soils. The upper foot or more of the bedrock is more or less decomposed, but in places the subsoil rests directly upon the unaltered rock. Wherever the soil is deep, it is quite retentive of moisture, but the shallow areas lose their moisture quickly during dry periods and soon become dry and hard. The type is easily tilled except for the unevenness of its topography.

The clay loam member occurs in small scattered bodies in association with the loam and resembles it except in texture and greater average depth of soil and subsoil material. It is also somewhat less friable and on the average slightly darker in color, and in some of the areas tends toward an adobe structure.

The soils are typical over most of their extent, but local variations occur. They include small bodies of Diablo clay loam and of the old valley-filling soils, such as the Cuyama loam. Some of the steeper parts include small areas of Rough broken land and frequently merge in their highest positions with extensive areas of the latter.

Location.—Several large areas of this group are developed in the Temblor and Caliente Mountains bordering the Carrizo Plain, and several of small size lie along the western boundary of the area, and on the foothills between San Emigdio Creek and Tejon Creek. Several large areas also occur in the rolling hilly region northeast of Bakersfield, and a few others of less importance are found in the Cuyama Valley and in the hilly region west of McKittrick.

Topography and drainage.—The group has a varied topography, the surface ranging from hilly to mountainous. Some of the hills have moderate to gentle slopes. In places erosion has been very active and has furrowed the surface deeply, causing the formation of many deep gullies or ravines and small valleys. Drainage is good on the more gentle slopes and on the steeper parts is excessive, causing much

of the rainfall to be lost. Where not too steep or eroded the surface is rounding and smooth and well adapted to agriculture.

Utilization.—Nearly all of the group is utilized as pasture land, the low rainfall making dry-farmed crops uncertain. On some of the higher lying bodies in the Temblor Mountains, where the rainfall is somewhat greater, the soils are used for grain growing, with moderate yields. In some situations the land might be profitably used for production of grain and grain hay, provided the best methods of farming were followed. Irrigation is practically out of the question for these soils, owing to unfavorable topography and lack of water supply. Most of the land is held in large tracts. Some producing oil wells are situated on the soils of the group northeast of Bakersfield and in a few other localities along the western slopes of the Temblor Mountains.

Diablo Series.

The surface soils of the Diablo series are dark gray to black. They are in many places slightly calcareous and contain a more abundant supply of organic matter than the soils of the Altamont series. The subsoils are dark gray to brown and generally highly calcareous, the lime being concentrated in seams or veins and thin layers. The series is derived from calcareous shales and sandstones and impure limestones. Bedrock occurs at variable depths, in places below 6 feet, but in places lies near the surface or outcrops. Both surface and subsoil are normally of heavy texture and compact structure. The topography ranges from gently rolling to steep and hilly, and the drainage good.

Altamont and Diablo loams and clay loams, undifferentiated.

The group, Altamont and Diablo loams and clay loams, undifferentiated, includes the loam and clay loam types of each of these series. The Altamont loam covers about 50 per cent of the total area, which is about 15 square miles.

Description.—The Altamont loam and clay loam have already been described in the discussion of the Altamont loam and clay loam group. The soils are typically developed in the present group and require no further consideration.

The Diablo loam, which is of small extent, consists of a dark-gray to black rather friable loam high in organic matter. It is retentive of moisture and is not difficult to till when in proper condition. Small quantities of lime are present in the soil and some gritty material and shale fragments occur locally. The soil is darker in color, more retentive of moisture, and forms the better seed bed where it has the greater depth. The subsoil below 12 or 15 inches

is a dark-grayish or brownish loam or clay loam. It rests upon shale or sandstone bedrock at depths ordinarily less than 6 feet. In places the surface soil rests directly upon the bedrock which in such cases lies near the surface. On the more gentle slopes, where small amounts of alluvial material may have been deposited, the bedrock may lie below 7 feet. Varying quantities of lime are present in the subsoil, appearing in seams and layers.

The Diablo clay loam in most places contains more organic matter, and is darker in color and deeper than the Diablo loam. It also in places tends toward an adobe structure. It is confined chiefly to the lower and more gentle hill slopes. It is somewhat more difficult to till than the loam.

The soils of the group are variable in character and are so mingled in their occurrence that it was not practicable to map them separately on a map of the scale used in this survey.

Location.—Two areas of this group of soils occur. One of these lies in the foothills of the Temblor Mountains about 5 miles west of McKittrick, and the other in the Caliente Mountains about 10 miles south of Simmler.

Topography and drainage.—The topography of the soils of this group ranges from rolling to hilly. The surface is smooth and but few obstructions to tillage exist. The drainage is good throughout the areas.

Utilization.—Only a small part of the soils of this group is utilized for crop production, and dry-farmed grain and grain hay are the only crops grown. Where good care is given the soil fair yields are obtained. Most of the land is owned in large tracts and is devoted to pasture. The Diablo soils seem better adapted to native legumes than the lighter colored soils. Most of the soils of this group are remote from railroads and towns and have no irrigation possibilities, which give them a relatively low market value.

Kettleman Series.

The Kettleman series of soils is residual from sedimentary rocks, chiefly shales and sandstones. The soils are gray or brownish gray in color, low in organic matter, and ordinarily contain enough lime to effervesce with acid. The subsoil is gray or grayish brown and similar to or slightly heavier than the surface soil. It is calcareous, lime in many places occurring in concentrations, giving a gray mottled appearance to the material. The subsoil commonly rests upon soft shale and sandstone at depths less than 6 feet. The soil material is typically shallow, the bedrock lying so near the surface that little or no vegetation can gain a foothold. Small areas of rock outcrop occur in places, ordinarily appearing in escarpment faces and on the

slopes of ravines. The series occupies rolling, hilly, or mountainous areas. Drainage is good to excessive, and much water is lost as run-off. Small deposits of alkali coming from the underlying shale are present locally on the lower slopes. The soils differ from those of the Altamont series of similar origin in their lighter color and in being more calcareous.

A sandy loam group and a loam and clay loam group of this series are shown on the soil map.

KETTLEMAN SANDY LOAMS.

The Kettleman sandy loam group includes the fine sandy loam, sandy loam, and gravelly sandy loam types of the series. Of these the fine sandy loam is the most extensive, covering about 75 per cent of the combined area of approximately 250 square miles.

Description.—The surface soil of the Kettleman fine sandy loam consists of a gray or light brownish gray, loose, friable fine sandy loam with a depth of 6 to 18 inches. It is low in organic matter and incoherent in structure and is in places modified by wind action. Small quantities of gravel, consisting principally of shale fragments, are present locally. The texture is variable, closely approaching fine sand in places and loam in others. The soil contains small to moderate amounts of lime. It absorbs and retains moisture well. Distinct differences between surface soil and subsoil are comparatively rare, but in the deeper and more typical areas the subsoil is a light grayish brown or gray friable fine sandy loam or loam. It is generally somewhat more calcareous than the surface soil, though in many places the lime is evenly distributed throughout the soil column. Bedrock typically occurs at depths less than 6 feet and rarely below that depth. In places where the bedrock is near the surface there is no distinctive subsoil. Some areas of deep soil have resulted from accumulation of alluvial wash upon the surface. Here the character of the material has suffered some modification.

The sandy loam member is much less extensive than the fine sandy loam. Except for texture and a somewhat greater tendency to drought, it resembles the fine sandy loam.

The gravelly sandy loam is also small in extent, being confined to the steeper hills where the bedrock outcrops or is near the surface. The soil is seldom more than 12 inches deep and a large proportion of it consists of small angular shale fragments. A subsoil is seldom developed, owing to the nearness of bedrock to the surface, but where present it resembles the surface soil. This type is the most droughty and least desirable member of the group. Much of its surface is wind swept and barren of vegetation. On the steeper slopes small areas of loose sliding shale fragments exist. The type also includes

small areas too rough and steep for tillage, and higher lying parts merge in many places with Rough broken land.

The group includes a number of patches and small valleys in which the soils are the Panoche sandy loam, Panoche loam, Cuyama sandy loam, and Altamont loam and clay loam.

Location.—Extensive areas of the Kettleman sandy loam occur in the hills along the east and west sides of the Kettleman Plain and also east and southeast of McKittrick. A rather extensive tract covers the Lost Hills, and others of considerable size occur in the hills south and east of Taft. A number of areas lie south and southeast of Maricopa and in the foothills east and southeast of Bakersfield. Many of the most productive oil fields of the State are situated in that part of the group along the eastern base of the Temblor Mountains and in the Lost Hills.

Topography and drainage.—The soils of this group occupy rolling hilly or mountainous topography and include a number of small, narrow valleys and rounded anticlinal ridges. Ravines occur at intervals and in some places give the surface a dissected, broken appearance, but these irregularities are not a serious handicap to tillage. There are places where the underlying bedrock is so feebly cemented and is so deeply weathered that it is difficult to distinguish the soils from those derived from old valley-filling material. Drainage is well developed over the deeper soils of the group and excessive where they are shallow.

Utilization.—The Kettleman sandy loams are practically worthless for crop production on account of the low rainfall in those parts of the area where they occur. Much of their area has been taken in the development of the petroleum industry and the rest is utilized for pasture, which at best is scanty. Most of the land is held in large tracts, and because of its droughty condition and the low rainfall has a low market value. Drinking water is almost unobtainable on the group and cattle must frequently travel many miles to obtain it. Water for irrigation is not available.

KETTLEMAN LOAM AND CLAY LOAM.

The Kettleman loam and clay loam group includes the loam, clay loam, and small bodies of the gravelly loam of the series. The entire group covers an area of about 100 square miles, about 75 per cent of which is occupied by soil of the loam type.

Description.—The surface soil of the Kettleman loam consists of a gray or light grayish brown, rather compact, medium to light textured loam. It is low in organic matter and ordinarily shallow, having a depth of only a few inches to about 1 foot. Its structure approaches that of an adobe soil in its heavier phases, more or less

checking occurring when the soil is dry. Small quantities of shale and quartzite fragments are present locally, especially in the hilly areas west of the Kettleman Plain. The soil in these stony areas is shallow, droughty, and in many places barren of vegetation. The surface soil rests directly on the partly weathered shale in many places, but in the deeper and more typical areas there appears below 8 or 10 inches a subsoil consisting of a light-brown or gray loam or clay loam. Bedrock is usually encountered at depths less than 6 feet, but it may lie at or within a few inches of the surface, and, on the other hand, may lie as deep as 7 feet or more. Both surface soil and subsoil are calcareous, but somewhat greater concentrations occur in the latter. The type includes small areas of the Kettleman sandy loam and gravelly loam, and when it occurs near soils of the Altamont series it becomes somewhat darker in color and to some extent resembles those soils.

The clay loam member is heavier in texture, has a more compact and adobelike structure, and greater depth than the loam. It includes small bodies of the Kettleman clay and mingles with the loam type of this series throughout its entire extent. It is somewhat more difficult to till than the loam, but in other respects accords with the description given for that type.

The group includes near its lower boundary a number of small areas of old valley-filling soils and recent alluvial deposits. Its great variation in texture and topographic features is mainly due to variation in the fineness of materials forming the parent rocks and to their resistance to weathering.

Location.—The soils of the group are associated with the sandy loams of the same series and normally lie at higher elevations. The most extensive areas occur in the hills on both sides of the Kettleman Plain, and a large number of smaller ones occupy the eastern slopes of the Temblor Mountains extending southward to a point several miles below McKittrick. Several still smaller ones occur in the foothills in the southern part of the survey.

Topography and drainage.—The soils of this group have a varied topography, the surface features ranging from rather gently sloping rounded ridges and hills to more or less dissected mountains. Ravines and small narrow valleys are numerous and steep broken escarpments and small roughly dissected areas are scattered over its rougher phases. Drainage is well developed and in areas of the shallow soil is excessive.

Utilization.—These soils support a scanty growth of grass in favorable localities, but many of the shallow and extremely heavy textured parts are wind swept and barren of vegetation. Land is usually held in large tracts and used only as pasture, for which, owing to the low rainfall, it has comparatively little value.

Water for drinking purposes is seldom available and irrigation from local sources is out of the question.

Holland Series.

The soils of the Holland series are residual in origin, being derived in place through the weathering of granite rocks. The surface soils are brown or grayish brown in color and contain little or at best only moderate quantities of organic matter. They normally are micaceous. The subsoils, which are brown or reddish brown in color, are somewhat more compact and heavier in texture than the surface soils. Bedrock is usually encountered at depths less than 6 feet. Accumulations of lime are seldom present in the surface soil or subsoil. The soils occupy gently rolling or mountainous positions and have a uniform surface except where broken by rock outcrops. Drainage is good and the soils are free from alkali. The series differs from the Olympic series in color, organic matter content, and in derivation. The soils which lie above the old valley-filling deposits are associated with Rough broken land or Rough stony land. One group including sandy loams is mapped.

Holland sandy loams.

The Holland sandy loams group includes the sandy loam, fine sandy loam, loam, and coarse sandy loam of the series. The sandy loam and fine sandy loam, the two most important types, have about an equal area and together cover a little less than 100 square miles.

Description.—The surface soil of the Holland sandy loam, where typically developed, consists of a brown, light-brown, or grayish-brown rather coarse, gritty, micaceous sandy loam. The soil is moderately friable, rather low in organic matter, and is easily tilled except where rock outcrops and stones interfere. Where the soil material is deep it is retentive of moisture, but where it is shallow it dries out quickly and, in places, becomes baked and hard. Much of the soil in this survey is darker in color than usual and in places is dark brown. Varying amounts of small angular quartz particles of the size of fine gravel and coarse sand are present over most of the type, the quantity depending largely upon the texture of the parent rock. Small rock fragments and bowlders are also scattered through the soil locally, being more numerous in the vicinity of rock outcrops.

The underlying parent granite frequently outcrops and on some of the steeper slopes and higher elevations is excessive, the type merging with Rough stony land. The surface soil remains uniform to underlying bedrock in places, but generally at depths below 12 to 36 inches is underlain by a subsoil of grayish-brown, yellowish-brown,

or reddish-brown sandy loam, somewhat more compact and, in places, slightly heavier in texture than the surface soil. Bedrock is usually encountered at depths less than 6 feet, but it may occur at any depth between the surface and 7 or 8 feet. The underlying granitic rock is in many places sufficiently weathered to a depth of several feet to permit of root penetration. In most places this zone resembles the unaltered rock, except that it has become partly disintegrated.

The Holland fine sandy loam closely resembles sandy loam except in texture. The fine sandy loam averages a little darker than the sandy loam and is usually associated with rocks of somewhat finer texture.

The small areas of loam and coarse sandy loam vary from the above soils only in texture. The group includes also small tracts of reddish-brown Sierra sandy loam and a number of dark-gray or dark brownish gray areas of Sheridan loam and sandy loam (soils mapped in other parts of the State), which, with the presence of varying quantities of coarse grit in places, give the soils of the group a somewhat variable appearance in the field.

Location.—The group is confined to the east side of the San Joaquin Valley, and is most extensively developed in a large tract extending from a point in the foothills east of Terra Bella southward for more than 20 miles. In addition to this there are small irregular areas in the foothills from Caliente Creek southward to the point where the State highway enters the mountains south of Bakersfield.

Topography and drainage.—The soils of this group possess a rolling, hilly, or mountainous topography. The steeper parts contain more rock outcrop and in many places merge with areas of Rough stony land on the east. The surface is rounded and smooth. Drainage is good and areas of shallow soil are inclined to be droughty. The soils of the lower slopes merge with lower lying old valley-filling soils and include varying quantities of alluvial material.

Utilization.—Most of the soils of this group lie too high for irrigation and are utilized principally as pasture land. Some of the better areas are tilled to dry-farmed grain of which moderate yields are obtained in favorable seasons.

Olympic Series.

Soils of the Olympic series are residual, being derived from the weathering of basic igneous rocks in place. The surface soils are brown or dark brown in color, the darker colors being associated with the heavier textures. They are moderately well supplied with organic matter and are practically free from concentrations of lime. The subsoil is brown, grayish brown or reddish brown and similar to or heavier in texture than the surface soil. Bedrock is in most

places encountered at depths less than 6 feet and some rock outcrop occurs. Lime is generally present in varying amounts in the subsoil. The series occupies hilly or mountainous country but has a smooth uniform surface where free from rock outcrops or stones. The soils are well drained and free from alkali.

A single group of adobe soils represent the Olympic series in this survey.

OLYMPIC ADOBE SOILS.

The Olympic adobe soils include the clay adobe and the clay loam adobe of the series which are so intermingled in their occurrence and of such small area that differentiation was not feasible in this survey. The variation in texture depends principally upon the composition of the parent rock. The two types of soil have about the same extent.

Description.—The surface soil of the Olympic clay adobe consists of a brown or dark-brown heavy-textured clay of pronounced adobe structure, the soil cracking badly when dry and becoming very refractory and hard in untilled fields. When wet the cracks close up and if good cultivation is practiced a favorable granular tilth that prevents the soil from checking and gives it the properties of an excellent seed bed is easily maintained. The soil contains a moderate amount of organic matter and a small admixture of angular stones and some rock outcrop are present in places. The stony and gravelly areas and those of steepest slope are usually associated with the shallowest soils and frequently border areas of Rough stony land. The surface soil sometimes extends to bedrock without distinct change but in the more typical areas a subsoil occurs at 12 to 36 inches below the surface. This consists of a brown, light-brown, or reddish-brown clay loam or clay. It is sometimes lighter in texture than the surface material. On the more gentle slopes and in slight swales, bedrock may lie below 6 feet. The areas of shallowest soil are inclined to be droughty and are often slightly lighter in color than areas of greater depth. As occurring in this survey small to moderate quantities of lime are usually present in the subsoil, the proportion depending upon the depth of soil, composition of the parent rock, and weathering conditions. A small admixture of alluvial and colluvial material has taken place in the lower lying positions, owing to erosion of soils of similar character lying at greater elevations.

The clay loam adobe member of the group resembles the clay adobe in nearly all respects except texture. It is not clearly defined in many places, and the two types commingle over most of their extent. The clay loam adobe is not quite as difficult to till as the clay adobe, and is usually somewhat more desirable for crop produc-

tion because of its lighter texture and somewhat more friable structure.

The soils of this group are fairly uniform, but in a few places the color is reddish and approaches that of the related Aiken series. In areas where the soil is deeper and older the color frequently is darker and resembles the black soils of the Climax series (mapped elsewhere in the State). The amount of alluvial material present increases toward the base of the slopes, and in places the group gradually merges with old valley-filling soils of the Porterville series.

Location.—The group covers an area of approximately 11.2 square miles. It occurs in two bodies, the larger situated in the extreme northeastern part of the area, and the other along White River southeast of Ducor.

Topography and drainage.—The soils occupy hilly or mountainous areas with moderately to steeply sloping surfaces marked by ravines and by somewhat dissected areas. Excepting the rougher or eroded areas, irregularity of surface seldom interferes seriously with tillage, but caution is necessary in irrigating to prevent gullying of the soil. Only the lower slopes can be profitably irrigated under existing conditions, because of the excessive lift in raising water to the higher elevations. The soils of the group are well drained. A considerable part of the rainfall is lost in the run-off on the steeper slopes.

Utilization.—Where irrigation water is available soils of the group are utilized for the growing of citrus fruits, their elevated position making them relatively free from frosts. Only a small proportion of these soils are, however, farmed in this area, though they are quite extensively used for fruit culture in the adjoining area to the north. Water is obtained by pumping from the underground sources in the lower lying alluvial soils. Grass makes a fair growth in favorable seasons, and the soils are used mainly for pasture. The soils are naturally productive and their chief requirements for good crops are proper cultural and irrigation methods.

OLD VALLEY-FILLING SOILS.

San Joaquin Series.

The soils of the San Joaquin series consist of old weathered and modified, unconsolidated water-laid deposits, derived from a wide range of rocks. The surface soils are reddish brown or red in color and low in organic matter. The subsoil is reddish brown or red and more compact and typically heavier than the surface material. At depths usually less than 6 feet the subsoil rests upon an indurated red or reddish-brown iron cemented hardpan. The substratum below the hardpan is usually more permeable than the overlying subsoil and is

partly stratified in places. Concentrations of lime are not common within the 6-foot profile. The series is free from alkali and is regionally well drained, but subdrainage is restricted and the soils become boggy in wet weather owing to the accumulation of water above the hardpan. The series occupies gently sloping or undulating valley plains, and the surface is usually marked by low broad hummocks, with intervening depressions in which water accumulates in wet weather. The soils differ from those of the Madera series in the more pronounced reddish color and a lower lime content and from the Placentia series in the occurrence of hardpan. The series is represented in this survey by a group of sandy loams, by the loam, and also by a group of undifferentiated San Joaquin and Madera sandy loams.

SAN JOAQUIN SANDY LOAMS.

The group San Joaquin sandy loams includes the sandy loam and fine sandy loam types of the series. The group covers an area of about 27.4 square miles, which is about equally divided between the two types.

Description.—The surface soil of the San Joaquin sandy loam consists of a reddish-brown or red, heavy textured, gritty sandy loam, somewhat sticky when wet, and containing organic matter. It becomes hard upon drying where untilled, but under proper moisture and cultural conditions forms a fair seed bed. Small shallow depressions in the type contain a somewhat darker soil of loam texture. On the hummocks characterizing this type the soil is generally deeper and better aerated, owing to better drainage, while the depressions are frequently covered with water during wet weather, making the soil boggy and puddled, causing it to bake hard upon drying. At a depth of about 18 or 20 inches the surface soil grades into a more compact, reddish-brown or red loam or clay loam subsoil which overlies a dense and relatively impervious brown or reddish-brown hardpan at 20 to 36 inches. The hardpan varies in thickness from several inches to 2 feet or more, and greatly retards the movement of water and growth of roots. The substratum beneath the hardpan is typically friable and favorable for root development when the hardpan is shattered by blasting.

This type is not as typically developed in this survey as in areas farther north, and the hardpan is usually not so thick or so well developed. In an area several miles north of Terra Bella the surface soil is browner in color than typical, the soil material is deeper and the hardpan less well defined.

The fine sandy loam member differs very little from the sandy loam except in texture. The finer textured type contains less grit, and it

includes areas of heavy texture which are generally somewhat darker in color and higher in silt and organic matter than the average.

The group includes also small areas of the browner Madera sandy loams and local patches of hardpan free soils of the Mohave series.

Location.—The soils of this group are not very extensive in this area, being confined to three tracts located near Jasmine and north of Terra Bella. In many instances the change from these soils to other associated types is so gradual that the boundaries have to be placed arbitrarily.

Topography and drainage.—The soils occur upon extensive gently sloping plains, the regional drainage of which is generally well developed. The surface is marked by "hog wallows" formed by rounded hummocks a foot or more high, with small intervening depressions. The drainage is imperfect, owing to the obstruction of downward movement of water by the underlying hardpan, and the general flatness of the plain and the uneven surface. Water is obtained from wells of considerable depth, and pumping for irrigation is usually too expensive to be practicable in growing any but the intensive crops of high acreage value.

Utilization.—Most of the group is utilized for the production of dry-farmed grain. A relatively small area is devoted to the growing of citrus fruits under irrigation. Grain yields moderately well in favorable years, and citrus fruits are successfully grown where the hardpan is broken and good cultural methods employed. Grapes and olives also do well in favorable localities when irrigated. Where grain farming is carried on summer fallowing in alternate years is practiced.

The soils respond to applications of organic matter such as stable manure or cover crops and to commercial fertilizers where citrus fruits are grown. Most of the soil areas are favorably located, and upon these the growing of intensive crops under irrigation is gradually being extended.

SAN JOAQUIN LOAM.

Description.—The surface soil of the San Joaquin loam consists of a reddish-brown or red, sticky, compact, heavy loam, usually containing some gritty material, low in organic matter, and having a depth of 12 to 24 inches. The texture is lightest on hummocks occurring in this and other soils of the series, and while it is not as friable as the lighter textured types, it nevertheless works into a friable seed bed under favorable conditions of moisture content and cultivation.

The subsoil varies in texture from loam to clay loam and in most cases is more compact and redder than the soil. At depths ranging from 2½ to 4 feet it rests upon a hard, reddish-brown to red firmly indurated hardpan, consisting of cemented sand, silt, and gravel, and

showing the same variation in thickness as in the soils of the preceding group. The hardpan greatly retards the downward movement of water and the development of roots, and in planting fruit trees or other deep-rooted crops is usually blasted. The substratum consists of a reddish or reddish-brown loam or clay loam.

This type varies locally in color, texture, and hardpan features, and in places includes small bodies of the Mohave loam and sandy loam and of the Ducor adobe soils. Areas of heavier or lighter texture also occur near the margin of the type, the amount of variation depending upon the nature of the adjacent soil bodies. The greatest variation occurs in the vicinity of Ducor, where small narrow areas mingle with soils of the Ducor series. In the areas east of Ducor the typical hardpan is displaced by cemented gravelly beds containing some lime.

Location.—The type covers an area of 28.2 square miles, principally in the vicinity of Ducor and west and southwest of Terra Bella. Another small area lies several miles northeast of Jasmine.

Topography and drainage.—The type occurs on very gently sloping old alluvial fans, which have been somewhat modified by erosion in places, as in the areas south and east of Ducor. Here the surface, which is undulating and quite uneven in places, is not typical. Hummocks with intervening minor depressions are general over the type, causing a somewhat defective surface drainage. The water table is deep, and aside from the effect of the impervious hardpan in arresting percolation, the subdrainage is good.

Utilization.—The greater part of the type still produces grain by dry-farming methods, the yields of which vary with climatic conditions. Citrus fruits are grown in the immediate vicinities of Ducor and Terra Bella, but the acreage is not large. For these plantings the hardpan is usually broken by blasting, in order to give the roots and water an opportunity to descend into the favorable subsoils below. These fruits, olives, and grapes do well with irrigation, and, where protected from injury by frosts, give moderately good yields. The application of organic matter and the use of cover crops are beneficial and increase the yields greatly where irrigation is practiced. A considerable expense is necessary in leveling the surface before irrigation is possible. The type is well located and is gradually being more extensively utilized for fruits and other intensive crops. Water for irrigation is obtained in most places by pumping from underground supplies.

SAN JOAQUIN AND MADERA SANDY LOAMS, UNDIFFERENTIATED.

The group San Joaquin and Madera sandy loams, undifferentiated, includes the San Joaquin sandy loam and fine sandy loam, and the

Madera sandy loam and fine sandy loam types. In this group the several types are so intermingled that separation was not feasible in this survey. The group covers an area of almost 12,000 acres, in which the sandy loams of each series are about equally extensive and include 75 per cent of the entire area.

Each of the soils is described in detail in other parts of this report.[5]

Besides these soils the group includes small areas of hardpan-free soils of the Delano and Ducor series.

Location.—The soils of this group are inextensive, occurring only in one area in the vicinity and to the west of Ducor. The soils pass gradually into other types and the boundaries are placed more or less arbitrarily.

Topography and drainage.—The soils of this group occupy a part of an old alluvial fan now slowly undergoing erosion. The surface is mostly hummocky and requires leveling for irrigation. Small shallow stream channels carry off part of the surface water; some remains during periods of wet weather in the depressions. The water table lies at considerable depths below the surface, giving good subdrainage except where the hardpan retards percolation.

Utilization.—Most of the area of this group is used for the production of dry-farmed grain. The yields depend upon the rainfall and the care given the land. Parts of the group in the vicinity of Ducor are being used for citrus and other fruits, in most cases the hardpan being shattered by blasting to allow water and roots to enter the deeper subsoil and substratum. Where this is not done the growth of the trees is slow and uncertain. Commercial fertilizer is used in growing citrus fruits and increases the yields. The application of organic matter is also beneficial, especially where irrigation is practiced.

Placentia Series.

The soils of the Placentia series are derived from old modified unconsolidated water-laid deposits having their source mainly in granitic rocks. The surface soils are reddish brown or red in color, a variation of dark reddish brown color occurring in this area. They are low in organic-matter content and do not effervesce with acid. The subsoils are reddish brown to red and are more compact and heavier textured than the surface soil. The lower subsoil and substratum are lighter textured and more permeable than the upper subsoil and are yellowish brown or reddish brown in color. Lime seldom appears in concentrations in the subsoil, although small quantities are present according to field tests with acid. The series has a smooth or hummocky surface and occupies gently or moderately

[5] See p. 49 for San Joaquin sandy loams, and p. 58 for Madera sandy loams.

sloping old eroded alluvial fans and moderately rolling areas in the more elevated marginal valley plains. The soils of this series are distinguished from the San Joaquin soils by absence of a cemented hardpan, and by their more definite granitic origin.

One group consisting of the loam and sandy loam types was mapped in this survey.

PLACENTIA LOAM AND SANDY LOAM.

The group Placentia loam and sandy loam includes the loam and sandy loam of the series. It is rather inextensive, covering only about 12.2 square miles, divided equally between the two types.

Description.—The surface soil of the Placentia loam consists of a reddish-brown to red light-textured micaceous, rather friable loam, varying in depth from 10 to 18 inches. In places where the surface is most uniform and gently sloping the color is dark reddish brown, but such dark-colored areas are not typical. The texture is variable owing to the steep gradient and to modification of the material by erosion and deposition of superficial alluvial wash by surface waters and streams. Varying quantities of coarse quartz sand, granitic gravel, and bowlders occur in different places but seldom in sufficient amounts to interfere with tillage or the growth of crops. The soil is low in organic matter, except in its darker colored phases, and absorbs and retains moisture quite well. It is not difficult to till when properly handled. The subsoil is somewhat redder than the surface soil, more compact, and heavier in texture, ranging from heavy loam to clay loam.

The substratum resembles in a general way the subsoil but is in most places less compact and not quite so heavy in texture. Both contain some gravel and cobblestones in places and are not as well aerated or favorable to rapid development of roots as the more pervious recent alluvial soils. No accumulations of lime are apparent in the typical areas, and very little lime is present elsewhere.

The type merges with the sandy loam. It resembles the Mohave sandy loam except in origin and lime content. A gravelly substratum is present in a few places, but it is localized and does not materially influence the type.

The sandy loam type resembles the loam in all features except texture.

Location.—The group occurs in three areas lying along the foothills in the extreme southeastern part of the survey. It lies between soils of the Holland and the Hanford series.

Topography and drainage.—The areas lie at a considerable elevation above the valley floor and have gently to steeply sloping surfaces, having in places a hog-wallow surface. They usually occupy elevated

and more or less eroded remnants of old valley-filling deposits, which, besides being modified somewhat by stream action, are in places separated from adjacent lower-lying soils by steep escarpment faces 100 feet or more in height. The drainage is good to excessive.

Utilization.—Part of the soils of this group occurring along Tejon Creek, where the soils and rainfall are most favorable, are farmed. Moderately good yields of grain are obtained in favorable seasons, but irrigation is necessary before the special crops can be grown. Most of the area of this group is still used for pasture, owing to the scarcity of water for irrigation.

Mohave Series.

The soils of the Mohave series are derived from old, weathered, unconsolidated, water-laid deposits, having their source in a wide range of rocks. The surface soils are reddish-brown to red in color and are low in organic matter. The subsoils are brown, reddish-brown, or red and contain much lime, which occurs as definite zones of concentration and as mottlings. The subsoil is usually more compact and heavier textured than the surface material and has a columnar or jointed structure. The substratum resembles the subsoil, but is less calcareous. The soils of this series are well drained and free from alkali. They occupy valley slopes, old modified alluvial fans, and undulating areas, and usually possess a hummocky surface. The soils differ from those of the San Joaquin series in the absence of hardpan and in their higher lime content; from the Delano series in their red color; and from the Placentia series in origin and lime content. The series is represented in this survey by a group of sandy loams.

Mohave sandy loams.

The Mohave sandy loams group includes the sandy loam and fine sandy loam types of the series. The group is only moderately extensive, covering an area of 23.8 square miles, of which about 80 per cent consists of the sandy loam type.

Description.—The surface soil of the Mohave sandy loam is a reddish-brown or red gritty sandy loam, 10 to 12 inches in depth, containing enough gritty quartz sand to give it a coarse, sharp feel when rubbed between the fingers. It bakes and becomes compact and hard when dry, owing in part to its low organic matter content and in part to the binding qualities of the finer soil particles. The type is marked by low hummocks and shallow intervening depressions, and the texture varies with position, being lighter on the hummocks and heavier in the depressions, where the texture may be a loam or light clay loam. The subsoil is usually redder than the sur-

face soil, and ranges in texture from a compact sticky sandy loam to a heavy clay loam. In a few places it is semicemented and somewhat resembles a hardpan. Definite concentrations of lime are present, the conditions being indicated by grayish mottlings, seams, and pockets. The quantity of lime in many places is large enough to give the subsoil the appearance of marl when wet. Most of the lime occurs between the second and the fifth foot, although in some places it appears to be uniformly distributed through the soil profile to a much greater depth. The substratum is less compact and usually somewhat lighter in texture, besides containing less lime than the subsoil. Both are rather poorly aerated and are much less favorable to extensive root development than are the subsoils of the recent alluvial types.

The fine sandy loam member occurs as rather small irregular areas interspersed with areas of the sandy loam. The soil is gritty and except for its slightly finer texture resembles the main type.

The soils of the group resemble the San Joaquin sandy loams in color, surface features, and in a few other respects, but differ in lacking a hardpan and in containing more lime.

Location.—The Mohave sandy loams are most extensively developed along the Southern Pacific Railroad northwest of Bakersfield and in a small valley in the highlands north of Edison.

Topography and drainage.—These soils occupy gently sloping old alluvial fans and valley slopes and usually have a hummocky or slightly undulating surface. They lie somewhat above the recent alluvial soils and have a deep water table and good drainage.

Utilization.—Owing to a scarcity of water for irrigation the soils are utilized mainly for pasture, but the grazing is scant. They are almost devoid of brush, but usually require a considerable outlay for leveling before irrigation is possible. The main body northwest of Bakersfield is well situated and with water would be quite desirable. A small acreage is used for grain, alfalfa, milo, grapes, peaches and olives. They all do well under irrigation.

Cuyama Series.

The soils of the Cuyama series are derived from old, weathered, and otherwise modified water-laid deposits coming from different kinds of rocks. The surface soils are gray or light grayish brown in color and are underlain by gray or light-brown subsoils which may be similar to or heavier in texture and more compact than the surface soils. The subsoils are underlain by a substratum which in most places lies at depths less than 6 feet, and which consists of gravel, cobblestones, and varying quantities of large bowlders, interbedded in a matrix of sand, silt, or clay. Free lime is usually present

in the surface soil, subsoil, and substratum, though it is rarely concentrated into definite zones except in the subsoil. The soils are low in organic matter, are well drained, and free from alkali. They are distinguished from the soils of the Pleasanton series, which are of similar origin and mode of occurrence, by their lighter and predominantly gray color and their uniformly calcareous nature. Along the northwestern boundary of the survey, however, the soils grade in color and character toward those of the Pleasanton series, and, in the survey of the Middle San Joaquin Valley, join with the Pleasanton soils as recognized in that survey. This apparent inconsistency is due to the fact that the two series merge imperceptibly, the zone of transition encompassing the country near the boundary separating the two surveys.

One differentiation under this series, consisting of a group of the Cuyama sandy loams and loam was made in this survey.

CUYAMA SANDY LOAMS AND LOAM.

The group Cuyama sandy loams and loam include the fine sandy loam, sandy loam, and loam types of the series. It covers an area of 57.6 square miles, 80 per cent of which is occupied by the fine sandy loam and loam types in about equal proportions.

Description.—The surface soil of the Cuyama fine sandy loam is typically a light grayish brown or light-gray medium-textured fine sandy loam, 10 to 15 inches deep. The surface material is rather compact in untilled areas, but when cultivated is friable and absorbs moisture readily. Small quantities of grit and gravel are present locally, but only where outcrops of an underlying gravel substratum occurs is the quantity of coarse material large enough to affect cultivation. The subsoil, though resembling the surface soil in color and texture in some places, normally is heavier in texture and more compact and browner in color. Both surface soil and subsoil normally contain lime which in the latter is concentrated in seams, lenses, or in scattered spots of grayish color. Lime is not always present in the surface soil, however, especially in places that have been little disturbed by erosion since the material was deposited. At depths averaging less than 6 feet and varying from a few inches to 7 or 8 feet, the subsoil rests upon a gravelly stratum which may be many feet in thickness or may consist of several alternating layers of gravel, silt, or sand. The gravel is not typically cemented but in places where it is exposed to the air and in a few other positions it is compact and quite firm. On the terraces and slopes lying nearest the valley trough the gravel is uniformly small in size, but near the mountains it includes many rounded bowlders. The gravel and bowlders are mainly of quartzite and granite but some are composed of basic igneous rock.

The interstitial material in the substratum ranges in texture from sand to clay loam. The subsoil and substratum are permeable and where the latter is close to the surface and incoherent in structure it tends to cause excessive drainage and to make the soil droughty.

The Cuyama sandy loam resembles the fine sandy loam in all features except texture. It is confined to the steeper slopes and is less desirable than the fine sandy loam.

The loam occurs most prominently in the areas northeast of Bakersfield. It is associated and merges with the other two types, and consequently is variable in texture. Except for texture, it is similar to the fine sandy loam.

The soils of this group lack uniformity. In their most eroded parts they may resemble the deeply weathered Altamont and Kettleman soils, and in other tracts the gravelly substratum may not be well defined or may be in places entirely absent. In the areas lying in the extreme northwestern part of the survey the surface and subsoil materials are slightly browner than typical, are less highly calcareous, and upon the north merge with the Pleasanton soils of the adjoining survey. The organic matter content is also slightly higher, and the soils are slightly more retentive of moisture than the grayer and more typically developed soils occurring farther south.

Location.—The most extensive bodies of the group lie on the high alluvial fan of Kern River east of Bakersfield. Three small areas occur along San Emigdio Creek in the south end of the area, and several along the bluffs of the Cuyama River in the extreme southwestern part of the survey. Other small areas are mapped in the extreme northwestern part.

Topography and drainage.—The soils of the group, which lie at elevations above the main valley floor, generally occupy old river terraces, and gently to moderately sloping alluvial fans. Erosion, which has been more or less active in places, has dissected and furrowed the surface, giving a hilly or rolling topography. A few small tracts of Rough broken land occur in ravines or on steep hillsides. The terrace areas are well adapted to tillage, and to irrigation where water can be provided; but the more hilly parts are usually more difficult to till and can not be irrigated. Drainage is good in the typical areas, but is excessive on the steeper rolling areas and where the gravelly substratum lies close to the surface, much water being lost by run-off.

Utilization.—The soils of this group lie above existing canal systems, and water for irrigation is costly and very difficult to obtain. The land is held in large tracts and is used for pasture purposes only. The growing of grain and grain hay has been attempted in a few places, but owing to insufficient moisture the yields are light and uncertain.

MADERA SERIES.

The Madera series of soils is derived from old, weathered, and otherwise modified water-laid deposits coming from a wide range of rocks. The surface soils are brown or grayish brown in color, and are moderate to low in content of organic matter. The brown or reddish-brown subsoil is more compact and typically heavier than the surface soil, and at depths usually less than 6 feet rests upon an iron cemented hardpan of varying thickness. The stratum below the hardpan resembles the subsoil lying above it and is more or less stratified in places. As occurring in this survey the subsoil, hardpan, and substratum are usually calcareous, lime concentrations occurring in many places in the first two. The surface is generally well drained, and alkali occurs only in a few low and poorly drained spots. The series occupies old alluvial fans of gentle sloping or undulating topography, and the surface is either smooth or hummocky. The soils differ from those of the San Joaquin series in color, which is predominantly brown rather than red, and from the Delano series in the occurrence of hardpan. In this area the soils are in many places yellowish brown, and the subsoil does not differ greatly in color from the surface soil. The hardpan also occurs nearer the surface than usual. The loam of the series is mapped separately; the other soils in a group of sandy loams.

MADERA SANDY LOAMS.

The Madera sandy loams group includes the sandy loam and the fine sandy loam of the series, the types covering a total area of about 27.2 square miles. The sandy loam is the more extensive, forming probably 85 per cent of the combined areas.

Description.—The surface soil of the Madera sandy loam is a brown or grayish-brown medium-textured, gritty sandy loam 10 to 36 inches deep, containing small to moderate quantities of organic matter. The soil is friable, of fair water-holding capacity, and is favorable to root development where not too shallow or waterlogged. The subsoil is a brown or reddish-brown compact heavy sandy loam, loam, or clay loam and rests directly upon a brown or gray cemented hardpan at a depth of 24 to 60 inches below the surface. This hardpan resembles the hardpan in the San Joaquin soils in most respects but ordinarily lies deeper and may contain seams, veins, or other accumulations of calcareous material. The material occurring beneath the hardpan consists of friable brown or reddish-brown sandy loam or loam. In variations the color of the surface soil ranges from reddish brown to a dark brown. Where hummocks occur the soil on their tops is lighter in color and texture, is more friable and rather a better soil than in the depressions. The latter contains more silt and organic matter, is shallower, and tends to puddle and bake

where water stands during wet weather. Some fine gravel and micaceous material are present along old stream channels and in parts of the type adjoining micaceous soils derived from recent alluvium. Locally the hardpan may either directly underlie the surface soil or be entirely absent or it may occur below a depth of 6 feet. More than 75 per cent of the group, however, is underlain by hardpan. The remaining 25 per cent consists of areas of soils belonging to the Delano series, which could not be separated on a map of the scale used in this survey. The area along Rag Gulch in the eastern part of the survey is underlain by a thick layer of hardpan which is exposed at the surface in a few places and in others lies close to the surface, in places resting upon a very compact sandy loam substratum.

The Madera fine sandy loam is a smooth, friable, fine sandy loam, free from coarse material. It contains a little more organic matter than the sandy loam and retains moisture better. The heavier variations of this type are somewhat darker colored and have a slightly less favorable structure than the typical soil.

Location.—The soils of this group are confined to several areas in the vicinity of Famoso, two isolated areas southwest and northwest of Ducor, and one along Rag Gulch. All of them lie well above the valley trough. These soils merge gradually with the soils of the Delano and Hanford series in places, but differ from them in possessing a hardpan.

Topography and drainage.—The general surface features of the group resemble those of the San Joaquin series, except that the Madera soils are somewhat smoother. The soils occur on gently sloping alluvial fans. The area along Rag Gulch occupies an old terrace lying 75 to more than 100 feet above the general level of the adjacent plains. Much of the surface of the soils is smooth and uniform, but "hog-wallow" hummocks and minor undulations which occur in many places add greatly to the cost of preparing the land for irrigation. Small ponds of water cover some of the depressions among the hummocks during periods of wet weather. The water table lies mostly well below the surface and as a rule the depth increases as the foothills are approached.

Utilization.—Much of the soils of the group is still used for pasture and for dry-farmed grain, on account of the difficulty of leveling and the occurrence of hardpan. In a few places water has been obtained by pumping, and success has resulted with such crops as alfalfa, milo, and some of the deciduous fruits.

MADERA LOAM.

Description.—The surface soil of the Madera loam consists of a brown, slightly reddish brown, or grayish-brown, friable loam, vary-

ing from 12 to 24 inches in depth. The surface soil is more compact than that of the Madera sandy loam, is somewhat boggy when wet, and upon drying generally bakes and becomes hard and flinty in untilled fields. The soil contains a moderate supply of organic matter and retains water well where properly handled. The subsoil is a light-brown or reddish-brown rather compact loam or clay loam, which rests at depths below 18 inches upon a similarly colored cemented hardpan. This hardpan is in most places only a few inches thick. A permeable brown or reddish-brown loam or clay loam substratum underlies the hardpan, and where the latter has been broken by blasting furnishes a good medium for root development.

The subsoil and hardpan both contain lime locally, but the quantity in typical areas is small. The hardpan frequently lies below 6 feet in the small area north of Jasmine, but elsewhere it may lie near the surface or be entirely absent.

Location.—The Madera loam is the least extensive soil mapped in this survey. Three tracts of small size represent the type, two of which lie west of Terra Bella and one north of Jasmine. All these areas occur along streamways and occupy positions slightly lower than that of the soils of the San Joaquin series.

Topography and drainage.—The surface of parts of the type is level and moderately smooth, but in places it is marked by hog wallows. Two of the areas occupy the lower parts of the gently sloping plain along Deer Creek, while that north of Jasmine is part of the old White River fan. The water table in most of the type is deep, but the western part of the areas near Deer Creek lies rather low and here the ground water is near the surface and accumulations of alkali have resulted. Hummocks are less abundant over the surface than on the Madera sandy loam, but where they do occur drainage is somewhat restricted and the soil in the intervening depressions becomes water-logged and puddled.

Utilization.—This type of soil is used either in the production of grain or grain hay for pasture. Leveling the land for irrigation is difficult and the alkali areas are not very profitably farmed. Pump water can be obtained in most places, the lift being less in those parts lying farthest out on the valley plains. The yields of grain are fair, but vary with the season and with the care given the soil. Alfalfa and fruits do well where drainage conditions are satisfactory and water for irrigation can be obtained at reasonable cost.

Delano Series.

The soils of the Delano series are derived from old water-laid deposits, the material coming from many kinds of rocks. The surface soils range in color from light brown, grayish brown, or yellowish

brown, to slightly reddish brown, the darker colors prevailing in the heavier types. The surface soil is in places calcareous. It is usually low in organic matter. The subsoil is brown or reddish brown and is typically more compact and heavier than the surface soil. It also contains concentrations of lime. The substratum resembles the subsoil, but contains less lime and in places is slightly stratified. The soils occupy gently to moderately sloping old alluvial fans, with smooth, hummocky, or rolling surfaces. Drainage is usually well established. The soils differ from those of the Madera series in absence of hardpan and in the greater lime content of the surface soil.

The Delano series is represented in this survey by a group of the Delano sands and sandy loams, and by the Delano loam types.

DELANO SANDS AND SANDY LOAMS.

The Delano sands and sandy loams group includes the sand, fine sand, sandy loam, and fine sandy loam types. The soils are confined to the east side of the valley trough and cover an area of 342.3 square miles. Soil of the sandy loam member covers about 80 per cent of the total area.

Description.—The surface soil of the Delano sand consists of a brown or grayish-brown, medium-textured, slightly micaceous loamy sand varying in depth from 12 to 18 inches. In many places in untilled areas it is of open and loose structure, but under irrigation it packs somewhat and becomes more coherent, approaching in general appearance the fine sandy loam. The type is low in organic matter, is easily tilled at all times, and retains moisture well if properly handled. Small quantities of coarse grit and some small gravel are present locally, and in more exposed positions some reworking of the material by wind has taken place. The subsoil is brown to slightly reddish brown in color and is somewhat more compact and heavier in texture than the surface material, being for the most part a fine sandy loam or light loam. The surface soil has for the most part no free lime, but small amounts are concentrated in the subsoil, as indicated by grayish streaks and discolorations. The substratum resembles the subsoil; both are readily penetrated by roots and water.

The soil of fine sand texture usually occupies the lower and flatter positions where it is interspersed with areas of the sand, separation being impracticable in a survey of this character. Except for texture and a slightly greater water-holding capacity, it is similar to the sand.

The surface soil of the Delano sandy loam consists of a brown, grayish-brown, or yellowish-brown gritty sandy loam, containing some mica in the smoother areas and ranging from 10 to 15 inches in depth.

It is friable in tilled fields, but tends to pack somewhat when left uncultivated. It is low in organic matter, but absorbs and retains moisture well if properly handled. The subsoil, which ranges from brown to reddish brown in color, is typically heavier in texture than the surface soil, in many places consisting of a loam or light clay loam. In other places it is compact, but similar in texture to the surface soil. In those parts of the group adjoining soils of the Madera or San Joaquin series the subsoil is very compact, and in places not easily distinguished from the Madera hardpan. Considerable quantities of lime are normally present, its occurrence in concentrations of light-grayish or nearly white color being characteristic of the subsoil. The substratum resembles the subsoil in some respects, but it is normally not so compact, is generally lighter in texture, and contains less lime.

The fine sandy loam member occurs as irregular areas in association with the sandy loam type with which it merges in most places. It is of somewhat finer but variable texture and in other features follows the description given for the sandy loam type.

A high rolling variation of this group of soils occurs in the hilly region north of Bakersfield. This variation is shown on the map by cross lines and occupies part of an old alluvial fan formed by Poso Creek that has been dissected and otherwise modified since its deposition. The soils of this variation are very similar to those of the same types farther out on the plains, but they differ in minor essentials, such as drainage and topographic features.

The soils of this group are distinct from the other soils of the survey, but resemble most nearly those of the Madera series, except for their absence of hardpan and more consistent and higher lime content. They include many areas of Madera sandy loam which were too small to be shown on the map. A few small tracts of Delano and Madera loam that would have been mapped separately in a more detailed survey are also included. Small strips of Hanford and Yolo sandy loam also occur in the group along Poso Creek and in a few other places.

Location.—The group is extensively developed on the plains northwest and southeast of Bakersfield and along the foothills southeast of Edison. Several areas lie on the plains west of Ducor and one extends along Poso Creek nearly to the eastern margin of the survey. The high rolling areas cover about 75 square miles in the elevated region north of Bakersfield.

Topography and drainage.—The soils, where typically developed, have in general a rather gently sloping and gently undulating topography. In detail the surface is in most places marked by a succession of hummocks and depressions giving locally a relief of about 1 to 3 feet. Where adjacent to lower lying soils of the Hanford

series, the surface is generally smooth and uniform and the soils closely resemble those of the latter series, but on the rolling areas the soils have a hilly, rolling, or moderately sloping topography. The hummocky areas require leveling to prepare them for irrigation, but dry-farmed crops are grown on the natural surface. Drainage is in general good, but water stands on the surface in depressions for some time after rains in areas where the subsoil is compact. Alkali is present in some of the areas west of Ducor and southeast of Bakersfield.

Utilization.—The soils of the group are used chiefly for pasture, but considerable areas are used in growing grain and grain hay, which give moderate to light yields with occasional crop failures in dry seasons. Some of the smoother and more desirable parts, where water is available for irrigation, are devoted to the production of alfalfa, potatoes, olives, milo, and deciduous fruits; and in a few of the most frost-free positions oranges are grown with fair success. The soils yield well with adequate irrigation, but in dry farming it is difficult to conserve enough moisture in the soil to mature crops properly. The rolling areas lie too high for irrigation and, with other parts of the group unfavorably situated with respect to water supplies, will continue to be utilized as pasture.

Irrigation development and incorporation of organic matter are the two essentials for the best returns from these soils.

DELANO LOAM.

Description.—The surface soil of the Delano loam consists of a brown, grayish-brown, or yellowish-brown rather compact medium-textured loam, locally containing varying amounts of coarse gritty sand and some gravel, low in organic matter, and from 10 to 15 inches deep. The smoother parts of the type contain some mica. In untilled fields the material is quite compact, but when well handled it absorbs and retains moisture well. The subsoil consists of a brown or reddish-brown compact gritty loam or clay loam. In places the structure is dense, approximating hardpan, but this is not typical. Accumulations of lime are present in many places. These occur as gray streaks and discolorations giving the material a marly appearance. The substratum is usually less dense, contains less lime, and is not so heavy in texture as the subsoil.

A high rolling development of the type lying in the hilly region north of Bakersfield is indicated on the map by cross lines. It resembles the typical material except in drainage and surface features.

The type is variable, owing to its occurrence in rather small tracts. It includes small areas of Delano sandy loam and gravelly loam, and also many spots and small strips of Madera loam. Including the

high rolling areas, the group covers an area of approximately 69.2 square miles.

Location.—The main areas are located on the plains southeast and southwest of Ducor and northeast of Bakersfield. A small one lies just northeast of Wasco, and several of very small extent are scattered over the plains and along Kern River northeast of Bakersfield.

Topography and drainage.—The typical areas of this soil have a gently sloping or slightly undulating topography, but the high rolling development includes rolling, moderately sloping, or hilly surfaces. The plains section in many places has a hummocky surface, but elsewhere the surface is smooth and uniform. Drainage is good to excessive, depending upon the slope. Much of the rainfall is lost in the run-off on the rolling areas. Where the subsoil is compact some water stands for periods in the depressions. Alkali occurs in some of the areas southeast of Bakersfield.

Utilization.—Most of the type is used as pasture land. It supports a moderate to scant growth of grass. Some of the more favorably situated areas are utilized for the production of dry-farmed grain and grain hay, but the yields vary and are dependent upon the amount of rainfall. In a few places, where water is obtained by pumping, alfalfa, milo, and deciduous fruits are profitably grown under irrigation.

Porterville Series.

The Porterville series includes soil derived from old, modified, unconsolidated alluvial deposits, mainly from basic igneous rocks. The surface soils are dark chocolate brown or dark reddish brown in color and contain considerable organic matter. The subsoil is brown, reddish brown, or yellowish brown, and more compact and heavier in texture than the soils. Accumulations of lime occur in the subsoil as gray mottlings and in places as seams and lenses of high concentration. The substratum resembles the subsoil, except that it is lower in lime and usually less compact. Some stratification is apparent locally. Drainage is well developed, and the soils are free from alkali. The series occupies foot slopes and remnants of eroded alluvial fans with gently sloping or moderately rolling, but smooth and uniform surfaces.

One group of soils of this series, the Porterville adobe soils, was recognized and mapped in this survey.

Porterville adobe soils.

The Porterville adobe soils group includes the clay loam adobe and the clay adobe types. It covers an area of 10,880 acres, about 85 per cent of which is occupied by the former.

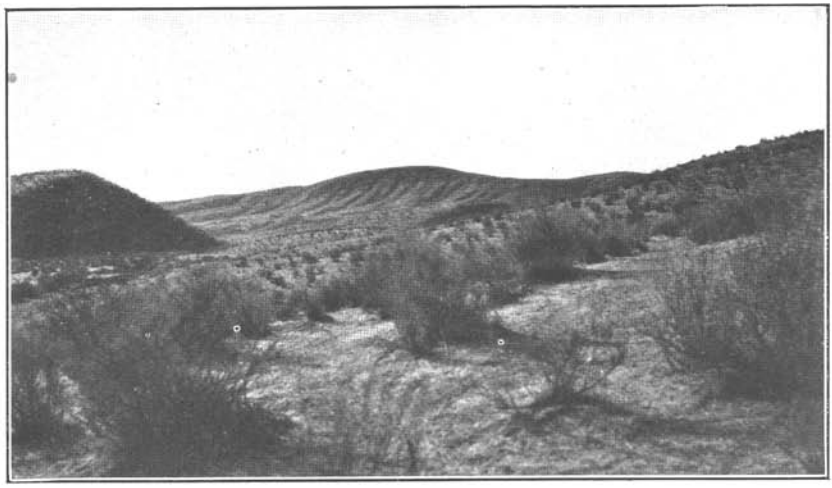

Photo by Univ. of California.

FIG. 1.—VIEW IN AREA OF THE KETTLEMAN SANDY LOAMS, SHOWING CHARACTERISTIC TOPOGRAPHY AND NATIVE VEGETATION.

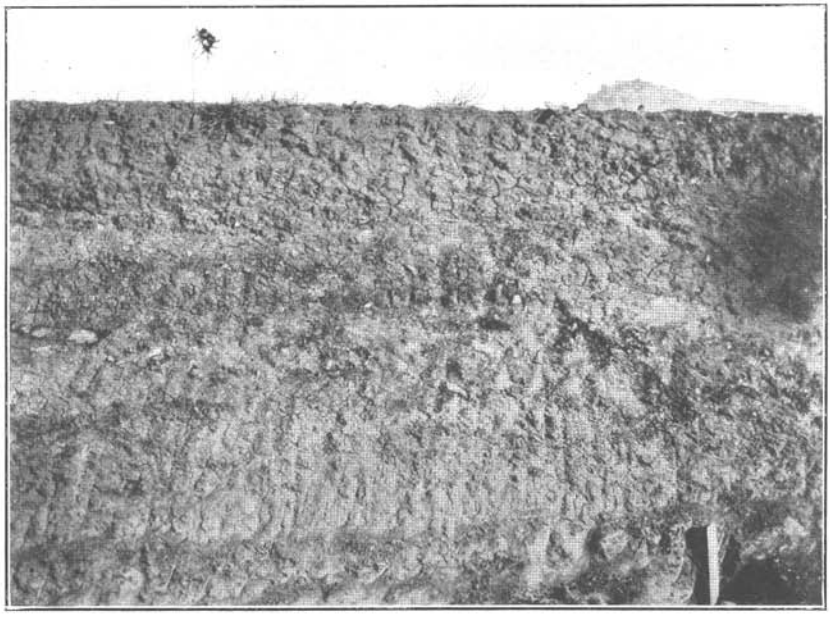

Photo by Univ. of California.

FIG. 2.—PROFILE SECTION IN THE PORTERVILLE ADOBE SOILS.

Description.—The surface soil of the Porterville clay loam adobe consists typically of a chocolate-brown, reddish-brown, or dark reddish brown, heavy textured, rather compact clay loam of adobe structure. The reddish color is most pronounced where the type adjoins soils of the San Joaquin series. The soil contains a fair proportion of organic matter and absorbs and retains moisture well. The heavy texture and compact structure make tillage quite difficult, and necessitate handling the soil when not too moist if baking and puddling are to be avoided. Areas lying well out on the plains are practically free from gravel, but varying amounts of gravel and some cobblestones occur near the foothills. At a depth of 12 to 36 inches the soil grades into a brown, reddish-brown, or dark-brown calcareous clay loam, or clay similar in structure and texture to the surface soil. Small deposits of coarse, gritty sand and some gravel and cobblestones are present locally, but they do not affect the relation of the type to plant growth or to the movement of moisture. The lime usually occurs in seams, streaks, or grayish mottlings, the quantity varying from small to large. (Pl. III, fig. 2.) In a few places it forms white layers or lenses of a floury or marly nature, which cause the surface soil to become soft and spongy. Such conditions are known among farmers as "dry bog." The substratum resembles the subsoil in texture and structure but ordinarily contains less lime.

The clay adobe conforms to the description of the clay loam adobe except in texture and in difficulty of tillage which is considerably greater.

The soils of this group are uniform in character in the larger areas but vary considerably where occurring in small areas associated with soils of the San Joaquin or Madera series. Some small areas of the latter soils are in some places included because separation is impracticable. The soils, though heavy and intractable, work into a very friable granular condition when tilled at the proper time and do not pack and lose their moisture so quickly as clay soils not possessing the adobe structure. The soils nevertheless bake and crack badly and become very hard in untilled fields when dry.

Location.—Three areas of the group are mapped. They occur north and east of Terra Bella in the extreme northeastern part of the area forming parts of the valley plains, lying somewhat higher than the recent alluvial types in that part of the survey.

Topography and drainage.—The topography ranges from moderately sloping or undulating to rolling, the surface in detail being smooth and uniform. Those parts nearest the foothills usually present the definite outlines of alluvial fans, little modification by erosion having occurred since the materials were deposited, while other areas have been more or less dissected. Little leveling is necessary to

prepare the land for irrigation. Drainage is good, except in a few depressions which collect seepage water.

Utilization.—The Porterville adobe soils are among the most important soils in the area. They are utilized extensively for production of citrus fruits, to which they appear very well adapted. Other parts are used in growing grain and grain hay, alfalfa, and deciduous fruits, with moderate to good yields. Water for irrigation is obtained by pumping from underground supplies, with lifts varying from about 75 to 150 feet or slightly more. The soils will amply repay intensive cultivation; they are well located and are supplied with good roads.

Ducor Series.

The soils of the Ducor series are derived from modified old water-laid deposits having their source principally in granitic rocks. The surface soils are dark brown or brown in color with reddish-brown or chocolate-brown variations. The darker shades of brown occur in the heavier textured types. The subsoil ranges from reddish brown to red. It is normally gritty and heavier and more compact than the surface material. It is usually mottled with lime, but is free from cemented layers. The substratum lying in most places below 6 feet resembles the subsoil, except in its lower lime content and in being in places slightly stratified. The soils are apparently high in organic matter. They occupy gently to moderately rolling old alluvial fans of smooth or slightly hummocky surface and are well drained. The soils differ from the Porterville series in origin and in their somewhat darker color. Two differentiations under this series were made in this survey, the Ducor loam and group of the Ducor adobe soils.

Ducor loam.

Description.—The Ducor loam is one of the important types in the area. The surface soil consists of a dark-brown, dark chocolate brown, or dark grayish brown rather friable loam, high in organic matter, and containing varying amounts of mica. In its heaviest variations it has a slight adobe structure, which in its lighter textured variations is grayer and contains varying quantities of coarse, gritty sand, which on the steeper slopes and tops of ridges often give it the appearance of a heavy sandy loam. Some gravel and cobblestones occur near the foothills, but not in sufficient quantities to be a serious handicap in tillage. The surface soil absorbs and holds moisture well where properly handled but becomes baked and rather hard in untilled areas. At a depth of 12 to 36 inches a reddish-brown, brown, or grayish-brown subsoil is encountered. This is slightly more gritty

and a little heavier than the surface soil. Over most of the type it is relatively high in lime, which appears as grayish streaks and discolorations, the content in most places being largest at depths less than 6 feet. Except for lower lime content, the substratum resembles the subsoil, and both are permeable to roots and water. The surface soil, subsoil, and substratum contain larger quantities of coarse, gritty sand than the soils of the Porterville series, owing mainly to the derivation of the Ducor loam from coarse-textured rocks. The type includes a few small tracts of Madera and Delano loams and also patches of the Ducor adobe soils. It covers an area of 50.4 square miles.

Location.—The Ducor loam occurs in a single large area situated in the region east of Delano. It lies at an elevation somewhat above the recent alluvial types in that part of the survey.

Topography and drainage.—The soil has a rolling or undulating topography and smooth, uniform surface. There is a difference of 50 to 200 feet in elevation between the depressions and ridge crests, which makes irrigation difficult and costly. Drainage is good except in a few of the depressions, where the soils remain somewhat waterlogged in spring during wet seasons.

Utilization.—A small part of the type is successfully used for growing citrus fruits where water is available for irrigation, but most of the area is still devoted to dry-farmed grain, to which the soil is well adapted, giving good yields under favorable moisture conditions. Some of the poorer parts are used as pasture. A fair growth of native grasses occurs on this land. Much of the type is somewhat remotely located and is poorly supplied with roads, which drawbacks, together with scarcity of water, give only moderate land value.

DUCOR ADOBE SOILS.

The group Ducor adobe soils includes the clay loam adobe and clay adobe, the former covering about 85 per cent of the combined area, which amounts to 20,352 acres.

Description.—The surface soil of the Ducor clay loam adobe is a dark-brown, dark chocolate brown, or dark grayish brown heavy clay loam of adobe structure, the untilled surface cracking badly when dry. The soil contains some micaceous material, is high in organic matter, and absorbs and holds moisture well. It is difficult to till, but if handled when in the optimum moisture condition it breaks down into a friable granular seed bed. Some gritty material is present in most of the soil, and some gravel and cobblestones occur on those parts near the main foothills. The surface soil rests upon a reddish-brown, brown or dark grayish brown, rather compact clay loam or clay subsoil at depths ranging from 12 to 36 inches. Varying amounts of lime, indicated by grayish seams and discolorations, are

present in the subsoil, especially within the 6-foot profile. Some gravel and cobblestones occur in the subsoil near the foothills, but they have little or no effect on the crops grown. The substratum resembles the subsoil in nearly all features, but contains less lime.

The type includes a few small areas of San Joaquin loam along its western boundary and a reddish cast occurs in the Ducor soil where the two types are commingled. A number of soft spongy spots are included. These are called "dry bogs" and are due to unusually large concentrations of white floury lime material at 1 or 2 feet below the surface. The type contains more coarse grit than do similar soils of the Porterville series owing to a difference in texture of the parent rocks. It is of more friable and desirable structure when properly tilled than soils of similar type not possessing an adobe structure.

The clay adobe occurs as small areas associated with the clay loam adobe and owing to its limited extent is quite variable. It normally occupies the more nearly level parts of the group area and except for its heavier texture and greater difficulty of cultivation, corresponds to the description given for the clay loam adobe.

Location.—The soils of this group are confined to a single large area of irregular outline situated in the rolling region east and north of Ducor.

Topography and drainage.—These soils have an undulating or rolling to gently sloping topography, the surface in detail being smooth and uniform. Those areas near the foothills occupy old alluvial fans that are still well defined and smooth and uniform in outline, but the main part of the body lying on the plains has been considerably modified in topography by erosion. The soils are well drained, except in a few minor depressions, which remain wet late in spring in seasons of relatively heavy rainfall.

Utilization.—The group is very important in the production of citrus fruits and is largely used for this purpose wherever underground water can be obtained at moderate depths. Grain and grain-hay are still the leading crops and give fair to good yields in favorable years. Some alfalfa and deciduous fruits are grown where water for irrigation can be obtained cheaply. The soils are quite well located and have good transportation outlets. Land values depend upon the crops which are possible under existing irrigation and moisture conditions. Where citrus fruits can be grown the price is $100 or more an acre.

Fresno Series.

The soils of the Fresno series consist of weathered and otherwise altered, unconsolidated water-laid deposits derived from a wide range of rocks. The surface soils are gray or brownish gray in color and

low in organic matter. The subsoils are gray, grayish brown or yellowish brown and more compact and heavier than the surface soil. At varying depths, in most places less than 6 feet, they rest upon a semicemented or indurated gray to light-brown, calcareous hardpan of greatly varying thickness. The substratum is generally more permeable than the subsoil and is often stratified. The surface soil, subsoil, hardpan, and substratum are relatively high in lime, and calcareous concentrations frequently appear in the subsoil and hardpan. In the San Joaquin Valley the series occurs on the outer parts of large alluvial fans extending into the valley from the foothills and along its eastern side. The surface, which in general is gently sloping, is characterized by hog wallows. Drainage is in most places deficient and alkali in many places is present. In this survey the soils generally occupy a position between the slightly more elevated Madera and Delano soils and the lower lying recent alluvial soils of the valley trough. The series differs from the related Pond series in having a hardpan and from the Madera series in color and greater content of lime. Two individual types, the loam and the clay loam, were differentiated in this survey.

FRESNO LOAM.

Description.—The surface soil of the Fresno loam consists of a gray or brownish-gray medium to heavy textured loam containing a relatively large proportion of silt. The soil is typically of compact, puddled structure, and poorly aerated. Lime is usually present in considerable quantities. The organic content is low. At depths of 10 or 12 inches the surface soil grades into a heavy, compact gray or brownish-gray loam or clay loam which in turn rests upon a more or less well defined hardpan at depths ranging from 15 to 48 inches. The hardpan varies in thickness from a few inches to several feet and overlies a substratum of loam or clay loam which is more or less stratified, and of variable compactness. The subsoil, hardpan, and substratum are somewhat mottled in many places and include concentrations of lime that give them locally a marly appearance.

The type is fairly uniform in character but marginal areas vary in texture and are either heavier or lighter than typical, depending on the texture of the adjoining surface soils into which they merge. Drainage waters following small poorly defined channels have deposited sand over part of the surface, and in places, as in the bodies at Kernell, the soil includes many spots of sandy loam, silt loam, and clay. The tracts north of Pixley are extreme phases of larger and more typical areas to the north. The soil on the hummocks is of lighter texture, browner color, and better drained, than that of the intervening depressions, the latter usually being affected by standing

water in wet weather which gives rise to a puddled grayish appearance. The areas near Angiola and to the south have been influenced somewhat by lake-laid deposits and have a smoother surface and a slightly darker color than the typical, and in places contain small quantities of shell fragments. Most of the type varies greatly in depth to hardpan which ranges from near the surface to depths of 5 or 6 feet, and in many places, especially near soils of the Pond series, small areas of hardpan-free soils of the Pond series are included.

Location.—A total area of 53.8 square miles of this soil occurs in the present survey. A number of areas of large size are situated east and southeast of Angiola, and others of prominence occur northwest of Kernell and southwest of Pond. Small tracts also lie north of Deer Creek. Large areas of this soil were mapped in the sections of the San Joaquin Valley covered by earlier soil surveys.

Topography and drainage.—The Fresno loam has a generally flat or gently sloping surface marked in many places by a hog wallow topography. The general slope of the land is very gentle and the run-off is considerably impeded by the uneven surface. Small sluggish streams which traverse the more elevated parts often spread their waters over the lower and flatter parts where it forms shallow temporary ponds. A high water table and seepage areas over most of the type give rise to poor drainage, and this condition has favored the accumulation of alkali in large quantities. Drainage is further impaired by the dense subsoil layers and hardpan, which obstruct the internal movement of water and make reclamation difficult. Pump water for irrigation is easily obtained in most places and the cost of leveling for irrigation is usually much less than for the soils of San Joaquin and Madera series.

Utilization.—The type is used almost entirely for pasture. The grazing is poor, the native vegetation consisting chiefly of alkali-resistant plants, and, in some places indeed, the salts are so concentrated that no vegetation can grow. From 10 to 25 acres are required to support one mature animal. Small parts of the type are coming into use for the production of rice, which has been successfully grown even on soils of high alkali content. Great care, however, is necessary in such places or failure results. The plentiful supply of cheap water and the rather impervious subsoil are features favorable to the growing of this crop. The soil puddles when improperly handled and is difficult to manage under unfavorable moisture conditions. Good drainage, with consequent aeration of the subsoil, and cultivation markedly improve these soils, but large unoccupied areas of more desirable soils tend to discourage the reclaiming of this type to any great extent.

FRESNO CLAY LOAM.

Description.—The surface soil of the Fresno clay loam is a grayish or brownish-gray, compact, clay loam or silty clay loam, 10 to 15 inches in depth. A poorly granulated, puddled, and generally unfavorable structure is usually characteristic of the soil of this type in this area. This is due mainly to its low-lying position, arrested subdrainage, and flooding by surface drainage water. In many places the soil is flinty and hard while in other parts not subjected to standing water it is more friable. In some of its lower parts and near soils of the Tulare series, the color is somewhat darker than the average and the soil tends somewhat toward an adobe structure. The surface soil is very low in organic matter. It contains varying amounts of lime. The subsoil differs but little from the surface soil in color and texture, except locally where it is slightly darker and heavier. It is in most places more or less compact, and rests at an average depth of less than 6 feet upon a calcareous hardpan from a few inches to several feet thick, and of varying hardness. This hardpan greatly impedes the downward movement of water and prevents development of roots. The substratum is usually less compact and contains less lime than the subsoil and is somewhat stratified in places. Both subsoil and substratum are mottled in many places with grayish concentrations of lime and some yellowish iron stains. The type as mapped shows minor variations due to included small tracts of lighter or heavier texture which in a detailed survey would be mapped as soils of the Pond series. Near Allensworth some lighter textured material of the Tulare series also is included. The character, composition, and depth of hardpan also vary greatly in the different areas of the type, and in many spots no hardpan is present, this condition being most common near soils of the Tulare or Pond series. Varying quantities of shell fragments are present in areas formerly influenced by the waters of Tulare Lake.

Location.—The type covers an area of 36.3 square miles which lies east and southeast of Allensworth. It occupies a low-lying position near the valley trough and some of its more sunken parts have been influenced by lake conditions giving the type in such places a flat or slightly depressed appearance.

Topography and drainage.—The surface of the type is nearly flat in most places, but there are locally present irregularities consisting of low, rounded hummocks or slightly elevated areas. Sluggish streams meander over the type and spread over the lower parts, causing them to become water-logged and to remain wet for long periods in the winter and spring months. A high water table and seepage are common, and alkali is present over the entire area. Irrigation water from underground sources is easily obtained at shallow depths, but

the amount and quality depend upon the location and the depth of the wells. Some leveling is necessary in preparing the land for irrigation, but the cost of such work is comparatively small. Both surface and subdrainage are poor.

Utilization.—The type is uncultivated at present and supports only a sparse growth of alkali-tolerant vegetation, which has some value for pasturage. Several tracts have been leveled and checked for growing rice and other crops, but these have now been abandoned. Reclamation of the soil can only be accomplished at a cost which is almost prohibitive, owing to the low position, heavy compact soils, and relatively impervious hardpan, high concentration of alkali, and lack of adequate drainage outlets.

Pond Series.

The soils of the Pond series consist of more or less modified water-laid deposits derived from a wide range of rocks. The surface soils, which are gray or light grayish brown in color, are low in organic matter, are similar in origin, color, and other essential characteristics to the Fresno soils except hardpan. Tests with acid show the presence of lime. The subsoils are gray or grayish brown in color, and are more compact and heavier textured than the surface soils. They contain concentrations of lime, but are typically free from cemented hardpan. The substratum resembles the subsoil in color, but is less compact, in most places somewhat lighter in texture, and contains less lime. It is stratified in places. The series occupies the lower and flatter parts of the plains east of the valley trough and has a smooth, slightly uneven, or hummocky surface. The soils are poorly drained and contain more or less alkali. In this area the series includes light-brown or grayish-brown variations which are most common in the better drained parts and where the soils grade into those of the Madera and Delano series. It also includes small areas of the Fresno series having the typical calcareous hardpan.

Two groups of types and one individual soil type were recognized and mapped under this series as follows: The Pond sandy loams, the Pond loams, and the Pond clay loam.

Pond sandy loams.

The Pond sandy loam group includes the fine sandy loam and sandy loam types of the series. These soils cover an area of 87.8 square miles, of which about 85 per cent consists of fine sandy loam.

Description.—The surface soil of the Pond fine sandy loam is a light grayish brown or light-gray, friable, somewhat micaceous fine sandy loam, the browner variations being developed in the proximity of soils of the Delano, Hanford, and Madera sandy loams and on the

higher elevations. The soil is low in organic matter, but is retentive of moisture when well handled, and is easy to till at all times of the year. Considerable lime is present in the surface soil and is uniformly distributed through it, concentrations occurring only in the subsoil. The subsoil, encountered at 12 to 20 inches, is a light-brown or gray heavy sandy loam or loam, and is more or less compact in places. In some of the areas of lighter texture the subsoil resembles the surface material in texture, though normally somewhat more compact and in many cases slightly stratified. Lime occurs in large quantities, appearing as grayish seams, lenses, and light-colored mottles. Here and there the calcareous layers have become firmly cemented into a hardpan, especially on the slight ridges in the region about Tropico School and at other places near the hardpan soils of the Fresno series. The substratum resembles the subsoil in color, but contains less lime, and is normally not quite so compact and heavy in texture. It, like the subsoil, may show stratification, layers of fine sand and silt alternating.

The Pond sandy loam, which occurs as small irregular areas, in most places is associated with the fine sandy loam. It is not quite as retentive of moisture and does not contain quite as much lime on an average as the finer textured soil. In other respects it conforms to the description given for that type. The soils of this group are well defined and comparatively uniform. About the only variation of enough importance to call for mention consists of small areas of Pond loam and fine sand.

Location.—Two large areas of the group lie northeast of Allensworth, several north of Buttonwillow, one northeast of Rio Bravo. There are also several small areas northwest of McFarland. The soils are associated with those of the Fresno and Hanford series, and in a few places the soils merge so gradually that the boundaries are placed arbitrarily, leaving narrow zones of untypical materials on each side.

Topography and drainage.—The group has a very gently sloping to nearly level topography, with local minor surface irregularities. It is confined to the plains east of the main valley trough, for the most part well out in the valley. The surface is normally smooth and uniform, except locally, where hog wallows occur and where near the margin of some of the areas erosion has somewhat furrowed it.

In some places where the soil is of lightest texture it drifts, and small mounds of sand have accumulated around weeds and brush. The soils are well drained over most of their extent, but seepage and a high water table have caused concentrations of alkali over much of the areas northeast of Allensworth and Rio Bravo and along the margins of a few of the tracts in other places. The pro-

portion of soluble salts is high, and under unfavorable drainage conditions the soils may be quickly reduced in value by further accumulations.

Utilization.—These soils are still largely used for pasture, though the grazing is scant. Where water is available for irrigation some parts have been planted with milo, alfalfa, and a few other crops. Little labor is required to level the land for irrigation, and in most places underground water is obtained at reasonable depths. Shad scale is the prevailing vegetation in untilled areas, but the cost of removing it is small. The soils are very deficient in organic matter, and should first be planted with alfalfa or some similar crop for a few years to get them into good condition for the more intensive crops.

POND LOAMS.

The Pond loams group includes the silt loam and loam types of the series. It is confined to the east side of the main valley trough and covers an area of 228 square miles, of which more than half is composed of soil of silt loam texture.

Description.—The surface soil of the Pond silt loam consists of a grayish-brown to gray rather friable and somewhat micaceous soil, varying in depth from about 12 to 24 inches. The color is very light in the typical areas, but near the Delano soils it is grayish brown. The texture varies somewhat, but is uniform over the larger areas. It is light near bodies of the Pond fine sandy loam and heavy near those of the Pond clay loam. The organic matter content is low and the soils, where relatively heavy, tend to puddle somewhat if handled when too wet. Tillage is slightly more difficult than on the fine sandy loam, but the soil usually forms a desirable seed bed when prepared under favorable moisture conditions. Rather large quantities of lime occur, in most places uniformly distributed through the soil, and this generally aids granulation. The subsoil is a plastic clay loam or clay of light-brown or grayish-brown color. It is also usually more compact than the surface soil and less favorable for root development than the lighter subsoils of the lighter textured types. In places except for its greater compactness it is less dense and closely resembles the surface material. It is high in lime, which is indicated by concentrations appearing as streaks and gray mottlings. Stratification occurs locally and in a few places lenses of a cemented calcareous hardpan are developed especially near soils of the Fresno series. The substratum resembles the subsoil but is usually less compact, lower in lime and in places somewhat lighter in texture. In the lower and more poorly drained places both subsoil and substratum are somewhat mottled with yellow stains.

The Pond loam occurs as smaller and more irregular areas than the silt loam. Except in texture the two types are similar.

Location.—The group is extensively developed in the vicinity of Pond and west of Wasco. It also occurs in important areas southeast of Bakersfield, south of Pixley, and east and northeast of Buttonwillow.

Topography and drainage.—The soils have a very gently sloping to nearly level or flat topography, with a slight tendency toward a hogwallow condition locally, and in a few places a surface furrowed by erosion. The subdrainage is restricted over most of the group, causing in many places the accumulation of alkali. This may occur in spots scattered over the area, as small quantities uniformly distributed are accumulations of such strength that only the most resistant vegetation can exist.

Utilization.—Most of the land of this group is used for pasture though the growth of grass is scant. Brush (shad scale) grows over much of it and adds considerably to the cost of preparing the land for crops. Irrigation is necessary for practically all the crops grown. Water is obtainable by pumping from underground supplies in most places. Rice is grown successfully, even where the content of alkali is high. The system of irrigation followed in its culture either removes the excess salts in the drainage waters, or forces them deep enough into the subsoil to permit the growing of alfalfa and other crops in the second or third year. This is a good way to reclaim these soils where ample water is available. Good yields of rice are obtained the first year, and, so far, this crop seems to be about the only one that can be grown in unfavorable places without first reclaiming the soil by an expensive system of underground drainage. Fruit trees do not do well on these soils.

POND CLAY LOAM.

Description.—The surface soil of the Pond clay loam consists of a gray or brownish-gray heavy, plastic clay loam containing some finely divided micaceous material. In flat or nearly level areas the soil is frequently compact, and in wet weather water stands over the surface in some places for short periods. The color becomes somewhat darker near soils of the Merced series and in localities approaches the color of the Tulare clay loam. The texture varies, being heavier in the low-lying positions. The soil is low in organic matter and is difficult to till. At 10 to 18 inches the soil rests upon a gray or light grayish brown very calcareous clay loam or clay subsoil. Lime occurs as mottles or as grayish seams and streaks, and in places has partially cemented the subsoil, giving it a resemblance to hardpan. The subsoil is slightly stratified in some of the areas and is in many places poorly aerated and too dense to allow the proper development of the roots of many crops. The substratum contains less lime than

the subsoil, and is typically not so compact or as heavy in texture, though in other respects they are similar. The type includes a few small areas of Fresno clay loam, from which it differs in not having a calcareous hardpan. It also includes a few spots of Tulare clay loam, but as a rule it is quite uniform and typical. Small quantities of shell fragments are present in the area south of La Hacienda Ranch in T. 24 S., R. 22 E.

Location.—The Pond clay loam covers an area of 78.6 square miles. It is most widely developed in the region west of Pond with several small areas situated west and northwest of Rio Bravo, and north of Buttonwillow. It occurs in many places as narrow strips around the lower margin of the Pond loam areas and in a few small bodies surrounded by the dark-colored Merced types.

Topography and drainage.—The surface features are very uniform and flat. The land is in many places nearly level and is sometimes covered to shallow depths by flood waters from the creeks, which spread over the plains in this part of the area. The soil is poorly drained for the most part and contains a high percentage of alkali.

Utilization.—On account of the accumulations of alkali nearly all the type is used for little except pasture. A small part has been in rice for a few years, and good crops have been obtained where water for irrigation is abundant. After growing rice a year or two, the land can be successfully planted with alfalfa, grain, and a few other crops; but these crops can not be grown the first year, unless the land has been drained and reclaimed from alkali. Varying amounts of shad scale and greasewood are present in places, the latter being most prevalent in areas containing the most alkali.

Merced Series.

The soils of the Merced series consist of old, slightly modified water-laid deposits derived from a wide range of rocks. The surface soils are dark gray to black, but include variations of dark grayish brown color. The organic matter content is high. The subsoils are grayish brown, or gray, frequently mottled, and contain concentrations of lime. They are also more compact and heavier textured than the surface soils. The substratum resembles the subsoil but contains less lime, is more mottled, and shows stratification. Calcareous nodules are present in places in the subsoil which here and there also contains thin softly cemented calcareous seams penetrated by roots. The series occupies low positions and is subject to overflow during wet periods in winter. It is rather poorly drained and some alkali is present locally.

Two groups of soils under this series, the Merced loams and the Merced clay loams are mapped in this survey.

MERCED LOAMS.

The group Merced loams includes the silt loam and loam types of the series. It covers an area of 60.2 square miles, more than 75 per cent of which is of the silt loam type.

Description.—The surface soil of the Merced silt loam consists of a dark-gray, dark brownish gray or black, friable, slightly micaceous silt loam, from 12 to 24 inches deep. In the higher lying situations the color and texture are somewhat lighter than the average, and in the lower parts where it merges with the Merced clay loam slightly heavier. The soil is high in organic matter, retains moisture well, and is easily tilled. The subsoil is a gray, dark-gray or dark grayish brown heavy loam or clay loam, mottled in places, and containing grayish concentrations of lime. It is more compact than the surface soil and in a few places local lenselike layers of calcareous hardpan appear. The substratum resembles the subsoil, except that it is less compact and contains less lime.

The Merced loam resembles the silt loam in all essentials except texture. It does not occur in well-defined areas, but is associated over most of its extent with the silt loam types, into which it gradually merges.

The soils of this group are typical in most of the areas, and its greatest variation occurs in the subsoil and substratum. A few small tracts of Merced fine sandy loam, too small to be separated, are included.

Location.—The most extensive areas of the Merced loams lie southwest of Alpaugh, and in the vicinity of Buttonwillow, and a small one is situated several miles north of the town of Lost Hills.

Topography and drainage.—The soils of this group have a very uniform smooth surface which is nearly level or very gently sloping. The low-lying positions of the group are subject to overflow in periods of unusually high water, but in recent years most of the land has been protected from high waters by levees. Periodic washing has prevented the accumulation of alkali even though the water table lies close to the surface, though a small amount of alkali occurs in one or two spots in marginal zones.

Utilization.—The group is nearly all under cultivation, grain, beans, alfalfa, and milo being the chief crops. Good yields are obtained under irrigation. A good supply of water is procurable either from gravity systems or by pumping from underground sources. The soils are productive, ranking among the best in the area for general farm crops. They lie rather low to be suitable for crops requiring intensive cultivation.

MERCED CLAY LOAMS.

The group Merced clay loams includes the silty clay loam and clay loam types of the series. It covers an area of 160.6 square miles, the silty clay loam occupying more than 75 per cent of the combined area.

Description.—The surface soil of the Merced silty clay loam consists of a dark-gray, dark brownish gray, or black silty clay loam, containing some mica. It is quite friable, high in organic matter, and is not difficult to till under favorable conditions. Upon drying the soil cracks somewhat, becoming hard and flinty in untilled fields. The dark-colored surface soil extends in many areas to a depth of 5 or 6 feet, but is more frequently underlain at a depth of 12 to 36 inches by lighter colored subsoils of grayish or brownish color. The subsoil usually resembles the surface soil in texture, but in places it is a bluish heavy clay, here and there containing sandy or silty strata. It is calcareous, the lime occurring in grayish seams and mottles, and in places cementing the subsoil material into hard layers, closely resembling hardpan. The substratum usually contains less lime than the subsoil and in many instances has a distinct grayish and brownish mottling, due to stagnated subdrainage.

The clay loam type usually occurs as small irregular areas associated with the silty clay loam and follows the description given for that type, except as regards texture.

The group is comparatively uniform, but in some of its lower lying positions includes soils of clay or clay adobe structure. Small spots of silt loam are also developed locally in the most elevated parts.

Location.—The group is extensively developed along the valley trough from near Buttonwillow northwestward to within a few miles of Tulare Lake. One tract lies east of Buena Vista Lake, and a long, narrow strip extends northward from near Buena Vista Lake to within a few miles of Buttonwillow.

Topography and drainage.—The soils of the group occupy some of the lowest parts of the area. The surface is for the most part very gently sloping or flat, but locally is somewhat uneven, owing to the presence of sloughways and shallow abandoned stream channels. It is also in the main well drained on the surface, but through most of the year the subsoil is in a water-logged condition. Some drainage work has been done here and there with very satisfactory results. Alkali is present only in a few small areas where the group is least typical and where it merges with other soils.

Utilization.—Most of the land in this group is still in pasture, the growth of grass being moderate to good. The part under cultivation is used in the production of grain, alfalfa, milo, and a few

other crops. Where irrigated these give good yields. Water is obtainable in ample supply, either by pumping from underground supplies or from gravity systems. A number of artesian wells are sunk on these soils, but the flow of water is not great and in places it is of poor quality. The soils are very productive and give good yields of the general crops, but are not well adapted to fruit or other special crops.

RECENT ALLUVIAL SOILS.

Panoche Series.

The soils of the Panoche series are derived from recent alluvial deposits washed from areas of sedimentary rocks. The surface soils are gray or light grayish brown in color, low in organic matter and owing to occurrence under arid conditions are normally calcareous. The subsoil is gray or light grayish brown and either resembles the surface material in texture and structure or is heavier and somewhat compact. Lime is present in the subsoil in varying quantities and frequently appears as gray seams or mottlings. (Pl. IV, fig. 1.) The substratum below 6 feet is frequently stratified and less compact than the subsoil and rarely contains concentrations of lime. The lighter textured and higher lying types are well drained, but in the lower and flatter parts of the alluvial fans alkali is present in harmful amounts. The soils occupy gentle to moderate slopes, and the steeper parts are occasionally marked by rather deep drainage ways with perpendicular banks. The surface is either smooth, slightly undulating, or hummocky.

There occur in this survey some high-lying areas of soils derived from somewhat older materials than those giving the typical soils. It also includes areas of recent alluvial fan soils that are browner than typical, and which approach in characteristics soils of the Yolo series.

The Panoche sandy loams, loams, clay loam, and the loam and clay loam, high phase, were mapped in the present survey.

PANOCHE SANDY LOAMS.

The Panoche sandy loams group includes the fine sandy loam, gravelly sandy loam, and sandy loam types. The total area is 397.3 square miles, of which the fine sandy loam forms about 75 per cent and the gravelly sandy loam about 15 per cent.

Description.—The surface soil of the Panoche fine sandy loam typically consists of a gray or light grayish brown, friable, open structured fine sandy loam. In some localities where the material is rather old and has been influenced by weathering, the soil is gray-

ish brown in color. In most places the surface soil is light in texture, approximating a loamy fine sand. In a number of places a thin veneer of wind-blown fine sand 1 or 2 inches deep covers the surface, and small hummocks have been built up around obstructions, such as brush. In places of greatest stream activity, the soil is variable and includes small quantities of shale gravel, strips of sand, and a few scattered bowlders. The soil is low in organic matter, is easily tilled at all periods of the year, and absorbs and retains moisture well. Varying amounts of lime are present in most places, and the tract southeast of Buena Vista Lake contains small quantities of mica due to an admixture of some granitic material transported and deposited by streams rising in the high mountains to the south.

The subsoil below 12 to 36 inches may resemble the surface material in texture, but where typically developed is somewhat heavier and more compact. It is in many places formed of alternating beds of sand, silt, and gravel, the latter being most common near the foothills. The subsoil is slightly browner than the surface soil. White mottlings and grayish seams and streaks of calcareous material occur. Below 4 or 5 feet the lime is distributed uniformly through the soil material, and the proportion is less. The substratum to a depth of many feet resembles the subsoil in color. For the most part it is formed of more or less stratified beds of sand, silt, and gravel.

The Panoche gravelly sandy loam consists of a medium-textured sandy loam containing varying quantities of small flat shale gravel, and where the small intermittent streams begin to subdivide and spread over the fans considerable coarse gritty sand and very small rock fragments occur. The soils in such places are more porous and droughty than the average, and in places appear as barren spots on the slopes. The soil has less organic matter and averages grayer in color than the fine sandy loam. In other respects the type follows the description given for the fine sandy loam.

The type is most uniform in the areas lying farthest out on the plains. A number of small areas of silt loam occur at intervals in the region southeast of Buena Vista Lake. In some of the more elevated older parts of the type and in areas near the browner old valley-filling deposits the soil is grayish brown or brown, and these areas might be separated as a different soil in a more detailed survey.

The Panoche sandy loam is of small extent. It occurs on the steeper alluvial fan slopes and where the streams are active. It is grayer in color and inclined to be more droughty than the fine sandy loam, but except in these features and that of texture accords with the description of that type.

The soils of this group are lighter in color, lower in organic matter, and much higher in lime than the Yolo soils (mapped in other parts

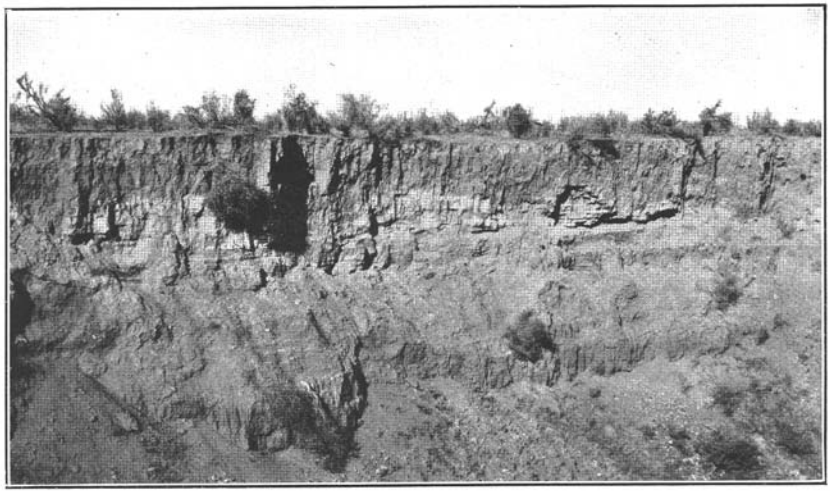

Photo by Univ. of California.

FIG. 1.—SECTION SHOWING PROFILE OF THE PANOCHE SANDY LOAM WEST OF TULARE LAKE.

Note columnar structure and zone of lime accumulation, indicated by light color in the subsoil.

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FIG. 2.—VIEW OF AREA OF HANFORD LOAMS SOUTH OF BAKERSFIELD, SHOWING VIGOROUS GROWTH OF GREASEWOOD.

of the State). Their less uniform surface and modified subsoil would indicate that the Panoche soils are of somewhat greater age than the Yolo soils. A few small knobs occupied by the Kettleman fine sandy loam were included with the group as mapped.

Location.—The Panoche sandy loams are widely developed on the west and south sides of the San Joaquin Valley. Many tracts occur along the eastern and western footslopes of the Temblor Mountains, and extensive areas are developed on the alluvial fans southeast of Buena Vista Lake. Areas of importance also lie along the lower slopes of the Kettleman and Elk Hills and over the valley floor southwest of Tulare Lake. A long narrow body occurs on Poso Creek on the east side of the valley, and one occupies part of the large fan south and southeast of Soda Lake. The gravelly sandy loam bodies are chiefly developed on the foot slopes north and northwest of Taft and McKittrick and also on the steeper fans lying on both sides of the Temblor Mountains.

Topography and drainage.—The soils of the group form uniform valley plains and large symmetrical alluvial fans with a few associated minor intermittent stream bottoms. The surface is sloping, the slopes being steepest near the hills and mountains and gradually decreasing toward the valley trough. Small undulating areas occur locally, but as a rule the surface features are those typical of recent alluvial soils. The surface is smooth and uniform over extensive areas, but a slight tendency to a hog-wallow configuration with other minor irregularities occur in a number of places. Part of the group north and northwest of Lost Hills has an undulating surface, due in part to the action of small streams, and in part to deposition of the material by wind. Small streamways cross the areas in a number of other places, but they have not influenced the character of the surface to any great extent. The drainage of these soils is good to excessive, and there has been no accumulation of alkali.

Utilization.—The soils of the group are inherently adapted to a wide range of fruits and other intensive crops, but owing to lack of water for irrigation nearly all their extent is used for pasture only. Shad scale and a scant growth of grasses constitute the native vegetation, and from 10 to 20 acres are required to support one steer. Small areas are used for the production of dry-farmed grain and grain hay in the most favorable locations, but the yields are small and uncertain. Much of the land in the foothills belt along the west side of the valley is occupied by oil companies. Most of the land is held in large tracts and will be of little use to agriculture, except for pasture, for a long time to come. Underground water is practically unobtainable, and where available is commonly of poor quality. The remote situation of the soils from other sources of

water supply make it unlikely that gravity systems will be installed, especially as long as there is an insufficient supply for readily accessible lands.

Panoche sandy loams, high phase.—The high phase of the Panoche sandy loams group includes high lying areas of the sandy loam types of the series. There are 45.1 square miles of soils of this kind in the area, the finer soil forming 85 per cent of the total.

Description.—The surface soil of the Panoche fine sandy loam, high phase, is light grayish brown or gray in color and friable and open in structure. It averages light in texture and in many places closely approaches a loamy fine sand, such areas here and there showing the effect of wind action. It contains in places small quantities of fine subangular or flat shale gravel. Small accumulations of lime also are present. The admixture of organic matter is small. At depths of 12 to 24 inches the soil rests upon a light-brown or grayish-brown subsoil, which is typically somewhat heavier in texture and more compact than the surface. In places, however, the subsoil differs but little from the soil, except in content of lime, which is greater in the former. The subsoil is usually friable and readily permeable by roots and water. The substratum is similar to the subsoil, except that it usually contains less lime and is in places somewhat stratified.

The high phase of the sandy loam is developed in only small tracts. It accords with the description given for the fine sandy loam except in texture and in being, as a consequence of the coarser material, somewhat more porous and droughty. It also contains larger quantities of gravel.

The high phase of the Panoche sandy loams is variable and includes a number of small recent alluvial fans, each of a few acres in extent, which are occupied by the typical soils. It also includes small patches of Panoche sand, fine sand, and gravel, and a few small knobs on which the Kettleman sandy loam is developed.

Location.—The phase is most extensive along the western footslopes of the Temblor Mountains, where it occurs in long, narrow strips. A number of small areas are also mapped along the foothills in the region about McKittrick and Taft.

Topography and drainage.—The topographic features vary considerably, but consist chiefly of areas of gentle to moderate slope or of undulating to slightly rolling character. The surface in detail is smooth for the most part except where wind action has heaped the soil into low hummocks. A number of small intermittent drainage ways cross the areas, but they are seldom deep and do not greatly affect the value of the land. The drainage is thorough.

Utilization.—Because of the low rainfall in the part of the area where these soils occur and the practical impossibility of securing

irrigation water, the soils are utilized only as pasture land. They carry a scant growth of grass and shad scale, so that it requires from 15 to 20 acres to support one steer.

PANOCHE LOAMS.

The Panoche loams group includes the silt loam, loam, and gravelly loam types of the Panoche series. It is extensively developed in the survey, covering an area of 682.9 square miles. Of this total the silt loam forms about 60 per cent and the loam about 30 per cent.

Description.—As typically developed, the surface soil of the Panoche silt loam consists of a light grayish brown or gray silt loam from 12 to 24 inches deep. In the lower and flatter parts the soil has a rather compact structure and there are included many areas of smooth playa flats, barren of vegetation, on which water stands for considerable periods in wet weather. On the more sloping areas it is granular and friable. In places near the browner old valley-filling soils, and where the soil-forming material is older, the color is darker, averaging a grayish brown or light brown, but such areas are not typical. The surface soil averages light in texture and in many places closely approaches fine sandy loam. It is low in organic matter. It is easily tilled and even in its most sloping positions retentive of moisture. Lime in varying amounts is uniformly distributed through the surface soil in most places. Small deposits of flat shale gravel are present in areas lying along drainageways and over parts of the more steeply sloping fans. The gravel content is greatest near the foothills, and in some places small bodies contain enough such material to warrant separation of a gravelly loam type in a detailed survey. The subsoil, which is grayish brown or light brown in color, generally resembles the surface soil in texture. It is inclined, however, to be somewhat more compact and slightly heavier than the surface material and is more or less stratified, especially on the steeper slopes and where the streams are active. Lime occurs in varying quantities, appearing in streaks and seams and grayish mottlings. In a few places it has partly cemented the subsoil materials. Most of the lime is concentrated between the second and fifth feet. The substratum resembles the subsoil except that it is lower in lime.

The type is most variable along the foothills, where some of the areas occupy relatively high positions and are somewhat weathered. Small areas of sandy loam and fine sandy loam occur in many places on elevations lying a foot or two above the drainageways. Deposits of sand 1 or 2 inches thick are present in some of the most exposed situations on the valley floor. The sand drifts considerably in windy weather and occurs as small heaps around bunches of weeds

or brush. Many small barren flats, lying a few inches to 1 foot below the general surface, also occur at intervals over the floor of the valley. These are covered by temporary ponds in wet weather. The soil in such places is somewhat puddled from the standing water and in many cases is somewhat heavier than the average for the type.

The Panoche loam is most prominently developed on the upper slopes of the group areas and is usually more open textured and friable than the silt loam. It also contains small quantities of grit and in most places higher percentages of gravel than the latter type. Except for these particulars the loam corresponds to the description given for the Panoche silt loam.

The gravelly loam is the least extensive of the types in this group. It occurs in small areas on the upper slopes of alluvial fans. Except for the presence of gravel, a slightly lower content of organic matter, and a somewhat compact surface, it resembles the loam type. The gravel consists principally of small flat shale fragments. The quantity of gravel in the soil varies greatly and in many places is not great enough to seriously affect tillage. The Panoche gravelly loam may be uniform in texture to the depth of 6 feet or more, or the material may be underlain at any depth by a gravelly sandy loam or a more gravelly loam. The substratum also is generally gravelly and of variable texture.

The large areas of the soils of this group are usually fairly uniform in character, but in marginal areas and in small valleys they depart from the typical material. Along the western edge of the Carrizo Plain the soils are of lighter texture than the average and in a few places resemble the Panoche sandy loams. As mapped along drainageways in the Cuyama Valley they approach in texture a fine sandy loam, sandy loam, or gravelly sandy loam. In much of the area of Panoche silt loam on the southern side of Buena Vista Lake the soil is higher in organic matter than typical and includes strips of Muck and Peat immediately along the lake. The soil of this body also contains much mica where it merges into soils of the Foster or Merced series, and in this respect approaches in character the Hanford types. The large body on the alluvial fan east of Maricopa is an unusually light textured variation and in a more detailed survey would be mainly mapped as a fine sandy loam. Areas of well-developed brown soils which approach in character the recent alluvial soils classed in the Yolo series are also included. These are somewhat higher in organic matter and less calcareous than the typical Panoche types. A few small knobs occupied by the residual Altamont and Kettleman soils and several small bodies of the high phase of the Panoche sandy loam were included in the group. About 4 miles west of Soda Lake a small narrow strip of dark-gray or black Dublin clay loam was also mapped with this Panoche group on account of

its small extent. It is a recent alluvial soil and resembles similar types of the Panoche series, except for its dark color and higher content of organic matter.

Location.—The group comprises the most important soils on the west side of the main valley trough. It is most extensively developed in the region south, west, and north of Lost Hills, on the west side and over most of the floor of the Carrizo Plain, and south and southwest of Tulare Lake. Several large, irregular tracts and many small ones are situated in valleys or on well-drained footslopes in other parts of the area. Important bodies also occur in McLure and Antelope Valleys, west, south, and east of Buena Vista Lake, and along the base of the Temblor Mountains and the Kettleman and Elk Hills.

Topography and drainage.—The soils occupy extensive, gently sloping to nearly level valley plains, alluvial footslopes, and well-defined, smooth-surfaced alluvial fans. The surface is gently undulating in the region west of Lost Hills and in a few other places, owing mainly to erosion and deposition by streams. In a few spots it is hummocky, but such areas are usually associated with the old valley-filling soils. Minor drainage ways cross the group in places, but they have added only slightly to surface irregularities. The soil is well drained in its more sloping positions, but water passes downward very slowly in many of the small depressions on the valley floor. Accumulations of alkali have formed in the east side of McLure Valley, in the vicinity of Buena Vista Lake, and in a few other places of small extent along the trough of the valley. These are the result of a high water table and defective subdrainage. The greater part of the group possesses good surface drainage and subdrainage.

Utilization.—The soils of this group are adapted to a wide range of fruits and general farm crops where water is available for irrigation, but because of the limited water supply more than 98 per cent of the group is utilized for pasture only. A fairly heavy growth of shad scale and a scant growth of grasses form the greater part of the vegetation. From 10 to 20 acres are required to support one grown animal. The underground water, which is rarely available, is mostly of poor quality, containing large quantities of alkali salts. Obtaining water for irrigation from outside sources is only remotely possible, as there is now not enough for the more easily accessible lands. Small crops of barley, grain hay, and milo are grown without irrigation in a few of the more favorable situations, but the yields are light and uncertain. Most of the soils of the group are far removed from shipping points, and except in the oil fields the land commands a low price. Development of water for irrigation and

domestic use is the greatest need of these soils. With this provided, the types would become valuable farming soils.

PANOCHE CLAY LOAM.

Description.—In its typical development the surface soil of the Panoche clay loam consists of a light grayish brown or light-gray rather compact clay loam, from 12 to 18 inches deep. In low-lying areas the soil is slightly darker in color and heavier than typical and in many places closely approaches a clay in texture and tends toward an adobe structure. The surface soil is low in organic matter, is usually difficult to till unless handled at the right degree of moisture, and is slow to absorb water in untilled areas. Small quantities of grit and fine gravel are present on the steeper slopes and along stream channels, and the texture is also lighter in such places. In most places the soil apparently does not contain free lime. Over part of the type there appear scattered "slick spots" which are devoid of vegetation and almost impervious to water. The subsoil resembles the surface soil in most respects, but is ordinarily more compact. It contains concentrations of lime, most of it being concentrated in the second, third, and fourth feet, but small quantities are present at greater depths.

This soil is of small extent, covering an area of only 15.7 square miles. Its occurrence in small tracts causes considerable variation in character. A high phase of this type occurs in connection with the Panoche loam high phase.

Location.—Two of the largest areas are situated in the northern part of Antelope Valley and a small one several miles north of Lost Hills. An area several square miles in extent lies about 15 miles south of Bakersfield, and a small one is mapped near the southern end of the Carrizo Plain. Another small tract occurs in the extreme northwestern corner of the survey, uniting with a similar one in the adjoining area to the north.

Topography and drainage.—The soils occur on gentle slopes and in low flat valley depressions. The surface is smooth and uniform except for a few small irregularities and stream channels which cross some of the areas. Most of the type is well drained, except the tract south of Bakersfield where the water table is close to the surface and large quantities of alkali are present.

Utilization.—The soil is used only for pasture. Dry-farmed crops are uncertain, and there is no water for irrigation. On the well-drained lands and elsewhere the alkali content is too high for cultivated crops. Most of the type is remotely situated and has a relatively low market value.

PANOCHE LOAM AND CLAY LOAM, HIGH PHASE.

This group of soils, including the high phases of the Panoche loam and clay loam types, covers an area of 91.2 square miles, of which the loam forms about 90 per cent.

Description.—The Panoche loam, high phase, consists of a light grayish brown or gray medium to light textured loam, from 12 to 18 inches deep. Some variations have a rather brown soil but such areas are small. The soil contains some gravel locally. It is friable, low in organic matter, easily tilled, and receptive of moisture. It contains some lime, which is uniformly distributed through the soil mass. The subsoil is in most cases a somewhat lighter brown than the soil but in many places does not differ greatly in color except for grayish splotches and streaks due to concentrations of lime. Where typically developed it possesses a somewhat heavier texture and more compact structure than the surface material, but in a number of places it is only slightly more compact. The substratum resembles the subsoil, except that it is slightly stratified and contains less lime.

In some of the lower and more gently sloping positions the material resembles the typical Panoche loam. The tract around Soda Lake on the Carrizo Plain contains lenses of calcareous hardpan, and in other parts the subsoil is distinctly heavier than the surface soil. It includes a few small bodies of the typical Panoche loam and sandy loam, which could be shown separately in a more detailed survey. In the areas north and northwest of Taft, the soil contains considerable quantities of coarse grit and small, light-colored shale fragments that interfere somewhat with tillage.

The high phase of the Panoche clay loam occurs as small irregular bodies, strips, and spots in association with the high phase of the loam, and except for texture and a more compact structure resembles the loam. The high phases of these soils represent a distinctly older soil condition than typical Panoche material, although the boundary between the two is not everywhere distinct.

Location.—The group occurs in many moderate to small tracts along the eastern slopes of the Temblor Mountains, from a point west of Dudley southward to Taft. A small area lies in the foothills in the southeastern part of the survey, near where the State highway enters the mountains, and one occupies the southern extension of Lost Hills. A number of bodies are mapped in the vicinity of Simmler, and several of greater extent in the hills around Soda Lake and to the west.

Topography and drainage.—The soils of this phase of the Panoche loam and clay loam have a sloping, undulating, or gently rolling topography. The most uneven surfaces usually occur at the higher elevations, where the soils unite with those of the Kettleman series.

Drainage ways passing through the areas have sloping banks. The surface in many places has a distinct hummocky appearance. The drainage is good except around the margin and north end of the tract adjoining Soda Lake. Some alkali is present in this poorly drained land.

Utilization.—Nearly all the group is situated in that part of the area which receives very little rainfall, and consequently most of the soils are unfit for anything except pasture. The bodies around Simmler are used for dry-farmed grain and grain-hay production, and in years of normal rainfall and where the soil is well handled, fair yields are obtained. The soils are somewhat more productive than the high phase of the Panoche sandy loams. Water for irrigation of these soils is practically unobtainable, and they must continue to be used for pasture, except in the most favorable situations where dry farming is possible.

HANFORD SERIES.

The Hanford series of soils consist of recent alluvial deposits derived mainly from granitic rocks. The surface soils are brown or grayish brown in color, are micaceous, and contain a small to moderate admixture of organic matter. The subsoil resembles the surface soils in structure and texture except where stratified. The substratum resembles the subsoil. Little or no free lime occurs in the soil, subsoil, or substratum, and no hardpan or other obstructions to root development are present. Drainage conditions vary, being restricted in the lower and flatter positions, where more or less alkali has accumulated as a result. The series occupies stream bottoms or alluvial fans with nearly level to gently or moderately sloping surfaces, smooth and uniform, except where modified by stream erosion or deposition. The series occurs in two definite positions in this survey, viz, along stream bottoms, and on extensive alluvial fans forming parts of the valley plains. The soils in the latter position occasionally resemble those of the Delano types, with which they gradually merge. The soils differ from the Delano types in character of subsoil and in lime content, and from the Panoche series in origin of material and in color.

Three Hanford groups and a group of Hanford and Foster soils were mapped in this survey.

HANFORD SANDS.

The group Hanford sands includes the fine sand and sand of the series and small areas of coarser Hanford material. It covers an area of 72.9 square miles, of which about 60 per cent is occupied by the fine sand.

Description.—The surface soil of the Hanford fine sand is a brown or light grayish brown, friable, micaceous, loamy fine sand, containing only a small to moderate quantity of organic matter. The subsoil varies but little from the surface soil in typical areas. At a depth of 12 to 15 inches it is somewhat lighter in color, and the texture and structure vary considerably, owing to stratification. The areas lying in the stream bottoms are most variable in subsoil and for the most part consist of stratified sands, fine sands, silts, or gravel without definite arrangement. This is especially true in the bottoms of Kern River and Caliente Creek.

The surface soil of the Hanford sand is a somewhat lighter grayish brown, more open in structure, and lower in organic content than the fine sand. It consists largely of micaceous sand, but small gravelly areas are numerous. The subsoil, like that of the Hanford fine sand, is generally more variable in stream bottoms than on the fans. The type is more droughty than the fine sand, but in general resembles that type. The tract lying just east of the Rock Pile School departs from typical in possessing a somewhat older and more compact subsoil, in containing more gravel and cobblestones, and in having a more steeply sloping surface.

Location.—The group is represented by several areas of large size as well as a number of smaller areas, situated in the eastern and southeastern parts of the survey. The largest areas were laid down by Caliente Creek and Kern River.

Topography and drainage.—The group varies little in topography. The parts situated in stream bottoms are marked by winding stream channels and modified somewhat by overflow conditions. The areas in the valley plains occupy ridges lying several feet above the adjacent soils. Here the surface has been modified considerably by wind action, but such irregularities are not pronounced, and the land for the most part may easily be prepared for irrigation. Surface drainage and subdrainage are good, except in some of the low-lying parts along Kern River. Some alkali occurs in these areas. In some of the higher and coarser textured areas the soils are porous and droughty.

Utilization.—The areas along Kern River west of Bakersfield, which support a growth of brush along the stream courses and grasses of poor quality, are used mainly for pasture. The large fan-shaped area formed by Caliente Creek is more extensively farmed, kafir, grain, alfalfa, and grapes being the principal crops. The yields depend largely upon the supply of irrigation water, upon the presence of organic matter, and upon good tillage. Underground water for irrigation is available for parts of the group, and in a few other places gravity supplies are obtained.

HANFORD SANDY LOAMS.

The Hanford sandy loams group includes the Hanford sandy loam and the Hanford fine sandy loam. Of these the fine sandy loam is much the more extensive.

Description.—The surface soil of the Hanford fine sandy loam is a brown or grayish-brown micaceous fine sandy loam ranging in depth from 12 to 72 inches. Where poorly drained the color is a darker brown, or where the type merges with the Foster or Tulare series, and along El Paso Creek, in the southeastern part of the survey, it is somewhat reddish brown. The color is in general grayer near the trough of the valley and in recent stream bottoms than elsewhere. While the typical surface soil is a fine sandy loam in texture many small areas approximate a loamy fine sand, and here and there a loam or silt loam texture is developed. Where not uniform in profile, to a depth of 6 feet the subsoil consists of strata of sand, silt, and, in places, gravel, without definite arrangement. The subsoil is usually a lighter shade of brown than the soil. Typically the surface soil contains only a moderate amount of organic matter, but the darker colored areas are higher in this constituent. The type retains moisture moderately well. The typical Hanford fine sandy loam occupies stream bottoms and overflow plains. An important variation lies on alluvial fans and alluvial valley footslopes. The flood plain, or stream bottom areas, often pass gradually into the alluvial fan areas, or they may be separated by a terrace or a slight change in topography. In alluvial fans the material is normally more uniform in profile than in the stream bottoms, being less definitely stratified.

The substratum closely resembles the subsoil, except that it is frequently saturated with water in the river bottoms.

The Hanford sandy loam resembles the fine sandy loam in color, and other soil and subsoil features except texture. It, however, contains less organic matter and is more open and droughty. The alluvial fan areas of this type are extensive, forming most of the plains along the south and east sides of the valley. The material is more uniform in texture than in the stream bottoms. The fan areas have more coarse, gritty sand than the stream-bottom developments. The soil on the fans also contains a little less mica on the average than the areas in the river bottom, and is generally a richer brown in color. The material of the alluvial fans is somewhat older than that of the stream bottoms and in places is slightly weathered, and is beginning to develop more compact subsoils carrying concentrations of lime. Here and there, through the bodies and in spots along their margins, the material already resembles some of the more poorly developed Delano types of the old valley-filling group, small

areas of which are included locally. As a whole the material is, however, similar to that mapped on the plains in other parts of the San Joaquin Valley, and resembles the typical Hanford sandy loam too closely to warrant differentiation. The areas occurring upon the valley plains are nearly always well drained, and sometimes extend up slopes of considerable gradient.

The Hanford sandy loams are practically free from gravel in their occurrence on the plains and along stream bottoms, but noticeable deposits, including some cobblestones and large bowlders, occur on the alluvial fans lying along the margin of the survey southeast of Bakersfield. These gravelly or stony strips mark the location of intermittent water courses, and in places extend several miles out into the valley.

Location.—The Hanford sandy loam group is developed only on the east side of the San Joaquin Valley. It is a very important and extensive group of soils and is widely distributed. The areas are associated with the larger stream courses and most are of large size. They generally occupy well-defined stream bottoms near the hills from which the streams emerge, but farther out in the valley the materials are deposited in extensive alluvial fans.

Topography and drainage.—The surface of the types of this group is generally uniform and smooth or slightly ridged, except near the streams where the slope varies considerably, ranging from 5 to 10 feet to the mile over much of the valley floor, to as much as 100 feet per mile on the steeper footslopes along the margins of the plain. Leveling for cultivation or irrigation is easily accomplished, except where stream action has been extremely active. The types for the most part are well drained, but the lower lying tracts near the valley trough are affected by a high water table and accumulations of alkali, especially on the large fan of Kern River west and southwest of Bakersfield. Here the alkali occurs in spots and irregular strips varying from a few square rods to many acres in size and ranging in amount from very low to high concentrations. Such areas are distinguished by a growth of alkali vegetation or by surface deposits of salts. Surface drainage is good over most of these soils, but small depressed spots and partially clogged drainage ways contain water most of the year. There is sufficient fall for drainage of these areas if adequate outlets are provided. Drainage conditions in this part of the area would be improved if more of the water for irrigation were pumped from the underground supplies, as this would tend to lower the water table.

The Hanford sandy loams are derived principally from granitic rocks and much of the material has been transported a long distance before reaching its present position.

Utilization.—Owing to a smaller rainfall the Hanford sandy loams of this area support in their virgin state a less abundant growth of vegetation than similar types farther north. Along the river bottoms and in other moist places if the content of alkali is not great, willow, vines, and brush flourish. Salt grass, greasewood, salt wort, shad scale, alkali heath, and a number of other alkali resistant plants predominate in the affected areas. On the dry plains a sparse growth of grasses and shad scale constitutes the principal vegetation. Probably somewhat more than 50 per cent of the area of this group of soils is under cultivation, and the most intensive agricultural development in the survey occurs on its alkali-free parts. Grapes, both for table use and raisin making, do very well under irrigation. Other crops such as peaches, apricots, alfalfa, milo, potatoes, grain, and vegetables give satisfactory returns, but all require irrigation except grain, and that is uncertain, being dependent upon the amount and distribution of the rainfall. The soils respond readily to manuring, good cultivation, and irrigation. Under irrigation two crops may be produced on the same land in one growing season. Most of the water used in irrigating these soils is obtained by pumping, and in many places large supplies can still be developed by this method.

Most of the area covered by these types is well supplied with good roads and lies near shipping points. Much of the land favorable for farming is thickly settled, but there are still large undeveloped tracts well suited for intensive cultivation.

Land values vary according to quality of soil, occurrence of alkali, location, and irrigation possibilities, ranging from $10 to $25 an acre for the least desirable parts to $100 to $250 an acre for the better lands.

HANFORD LOAMS.

The Hanford loams group includes the loam and silt loam of the series, the latter comprising about 60 per cent of the combined area.

Description.—The surface soil of the Hanford loam consists of a brown or grayish-brown, friable, micaceous light-textured loam containing a small to moderate admixture of organic matter, and having a depth of 12 inches to 6 feet. Typically, the subsoil resembles the surface soil in texture and structure, but in places it is slightly more compact. The color is brown but lighter than the surface. The substratum is similar to the subsoil. Both are retentive of moisture and are readily penetrated by roots and water. In the tract along the San Emigdio Creek the soil contains some coarse grit and gravel and in some of the lower lying areas south of Bakersfield the subsoil is stratified, layers of fine sand, silt, and clay loam alternating. Tests with hydrochloric acid indicate the presence of small

amounts of lime. In places of poor drainage the subsoil has a grayish cast and is sometimes mottled with iron stains. Small spots of lighter or heavier textured soils are included with the type as mapped. The type becomes somewhat browner or grayer where it merges with darker or lighter colored soils of other series, and in some instances it possesses a slightly heavier and older subsoil, somewhat resembling the old valley-filling soils.

The Hanford silt loam differs little from the loam except in its higher content of silt and consequent smoother or more velvety texture. The subsoil at a depth of about 12 inches becomes a more grayish brown than the surface soil. It may include layers of material of heavier or lighter texture, some of which are a little calcareous. Silt loam is the prevailing texture in the two bodies south of Fairfax School. The soil of these areas is highly impregnated with alkali and the land will be of little value until reclaimed.

Location.—The Hanford loams group covers but a few square miles. The principal bodies lie south of Bakersfield and northeast of Buena Vista Lake. Other small areas are mapped in the southern part of the survey along San Emigdio Creek, and one occurs south of Wasco.

Topography and drainage.—The topography of the group is generally level and smooth, resembling that of the other types of the series. The areas occupy low-lying marginal parts of large alluvial fans. The retarded drainage and high capillarity of the silt loam type have caused excessive accumulations of alkali. The concentration in the surface is enough to make the soil soft and spongy, the foot sinking into the dry soil several inches at every step. The loam body near Buena Vista Lake has a high water table and is likewise affected by alkali, though to a much less extent. Elsewhere the soils are well drained and free from alkali.

Utilization.—Not much of the group is used for farming, because of unfavorable alkali conditions. The badly affected silt loam areas have a growth of greasewood (Pl. IV, fig. 2) and saltwort, with practically no other form of vegetation. The body near Buena Vista Lake produces some grain and scanty salt grass pasturage. The area near Wasco produces corn, grain, alfalfa, and fruits, and the body along San Emigdio Creek has been planted with oranges. Irrigation is practiced where the soils are good if water is available. Underground water is available by pumping in the areas south of Bakersfield. The soil is easily handled and yields are high where drainage and alkali conditions are favorable. The value of the land ranges from a few dollars to $100 or more an acre depending upon location, freedom from alkali, and drainage conditions. Drainage and the removal of alkali are necessary for the best use of most of these types.

Foster Series.

The Foster series includes types derived from recent alluvial deposits washed mainly from granitic rocks. The soils are dark brown or dark grayish brown, micaceous, and high in organic matter. The subsoils are brown, grayish brown, or dark brown, and either resemble the surface in texture or are stratified. The substratum resembles the subsoil, but locally it may consist of old valley-filling material over which the recent Foster soils have been deposited. The soils of this series occupy the lower and flatter extensions of alluvial fans, small depressions, and long, narrow, irregular areas along present or abandoned drainageways. The surface is smooth and uniform. Drainage is generally deficient and locally some alkali has accumulated. The series in this area departs from the typical in having in places small concentrations of lime in the subsoil. The series differs from the Hanford series in its darker brown color and higher organic matter content and from the Chino series in its lighter color and more calcareous subsoil. The series is represented in this survey by a group of the Foster sandy loams and a group of Hanford and Foster sandy loams.

FOSTER SANDY LOAMS.

The Foster sandy loams group includes the fine sandy loam and sandy loam types of the Foster series. Of the combined area the fine sandy loam forms about 75 per cent.

Description.—The surface soil of the Foster fine sandy loam is a dark grayish brown, friable, micaceous fine sandy loam. The soil contains more organic matter than the types of the Hanford series. Like the latter it absorbs and retains moisture well and is easily tilled under all moisture conditions.

The subsoil, beginning at 12 to 20 inches, is generally lighter in color than the soil, ranging from brown or light grayish brown to gray, the shade bearing a relation to drainage conditions. The texture varies from a fine sandy loam to a sandy loam or silt loam, and the material in many places is stratified. The substratum is similar to the subsoil. Little or no gravel occurs in either surface soil or subsoil of typical areas, but small quantities may be present in places near the streamways. Lime is rarely present within the 6-foot profile, but accumulations are present here and there in the substratum.

In general characteristics the Foster sandy loam differs little from the fine sandy loam, the chief variations being in texture and color, which is a slightly darker shade of brown. The two types are closely associated; in most cases the sandy loam occupies the higher position.

Location.—Several areas of this group of soils lie south and southwest of Bakersfield. They are surrounded by heavier types of the

same series, or by soils of the Hanford series; in many places occupying narrow depressions winding through the latter.

Topography and drainage.—The surface is level and uniform and slightly lower than that of the Hanford series. The land is easily prepared for irrigation. Over much of the group there is a high water table and drainage is necessary for the best results with cultivated crops. Owing to restricted drainage, some alkali has accumulated, appearing in numerous scattered spots of surface concentration on the slight elevations.

Utilization.—Much of the land of this group is producing moderate yields of alfalfa, corn, grain, and fruit, while parts are still covered with salt grass and used only for pasture. Where the soil is irrigated and free from alkali the yields are good, but alkali in many places causes poor yields. Water can be obtained for irrigation by pumping from the underground supply. The soil is easily tilled at all times.

HANFORD AND FOSTER SANDY LOAMS, UNDIFFERENTIATED.

The Hanford and Foster sandy loams, undifferentiated, include the Hanford sandy loam and fine sandy loam and the Foster sandy loam and fine sandy loam. In this group the types occur in small areas, intimately associated, making separation impracticable. The group area is 37.1 square miles, of which the fine sandy loams cover about 75 per cent, the rest being about equally divided between the sandy loam types.

Description.—Each of the types has been described in detail elsewhere in this report, and the reader is referred to these descriptions.[6]

Location.—The only body of this group of soils mapped lies north of Kern Island. It is of very irregular outline, and the boundaries are more or less indistinct.

Topography and drainage.—The group occupies a low position on the extensive fan formed by Kern River. The surface is slightly undulating, the area including shallow swales and small, narrow depressions bordered by ridges rising several feet above them. In a general way, the swales are occupied by the Foster soils and the ridges and more elevated parts by soils of the Hanford series. The areas of the Foster soils are in many places poorly drained, have a high water table, and here and there contain local accumulations of alkali. The alkali is commonly confined to the more elevated parts, which are least disturbed by overflow. Surface and seepage waters from the higher lands collect in the low places, making it necessary to drain the land before attempting to grow crops.

[6] See p. 90 for Hanford sandy loams, and p. 94 for Foster sandy loams.

Utilization.—About 75 per cent of the area is producing alfalfa, grain, corn, sugar beets, and other farm crops. Dairying and hog raising are also important. The least desirable parts are used for pasture. The yields under present conditions are only moderate. The addition of organic matter and the drainage of wet areas would result in marked improvement over most of the group. On parts of the group crops can be grown by dry-farming methods, but irrigation gives best results. Water is supplied by canals and by pumping from underground supplies. Land values depend upon the quality of the soil, alkali, drainage, and location.

Chino Series.

The Chino series consists of recent alluvial deposits having their origin mainly in granitic rocks. The series is thus similar in origin, mode of formation, and in occurrence to the soils of the Hanford and the Foster series.

The surface soils are typically dark gray to black, but there occur variations in which the material is of a dark brownish gray shade and which approach in color the soils of the Foster series.

The Chino soils are distinctly micaceous, high in organic matter, and here and there mildly calcareous. The subsoil is similar to the soil in color or of lighter grayish or brown color, and generally calcareous material of high lime concentration occurs, this being gray or light gray in color and resembling marl. In texture and structure the subsoil may be similar to the soils, or it may consist either of lighter or heavier textured materials stratified but without regular order of occurrence. Occasional compact or partly cemented calcareous seams or layers are present. The series occupies the lower and flatter parts of alluvial fans and in many places lies in shallow depressions or swales with soils of the Hanford and Foster series. Drainage is poorly established, many of the areas having a high water table and accumulations of alkali salts. The series is distinguished from the Hanford and the Foster series by the darker color of the soils and by the calcareous nature of the subsoil.

In this survey the soils of this series in places approach in character the lake-laid soils of the Tulare series, and some Tulare material may be included. The Chino series is represented in this survey by one group, Chino and Foster loams, undifferentiated.

Chino and Foster loams, undifferentiated.

The Chino and Foster loams, undifferentiated, include the silt loam and the loam types of both the Chino and the Foster series. The group occupies an area of 45.8 square miles, of which the silt loam types cover about 80 per cent. The Foster soils predominate.

Description.—The surface soil of the Foster silt loam is a dark-brown or dark grayish brown, micaceous, friable silt loam, containing a relatively large proportion of organic matter. The surface soil in places extends to a depth of 4 feet or more without change, but a change to lighter brown or grayish brown generally occurs at a depth of 12 to 24 inches. The subsoil may be similar to the surface soil in texture or may consist of strata of silt, sand, and clay. It is for the most part friable and a good medium for root development where not water-logged or impregnated with alkali. The Foster silt loam is uniform over most of its extent, but a variation covering small areas has a compact subsoil with accumulations of lime, and a few other minor irregularities occur locally. The texture in parts of the areas varies greatly within short distances, being lighter or heavier than the typical, depending upon the situation with respect to stream channels. Shell fragments are present in the tract east of Buena Vista Lake, which indicate a former higher level of the lake waters, and such areas approach in character the soils of the Tulare series. The heavier textured variations of the soil crack somewhat upon drying.

The Foster loam is very closely associated with the silt loam, from which it differs chiefly in texture. Typically it is a medium or heavy textured loam, but the type is more variable than the silt loam. The loam areas are developed along the stream channels, and the drainage is ordinarily somewhat better than in the heavier type.

The surface soil of the Chino silt loam is a dark-gray or black silt loam, with dark-brownish variations where the soil merges with the Foster soils. It is generally micaceous, though less so than the Foster silt loam, and the content of organic matter is usually greater. It has a tendency to puddle and bake if cultivated under unfavorable conditions of moisture, but when properly handled it is loose and friable. The subsoil consists of light-gray or dark-grayish to brown materials which may be like the surface soil in texture and structure or may consist of alternating strata of differing textures. It is normally distinctly calcareous and in many places contains lime nodules, partly cemented calcareous seams and layers, or soft marly material of light-gray color when dry. In surface features and topographic position it is similar to the Foster silt loam, with which it is intimately associated and from which it is distinguished by its darker color and more highly calcareous subsoil.

The Chino loam conforms in essential features to the Chino silt loam, from which it differs in its slightly lower content of silt.

Location.—The soils of this group are not very extensive but several areas of importance exist. The larger of these lies east of Buena Vista Lake in the Kern Island district. Isolated tracts also occur

north of Kern Island, two north of Buena Vista Lake, several in the vicinity of Pond, along Poso Creek, one along the northern boundary of the area near Angiola, and a small one northeast of Delano, in Rag Gulch.

Topography and drainage.—The surface is very gently sloping along streams and nearly flat where influenced by lake conditions. The group, as a whole, lies lower than adjoining soils of other series, and its surface is marked by shallow depressions or swales. Both the run-off and seepage from higher lying soils collect in the areas of this group, and artificial drainage in many places is necessary for good results with tilled crops. Only small parts of the land are affected by alkali. The preparation of the soil for irrigation is comparatively easy. The large tract east of Buena Vista Lake has been protected from overflow by levees. Formerly it was under water much of the time in wet weather. It supported a growth consisting entirely of water-loving plants. The small isolated tracts in other parts of the area have vegetation similar to the surrounding soils. A scattered growth of thrifty mesquite trees occurs on the two small areas north of Buena Vista Lake.

Utilization.—Nearly all of the group is now used in the production of the general farm crops, to which it seems well adapted. Among the crops giving good yields are alfalfa, grain, corn, and sugar beets. These can be grown on the moister lands without irrigation, but even here irrigation gives better results. Underground water is available for pumping and gravity supplies are also obtainable.

LAKE-LAID SOILS.

TULARE SERIES.

The surface soils of the types included in the Tulare series are gray to light gray, the heavier soils, which predominate, being medium gray to light gray and the lighter textured types usually light gray, in places of light-brownish tint. The subsoil is of similar or slightly browner color. The upper subsoil generally resembles the surface soil in texture, but the deeper subsoil and substratum are in places slightly heavier, more compact, and mottled with gray and yellow iron stains. Both surface soil and subsoil are for the most part calcareous and contain numerous fragments of the shells of fresh-water mollusks. The soils of this series occupy smooth, flat, recently exposed lake beds, and consist of sediments of mixed origin, including small areas of undulating wind-modified beach deposits. Drainage is poorly developed. In places a high water table occurs, and parts not protected by levees are subject to overflow. Alkali salts occur here and there.

A group of sandy loams and sands, and the loam, clay loam, and clay types are mapped in this survey.

The soils of this series merge and join along the northern boundary of the area with soils of the Sacramento series.

TULARE SANDY LOAMS AND SANDS.

The Tulare sandy loams and sands group includes the fine sandy loam, sandy loam, sand, and fine sand types of the Tulare series. Soils of these various textures are intimately associated and merge one into another, but the fine sandy loam and fine sand predominate in the vicinity of Alpaugh, the sand is developed largely west of Alpaugh, and the sandy loam is most prominent just south of Tulare Lake. All the soils are of agricultural importance.

Description.—The surface soil of the Tulare fine sandy loam is a gray, light-gray, or light brownish gray, friable, fine sandy loam or silty fine sandy loam ranging in depth from 10 to 14 inches. It contains a small to moderate amount of organic matter and is fairly retentive of moisture. Mica and many shell fragments are present in the surface soil and subsoil. The latter is gray or dark gray, in places mottled, and ranges in texture from a compact fine sandy loam to a loam or heavy silt loam. The material is stratified in places and thin layers of peaty material are encountered locally. Lime is uniformly distributed through the soil profile, with small concentrations in the subsoil. The substratum is similar to the subsoil in color, but it is usually of heavier texture, more mottled, and not so well drained.

The type is free from gravel or stones, but is in some respects variable, owing to action of waves and currents. The type occupies a position between true lake bottoms and stream-laid deposits and has been modified by these agencies acting separately or together.

The sandy loam differs but little from the fine sandy loam except in texture. It is somewhat more gritty. The lower lying areas are usually of darker color and contain more organic matter. Toward the outer margin of the type, where it joins heavier textured soils of the valley plains, the lake-formed material is shallow. In some places the texture is very light and the material has been influenced somewhat by wind action. In general, the type is much more variable than the fine sandy loam. It lies at a slightly higher elevation.

The Tulare sand is a gray or light brownish gray open, porous, droughty sand of medium texture. For the most part it is more than 6 feet deep, but may be underlain at any depth below 36 inches by a slightly more compact fine sand or fine sandy loam. The type represents an old beach line partly encircling Tulare Lake. It has been modified considerably in distribution and topography by wind action. It contains little organic matter and still drifts more or less. Both

surface soil and subsoil are calcareous, owing largely to the presence of shell fragments. The Tulare sand represents a wind-modified material not entirely typical of the Tulare series. It is easily tilled at all times, is normally excessively drained, and is the least productive member of the group. The fine sand differs little from the fine sandy loam with which in many places it merges. It is of slightly coarser texture, more open structure, lower in organic matter, and less retentive of moisture. It has about the same depth as the Tulare sand, but has not been modified to such an extent by wind. Where the soils of the group join the Merced series or the heavier textured Tulare types they are darker in color, and in such places may include small areas of poorly drained material of heavy texture.

Location.—All the land of this group is situated in the vicinity of Alpaugh and in the depression south and southeast of Tulare Lake. There are four moderate sized areas and one large one shown on the map.

Topography and drainage.—The soils in this group, excepting the sand, have a smooth, nearly level surface. They occupy part of the original bed of Tulare Lake, which has been left dry by the natural recession of the lake or reclaimed by construction of levees. In places artificial drainage has been necessary for crop production. A high water table and active capillarity have caused the accumulation of alkali over much of the group. Alkali is rarely present in the lower positions, owing largely to periodic overflows, and as a rule it is not a serious menace where irrigation is practiced. Preparation of the land for irrigation is easily accomplished, except in case of the sand. Water for irrigation of parts of the areas is obtainable from the lake either by gravity or by a series of small lifts. The Tulare sand occurs typically as an old beach deposit, and much of it is slightly elevated above the adjacent soils. It has an uneven, hummocky, or undulating surface, is well to excessively drained, and is not subject to seepage or overflow. The soil blows, and is difficult to level and irrigate. It lies above gravity canals. Little alkali occurs in the sand, though marginal areas are spotted in places.

The material forming this group of soils has been transported from a great distance. It is derived from various kinds of rocks, among which granitic rocks are conspicuous, and was accumulated mainly under lake conditions, though modified somewhat over much of its extent by later alluvial deposits.

Utilization.—With the exception of the sand the soils of this group are used more or less for the production of cultivated crops. Grain, corn, alfalfa, sugar beets, and truck crops are among the most important products. Alfalfa does well on the better drained lands, but is rather short lived where the water table lies near the surface. With moderate care the root and grain crops give very good yields.

The soils are not generally well adapted to tree fruits on account of their low position, exposure to frost and winds, a fluctuating water table, and the possibility of injury from overflow and alkali. The best crops are produced in years of moderate rainfall. Nearly all the sand, and a considerable area of the other types, are used for pasture only. The soils are friable, easily worked at all times, and responsive to the application of manure or other forms of organic matter. The areas lack good roads. They are sparsely settled, and extensive areas are farmed without anyone living on the land. Land values range from about $15 to $20 an acre for the sand and areas affected with alkali to $75 or $100 for the most desirable soils in favorable situations.

TULARE LOAM.

Description.—The surface soil of the Tulare loam is a gray, dark-gray, or dark brownish gray, friable, light-textured loam, containing a moderate quantity of organic matter and numerous shale fragments and ranging in depth from 12 to 18 inches. The color varies considerably, and in some of the least typical areas is a slaty gray when dry. A fair amount of lime is present in the surface material. The subsoil consists of a grayish-brown or dark grayish brown heavy loam, silt loam, or clay loam, showing in places slight stratification and mottling. Color variations due to concentration of lime and to iron stains occur in the lower subsoil and substratum. The latter also varies greatly in drainage conditions. The type is most uniform in its lowest positions near the lake, the higher margins having been modified by alluvial deposits. The tract located northeast and east of Alpaugh shows the greatest departure from the typical. In this and in some other localities the subsoil is often heavier and more compact than in typical areas, and the type somewhat resembles the old valley-filling deposits, with a veneer of recent materials. Small areas of soils of the Fresno and the Hanford series are included. Minor differences in texture also exist in the zone of gradation between the loam and Tulare types of lighter texture. In the vicinity of small drainageways some spots and strips of the Tulare fine sandy loam and Tulare sand have been formed, which could not well be shown separately on a map of the scale used in this survey. Some of these areas resemble the types of the Foster series and are conspicuously micaceous.

Location.—Three soil areas, all in the vicinity of Alpaugh, represent the type. They cover a total area of 68.6 square miles and merge with other types of the Tulare series, the boundaries in many places being indefinite and difficult to trace.

Topography and drainage.—The surface of the type is flat or nearly so, and removal of excess surface water is slow. Leveling and

preparation for tillage are simple, except in the area northeast of Alpaugh, where irregularities exist that make the preparation more laborious and costly. The greater part of the type has been reclaimed from the lake and is protected from overflow by levees. A high water table generally underlies it, and because of its low-lying position in the valley trough drainage is not easily accomplished. Small drainage channels traverse the higher lying parts of the type and discharge their waters over the lower lying parts toward the valley trough. The tract northeast of Alpaugh is spotted with alkali accumulations, but elsewhere very little is present. Practically all the type can be irrigated either from the waters of Tulare Lake or from wells.

Utilization.—The two areas at Alpaugh are used in the production of sugar beets, grain, corn, alfalfa, and general farm crops. The other area, northeast of Alpaugh, is in pasture, brush and alkali-resistant weeds and grasses forming the vegetation. Crops are grown under irrigation, water being obtained from Tulare Lake by gravity or by a series of low lifts. The yields are usually good. Alfalfa is grown only on the better-drained parts, the high water table at the lower levels being unfavorable to this crop.

TULARE CLAY LOAM.

Description.—The surface soil of the Tulare clay loam consists of 12 to 16 inches of slaty-gray to dark-gray or dark brownish gray clay loam, as in most of the lake basin soils, the color differences in the dry and moist soils being pronounced. The soil contains coarse sand particles and shell fragments. The subsoil to the depth of 6 feet or more is lighter in color but typically similar to the surface soil in texture. In places it is slightly lighter or heavier, owing partly to stratification and partly to modification through age. Lime is abundant in surface soil, subsoil, and substratum, but it seldom occurs concentrated in zones or spots. The substratum consists of layers of mottled and usually stratified heavy materials which resemble the surface soil except in color and moisture conditions. The chief variations in this soil are apparent where it merges with other lighter textured soils. Here changes in texture are common. A more compact subsoil and higher content of lime appear along the margin of the areas, where they join the Merced soils, and in parts modified by recent stream deposits some micaceous material occurs.

Location.—The Tulare clay loam covers an area of 78.3 square miles. A large area lies south and southeast of Tulare Lake and one east of Alpaugh. A small one is mapped along the northeastern side of Buena Vista Lake. These all merge gradually with other

types of the same and of other soil series, causing boundaries in many places to be indefinite.

Topography and drainage.—The type occupies a low-lying position near or in the valley trough and has a smooth, uniform surface, interrupted only by shallow beds of small streams. Little difficulty is met in leveling or preparing the surface for irrigation. Owing to the slight slope, water accumulating over the lower parts in winter is removed slowly. The underground water commonly lies close to the surface. Little alkali is present in any of the areas.

Utilization.—Until reclaimed from overflow practically all the type was, except in years of low water, of little value for crops. At the present time the area southeast of Tulare Lake producing sugar beets and grain is the only extensive one under cultivation. Irrigation by means of flooding is practiced here. The usual method is to irrigate and then plow after the water has percolated into the subsoil. A dike confining Tulare Lake protects part of the type from overflow. Much of the unprotected part is used for pasture, to which purpose it is well suited. Crop yields are generally high, yet land values are only moderate. Much of the type is not well suited for home sites on account of its low position.

TULARE CLAY.

Description.—The surface soil of the Tulare clay consists of a gray, or drab, heavy, sticky, compact clay. It carries a moderate quantity of organic matter, and under proper moisture conditions is moderately friable and favorable for tillage. The typical soil is free from grit or gravel, but contains large quantities of shell fragments and moderate amounts of lime. Some micaceous material occurs near the outer boundary. It includes thin, compact layers of fine silt and clay which form very hard lumps if not tilled at the right time. These compacted layers upon drying sometimes resemble shale, and fragments several inches in thickness are difficult to pulverize. At 12 to 18 inches the surface soil grades into a lighter colored gray or dark-gray subsoil closely resembling the surface material. The substratum is similar to the subsoil, but is more inclined to be stratified and mottled. Both contain lime, uniformly distributed through the material. The type is uniform in character except where stream channels entering the lake have deposited coarser sediments, or in the zone of gradation into other soils. The chief variation is in texture and it is more uniform in this than the other types of the Tulare series in this survey.

Location.—The Tulare clay covers an expanse of 8,128 acres, and joins with larger areas of the Sacramento clay, as mapped in the survey of the Middle San Joaquin Valley upon the north. The more

important body lies east of Tulare Lake along the northern boundary of the survey. A small area is situated on the west side of the lake. All the type occupies portions of the recently reclaimed lake bed.

Topography and drainage.—The surface is level or nearly flat, the type occupying about the lowest part of the valley trough. Through a system of diking the lake has been restricted to a smaller area and the level of the water has been raised several feet above the reclaimed surface, but this has little or no apparent influence on the subdrainage of the soil because of the slow movement of water through it. Drainage ditches occur at intervals over the reclaimed land to remove surplus water in wet weather. The excess is brought to the levees and pumped over them into the lake. Water for irrigation is abundant and is easily placed upon the land by gravity. Overflows occur at times through the inability to retain the lake within its bounds, especially during a series of wet years, but these are infrequent. No alkali is present and accumulations of salts will probably be prevented by the system of surface flooding and of drainage now in use.

Utilization.—Practically all the type is used for growing grain and sugar beets. These crops give good yields. Proper handling of the soil is very important, because of its heavy texture and the possibility of injury from puddling. The type is not well suited to fruit culture.

WIND-LAID SOILS.

Oakley Series.

The soils of the Oakley series are brown or grayish brown in color and consist of wind-laid deposits which have been derived from a wide range of rocks. The material has been blown from the soils of other series and from exposed sandy deposits of lake and stream beds. The soils are generally uniform to 6 feet or more, except where the materials have accumulated as a shallow covering over older soils. They are low in content of organic matter and are moved freely by wind. The surface is irregular, ridgy, or undulating, and in places somewhat dunelike. Drainage is good, and no alkali is present. The series in this area is typical, except for small amounts of lime occurring locally in the subsoil.

A group of the Oakley sands was the only differentiation made in this survey.

OAKLEY SANDS.

The group Oakley sands includes the sand and fine sand of the series. The two are intimately associated, the sand ordinarily occuring upon the crests of the hummocks and ridges and the fine sand in the lower positions. The total area covered by the group is

24.8 square miles, of which approximately 75 per cent is included in the sand type.

Description.—The surface soil of the Oakley sand consists of a brown or light-brown medium-textured loose, incoherent, slightly micaceous sand or loamy sand 6 feet or more deep. The color of the surface material is generally uniform, but small tracts have a light grayish brown color. The loose, porous structure enables the soil to absorb all the rainfall. The soil contains a small amount of lime. It is low in organic matter. Below a depth of 2 or 3 feet the material becomes a somewhat lighter brown in color and in most places is slightly compact. The substratum is slightly calcareous, and except for the characteristics mentioned above resembles the surface soil. Departures from the typical are common in tracts of more uniform topography and near the outer margin of the soil area. Here the subsoil is more compact and slightly heavier in texture, owing in part to the occurrence of underlying material of the Panoche sandy loam on which the Oakley material has been deposited.

The Oakley fine sand is similar to the Oakley sand in all respects except texture. It consists of a fine sand or loamy fine sand and is usually more uniform in surface features than the sand.

Location.—Only one area of the Oakley sands group is mapped. This lies east of Kern Island and about 18 miles south of Bakersfield. The soils of the group merge gradually with adjacent soils.

Topography and drainage.—The surface is uneven and consists of low rounded hillocks and semidune-like ridges, the result of wind action. The group occurs on the moderately sloping alluvial fan near the south end of the valley and has a deep water table. Drainage is good to excessive, and the soils are inclined to be droughty.

Utilization.—Vegetation is sparse on the soils of this group, owing partly to the action of wind and to low rainfall and excessive drainage. A scant growth of brush and some grass affords a little pasturage during parts of the year. Water for irrigation is not available and can only be obtained from outside sources, which fact retards agricultural progress for the present in this group of soils and keeps land values low.

MISCELLANEOUS MATERIALS.

ROUGH BROKEN LAND.

Rough broken land consists of hilly or mountainous areas too steep or broken for cultivation. The type as mapped in this survey is principally confined to areas of residual soils from sedimentary rocks, but includes some old valley-filling deposits and a number of small tracts of residual soils from igneous rocks along the south and east margins of survey. It is mainly confined to the mountainous parts, but also occurs as badly eroded tracts flanking their lower

slopes and as isolated, severely dissected hills detached or paralleling the main ranges. There are included within the type many areas of a few acres extent which lie on gentle slopes and are capable of tillage where accessible and where the soil depth and rainfall are favorable for crop growth. The residual soil material over that part derived from sedimentary rocks represents soils of the Kettleman and the Altamont series. Bedrock is encountered at a few inches to a foot or more below the surface, and the mantle of soil is too shallow and droughty in places to support any vegetation. Most of the rainfall is lost as surface run-off. The soils are gray or light brown in color and are very deficient in organic matter. A small amount of rock outcrop is present over the surface, and the underlying shales are upturned at various angles. In those parts occurring in areas of basic igneous rocks the material represents soil of the Olympic series, but the soil is too shallow, steep, and droughty for crops. They are also rocky. In places the areas are covered by a growth of brush. The areas representing eroded old valley-filling deposits resemble the brown or gray soils derived from this class of materials. The soils here are deep, but their hilly, broken surfaces make them unfit for any use except grazing. They usually produce a growth of grasses equal to that in the higher parts of the Temblor Mountains and the range northeast of the Cuyama Valley.

Rough broken land is very extensive. Its main development occurs in the Temblor Mountains, in the range northeast of Cuyama Valley, in the foothills south of Buena Vista Lake, in the Elk Hills, and northeast of Bakersfield. Other smaller areas lie in the low, broken hills west of Kettleman Plain and in a few other places along the eastern and southern margins of the survey.

The type is dissected and broken by ravines, canyons, and gullies, which, with the steep slopes, make it undesirable for agriculture. Drainage is excessive. Some alkali occurs in places where it has been brought out from the underlying shales by percolating waters. The soils are usually too shallow to retain sufficient moisture to produce a good growth of grasses.

The type is utilized entirely for grazing, though it ordinarily affords but scant pasturage. Grasses dry up early in summer and remain so until the winter rains begin. A scattering growth of oak and juniper occurs in the more favorable localities, but it is confined almost entirely to the eastern and northern hill slopes. Land values for agriculture are low and are based upon the suitability of the soil for grazing.

ROUGH STONY LAND.

Rough stony land consists of areas which are too rough in topography and in which the soils are too shallow and steep and stony for agriculture. A large amount of rock outcrop or of fragmental

stone in the soil material are the main characteristics distinguishing the type from Rough broken land. As occurring in this survey the type is very steep, rugged, and dissected and is confined to rough, mountainous areas with an occasional outlying tract of more subdued topography. Nearly all the type is confined to areas of igneous rocks. The soils are very shallow, and in many places loose rock and stony escarpment faces prevail. On the more moderate slopes the type gradually merges into soils of the Holland series. The soils are brown or grayish brown in color, low in organic matter, and droughty. A few small, scattering tracts of tillable land are included within this type, but they are quite inaccessible and are not well suited to crop growing on account of insufficient rainfall. The type is excessively drained, much of the rainfall being lost as run-off.

The type, which covers a large area, is most extensively developed in the mountains along the eastern and southern margins of the survey, with one tract situated on Avenal Ridge, southwest of McLure Valley.

A growth of brush covers part of the type and a few scattered oaks grow on the more protected slopes. Pasturage is the main use of this land, but the growth of grasses is light and soon dries up in summer. Land values, which are low, depend upon the character of the native vegetation.

IRRIGATION.

The low rainfall of the area and its seasonal distribution with other modifying climatic features render irrigation necessary for assured returns in the case of nearly all the crops grown. Irrigation was begun about 1860, and the area watered has gradually increased to the present time. The available supply of gravity water was soon exhausted, but to this has since been added water obtained from artesian and pumped wells. The necessity for irrigation in the area, as compared with other parts of the San Joaquin Valley, becomes evident since the rainfall gradually decreases from an average of about 15 inches per annum at Stockton to about 5 inches at Bakersfield, this decrease being concurrent with a gradual rise in the average annual temperatures from 59° F. in the former place to 66° F. in the latter.

Kern River supplies practically all of the gravity water entering the area, the rest being drawn from flood waters of a number of intermittent creeks emerging from the surrounding mountains. Kern River rises in the high Sierras and receives the run-off from about 2,345[7] square miles of watershed, giving it an average annual discharge of about 670,000 acre-feet. The highest stage of the river

[7] See U. S. G. S. Water Supply Paper 222 on Ground Waters of the San Joaquin Valley, Calif., by Walter C. Mendenhall.

is usually in May and June and the lowest from about September to February or March. A large volume of the flood water is stored in the Buena Vista Lake reservoir and a few other reservoirs of small size.

The water available for irrigation does not appear to be nearly adequate for the needs of the area, although the present supply can be greatly augmented by development of the underground supply and by increasing storage facilities for flood water.

The canal systems depending for their supply of water upon Kern River cover more land than they can properly serve in average seasons, and, as a result, yields of the long-season crops are greatly reduced, except in years of unusually abundant supply. Fortunately the period of high water comes at a time when most of it can be used in irrigation of such crops as alfalfa, grain, milo, and the fruits, and one good application at this time, followed by careful cultivation, is frequently sufficient to enable some of these crops to mature with moderate to satisfactory yields. Water from this source usually costs less than $1 per acre-foot, which is from one-half to three-fourths the cost of pumped water. Practically all the irrigated area is confined to the east side of the valley trough. Irrigation has reached its greatest development in the region south and west of Bakersfield, in the vicinities of Wasco, Famosa, McFarland, and Delano, and for about 18 miles along the valley trough northwest of Buena Vista Lake. As in other parts of the great valley, the lowlands along the main streams were the first to be irrigated, because of their advantageous position in relation to water supply and distribution.

Irrigation by pumping from underground sources has developed rapidly in recent years in the area and is confined to places where gravity water is not available. Centers of considerable irrigation development of this character occur on the Caliente Creek fan southeast of Bakersfield, and in the vicinities of Wasco, McFarland, and Delano. The supply of underground water varies greatly in different places and the depth of wells ranges from about 75 to 650 feet. The depth to water is greatest near the foothills and between the stream deltas. It is least on the lower parts of the alluvial fans and over the delta fan of Kern River. Water usually rises to less than 50 feet from the surface in most of the wells, this being considered about the limit of profitable lift for all crops except citrus fruits. The depth to water is much greater in the region east and southeast of Ducor, and it is necessary to lift it 100 or more feet, but profits from citrus industry there warrants the extra cost. Gas and steam engines and electricity are used as power for pumping.

More than 100 artesian wells are sunk along the valley trough, principally in the lowlands east and north of Buena Vista Lake and extending northwestward to the boundary of the area. The width of this belt along the northern boundary of Kern County is about 26 or 27 miles.[8] The flow varies greatly in different places and ranges from a mere trickling stream to one of fair size and pressure. Most of the water is of fair quality for irrigation purposes, but some is too high in content of soluble salts to be of much value. The general tendency is for the flow of wells to decline with age and with increase in their number, so that in some instances it has entirely stopped. Most of the water from this source is allowed to go to waste largely because the wells generally occur in places where the soils are rather high in alkali for successful farming. Considerable amounts of water, however, can be obtained from such wells by pumping with a lift so small as to make the cost of water very low.

The quality of water from most of the artesian and pumped wells on the east side of the valley trough is good for irrigation and household purposes, but in nearly all places on the west side it is undesirable for such use.

The methods of applying water in the area vary and depend upon the kind of soil, upon the slope of the land, and upon the crop grown. Contour checking is most extensively practiced, as it enables large heads of water to be used. It is somewhat wasteful, but enables the covering of broad acreages with little labor where large volumes of water are available for a short time only. The checks vary greatly in size and range from about 1 to 7 or 8 acres in extent. In places rough leveling is done, and large heads of water are run over the land to irrigate it before planting, the checks sometimes covering 50 or 75 acres of land. Under other conditions border checks are used, wherein the water is run from one end of the field to the other. The furrow method is most popular for fruits, vegetables, and in places for milo. When water is plentiful it is extravagantly used, and when there is a scarcity the duty is high.

The quantity of water used and the time of application depend upon the rainfall and its distribution and upon the soil type and crop grown. One application is usually required for each cutting of alfalfa and about three for milo, potatoes, beans, and fruits, while oranges receive from four to five irrigations. The length of the irrigating season varies considerably, and extends from about the middle of March until the last of September, but may be either longer or shorter according to the season and the crops grown.

The extension of irrigation will depend upon the increased storage of flood waters, a greater draft upon the underground supplies by

[8] Idem.

pumping, an increase in the duty of water by the use of more economic methods of application, a reduction of loss by seepage, and by better methods of cultivation. This will greatly increase the acreage of excellent land which now only affords scant pasturage, but which is capable of a wide range of crops under irrigation. According to tests made, there appear to be large volumes of underground water in the trough of the valley which could be utilized to great advantage on the vast areas of the west side plains, with their gently sloping soils, if some means were devised to bring it to the land. Yields would also be greatly increased if the water supply could be used upon the best soils instead of on lands of poor quality and those badly affected by alkali. The area of good land in the survey is far in excess of what can be watered with the available water supply, and the full utilization of the water resources yet undeveloped will greatly increase the wealth of the area surveyed.[9]

ALKALI.

Conditions in the area with regard to accumulations of alkali salts are similar to those in other parts of the San Joaquin Valley. In the aggregate there were between 600 and 700 square miles of alkali-affected soils mapped in the survey, part of which includes numerous tracts of alkali-free soil varying in extent from about 1 to 25 acres, but too irregular in their occurrence to permit of separate mapping. Also many small spots of alkali accumulation are scattered over the soils mapped as alkali free, which are of too small extent and little importance to be shown on a map of the scale used in this survey. The areas of alkali accumulation are outlined in a general way only, and there may be additional bodies of soil having an excess of salts in the subsoils which could be outlined upon a more detailed study.

Affected areas are inclosed on the soil map by broken red lines. Two conditions or classes of alkali accumulation are mapped, represented by appropriate symbols, in one of which the entire surface is affected with greatly varying concentrations, represented by the symbol **A**, and the other where spots and strips of alkali accumulations are mingled with alkali-free soils in such a manner as to give a very spotted condition, represented by the symbol **S**. Under the latter condition the concentrations of salts in the spots vary from low to high and the boundaries between alkali free and affected bodies are often quite definite. In some places the alkali-free and

[9] For a more detailed discussion of irrigation and water supplies in the area see U. S. G. S. Water Supply Paper No. 398, "Ground Water in the San Joaquin Valley, Calif.," 1916; U. S. G. S. Water Supply Paper No. 299, "Stream measurement in San Joaquin River Basin," 1912; Office of Experiment Stations, U. S. D. A. Bull. No. 254, "Irrigation Resources in the San Joaquin Valley, Calif.," 1911. These publications contain much valuable information and can be consulted in the public libraries and at the California State Experiment Station, Berkeley, if not available elsewhere.

affected spots are small and fifty or more of each may be present in a square mile, while in other localities they are larger and in some instances cover 25 or more acres each.

The most pronounced areas of the class first mentioned occur in the slightly depressed valleylike basin southeast of Bakersfield and extend along the south side of Buena Vista Lake eastward nearly to the State highway. A well-defined area of large extent lies west and northwest of Rio Bravo, several occur west and north of Pond, and notable developments are situated east and southeast of Angiola and Allensworth. A number of others of small extent occur along the valley trough and in a few other places west and southwest of Bakersfield. This class covers about 350 square miles and occurs in well-defined tracts, of high concentration. In a few places the salts occur in much smaller amounts and are mainly confined to the surface soil, this being especially true of the lighter textured types on the Kern River delta. The class indicated by the symbol **A** is not quite so extensive as the other, and covers about 300 square miles or a little more. It is prominently developed on the Kern River delta south and west of Bakersfield, in the general region south, west, and north of Wasco, and in the vicinities of Pixley, and a large tract occupies the lower part of the floor of the Carrizo Plain. An area of less extent also occurs on the east side of McLure Valley, and a number of others are scattered along the trough of the San Joaquin Valley and along the west side of Buena Vista Lake. Spotted areas frequently occur as intermediate strips between tracts of uniform concentration and alkali-free soils. The concentration of salts in the spotted areas varies greatly, but averages less than that in those of the **A** grade. These areas are commonly associated with other soils that vary greatly in texture, capillarity, subdrainage, and surface features.

The alkali in all cases is confined to areas with a high water table, and is most common in slight depressions, on nearly level areas, and on very gentle slopes, where shallow ground waters carrying salts in solution lie at depths shallow enough to enable capillary rise to the surface. Because of their better drainage, the higher and more steeply sloping parts of the valley plains are free from such accumulations.

Inefficient and wasteful diversion of water through irrigation practices and open unlined canals in porous soils are responsible for loss of water by seepage and increased accumulations of alkali, and also for injury from a rising water table in a number of places on the Kern River delta; but by far the greater part of the total area of alkali accumulations mapped has its origin in seepage caused by the long-continued spreading of flood waters over the valley plains.

Practically all the alkali deposits consist of several kinds of salts, each of which is toxic to plant growth when present in excessive quantities. Among these, sodium sulphate is by far the most common. Sodium chloride, or common salt, also occurs in varying amounts, and sodium carbonate, or "black alkali," is conspicuous in the affected areas east of the valley trough, though rarely present in the west-side soils, owing largely to the occurrence of gypsum in the sedimentary rocks giving rise to these soils. A number of other salts occur, but not in quantities large enough to make them of consequence.

Of the salts represented, sodium carbonate and sodium chloride are by far the most harmful. During the summer months, or dry season, deposits of alkali salts usually appear at the surface as white, grayish, or brownish incrustations, and the amount showing at such times is frequently an indication of the concentration in those soils. In soils of light texture, such as the loams, sandy loams, and sands, the alkali is ordinarily most concentrated near the surface, but in the soils of heavier texture, especially where the subsoils are heavy, the highest content is frequently in the subsoil, though it may be distributed through the entire soil profile or concentrated in the surface foot. Large amounts may be present without the fact being recognizable from the surface appearances, but areas of this kind may often be identified by the growth of alkali-resistant plants.

Thus greasewood often grows in areas of high concentration, sometimes to the exclusion of all other plants. This is the case over much of the affected lands southeast of Bakersfield and east of the south end of Buena Vista Lake, In other places the presence and concentration of salts are indicated by other kinds of alkali-resistant plants, such as saltwort (*Suaeda sp.*), alkali bunch grass or tussock grass (*Sporobolus airoides*), salt grass (*Distichlis spicata*), alkali heath (*Frankenia grandifolia*), Australian salt bush, shad scale (*Atriplex*), and a few others. Shad scale is not a true alkali indicator, as it thrives best on alkali-free soils and decreases in vigor and size as the alkali content increases. In places where surface crusts form the land supports no vegetation at all.

Most of the alkali-affected lands in the area are used for pasture. Where the concentration of salts is high the pasturage is very poor, and in some instances 15 or 20 acres are required to support one grown animal. In other places the lower concentrations permit the growth of salt and tussock grasses, which afford fair pasturage.

The effect of the alkali is reflected clearly in the crops grown. Many of the fruits and vegetables and nearly all the legumes, which are very sensitive, are grown only where the percentage of alkali is very low, usually less than two-tenths of 1 per cent. Sugar beets and barley and a few other crops are quite resistant and sometimes do well

where an average of 1 per cent of alkali is present in the soil profile, providing the salts are mainly concentrated in the subsoil and the crops can get a good start before warm weather begins. Cloudy or foggy spring weather is generally helpful in getting crops started in regions affected by alkali, because the reduced evaporation tends to retain the salts in the subsoils until the plants get well rooted. Where water is available, it is a common practice to flood the land. This carries the alkali down and enables the seeds to germinate and make some growth before the salts again return to the surface. The growing of rice appears to have been effective within the area of this survey in reclaiming alkali land. The use of the large volumes of water necessary in its culture tends to carry the alkali down beyond the root zone, or gradually to leach it out and remove it in the drainage waters. It is not unusual for fair or even good yields of rice to be obtained the first year on badly affected alkali lands where the subsoils are favorable, where proper checking and good care are given the crop, and where plenty of water is available. Extreme caution and care are necessary, however, in this undertaking if success is to be attained.

The soils of the Delano, Pond, Fresno, Hanford, and Panoche series include nearly all the alkali areas mapped in the survey. Small amounts are present in some of the soils of other series, but the affected areas are of little importance. The dark-gray or black-colored soils are less likely to carry excessive quantities in this survey than the others named on account of overflows, which tend to remove the salts as fast as they accumulate.

A vast acreage of good land could be brought under cultivation if means could be devised to remove the alkali and lower the level of the water table. Much of this is situated in places where underground water is readily available for irrigation. In some instances heavy flooding of the surface several times has enabled the growing of crops on soils otherwise practically useless, but this method is hardly effective on soils of textures heavier than loam. In other instances the installation of tile-drainage systems coupled with surface flooding has given good results, but the cost of such systems is considerable and farmers are slow to adopt this plan while there are lands available that do not require reclamation.

SUMMARY.

The area covered by this survey is located a little south of the center of the State. It includes the southern third of the San Joaquin Valley. In addition to the included part of the main valley the area includes a small valley to the west called the Carrizo Plain and a small part of the Cuyama Valley. The total extent is 5,130 square miles, or 3,283,200 acres.

The average elevation of the main valley is about 350 feet and that of the Carrizo Plain about 2,000 feet above sea level. Mountains lying to the east and south reach altitudes of 4,000 to 10,000 or more feet.

Bakersfield is the principal city of the area, with a population of 18,638 in 1920. Taft, Maricopa, McKittrick, and a number of others are busy cities and towns, depending upon the petroleum industry for their existence. A number of other towns and villages form the centers of agricultural communities.

The area is served by the main lines of the Southern Pacific and the Atchison, Topeka & Santa Fe Railways, with branches extending to most parts of the main valley. An excellent system of State and county highways exists. Telephone and daily mail service and public schools are available in the settled parts of the area. Local demand for most agricultural products is met by the farmers, and considerable shipments of produce are made to outside points.

The climate of the area is arid, the rainfall averaging less than 10 inches per year. The rainy season extends from about November to April, inclusive. Winter temperatures rarely drop below 30° F., while those of summer sometimes rise to 112° F. or a little higher. The steeper foothill slopes have good air drainage and are usually safe for the growing of citrus fruits. The growing season is long and permits a second crop to be grown in practically all parts where irrigation is practiced. Vegetables are produced in gardens throughout the entire year.

Active agriculture, which dates back to about 1880, has steadily developed to the present time. Agricultural development is almost entirely confined to the east side of the San Joaquin Valley, and all crops require irrigation except grain, which gives light and uncertain yields where dry farmed.

Stock raising ranks first among agricultural pursuits. Nearly $3,000,000 worth of beef cattle were marketed in 1916 in that part of Kern County lying within this survey. Dairying and the raising of hogs, sheep, horses, and mules are also prominent occupations and are developing rapidly.

Rice, sugar beets, alfalfa, beans, and the nonsaccharine sorghums are the important field crops, and oranges, grapes, peaches, prunes, and apricots the leading fruits. Yields are fair where good care and irrigation are practiced. The climate is very favorable for drying fruits.

The soils of the area are placed in five broad groups, as follows: (1) Residual soils, or those derived from the weathering in place of consolidated rocks; (2) old valley-filling soils, which are derived from old, weathered, and otherwise modified, unconsolidated water-laid deposits; (3) recent alluvial soils, or those of recent stream-laid

deposition which have not undergone any marked internal changes in profile since they were laid down; (4) lake-laid soils or those deposited in lake basins; and (5) wind-laid soils or those owing their accumulation and distribution to wind action.

The residual soils, which are extensively developed in the hilly and mountainous parts of the area, are classified into five soil series, viz, the Altamont, the Diablo, and the Kettleman series, derived from sedimentary rocks, the Holland series, derived from granitic rocks; and the Olympic series, derived from basic igneous rocks.

The soils of the old valley-filling materials give types of eleven series, the recent alluvial materials four series, the lake-laid materials one series, and the wind-laid one series.

The soils of the old valley-filling and recent alluvial origin include the most valuable agricultural lands of the survey.

In addition to the soils of the series enumerated above two types of miscellaneous materials, Rough broken land and Rough stony land, were mapped. These are nonagricultural types.

The soils of the survey vary greatly in character and their productiveness depends largely upon their depth, permeability, alkali content and whether or not irrigation is practiced. There are many thousand acres of excellent soils in the area which would be very productive if some means could be devised to secure water for irrigation.

Irrigation is essential to a diversified agriculture in the area. The grain crops are about the only ones that can be grown without the application of water. Drainage waters from extensive mountainous areas enter the survey, but they have been mainly appropriated by a very few extensive land owners. Extensive underground supplies occur over much of the region between the San Joaquin Valley trough and the eastern foothills. Underground water is readily available in the lower lying parts of the valley, but the water-bearing stratum generally increases in depth below the surface as the foothills are approached. Supplies from this source are great and have only been partly developed, though many new wells are being put down each year. Storage of flood waters of Kern River is possible and would greatly increase the area suitable for crops. Alfalfa receives about one irrigation for each crop after the first, and the supply received by other crops depends upon the season and is restricted by the supply of water available.

There are between 600 and 700 square miles of land in the area affected by alkali. The acreage and distribution vary greatly. In cases the land is spotted in others uniformly impregnated with moderate to high concentrations.

The effects of alkali accumulation are manifested clearly in the character of native vegetation and in the development of the crops

grown. Most of the badly affected alkali areas are used for pasture, from 15 to 20 acres being required to support one grown animal. Many of the spotted areas and those of low concentration are used for annual crops by washing the alkali into the subsoil. Alkali lands are utilized to some extent for the growing of rice where the subsoils are heavy and compact, and ample water available for irrigation. In some of the areas of lower concentration the salts are kept below the zone of plant roots by careful practice of cultivation and irrigation.

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[PUBLIC RESOLUTION—No. 9.]

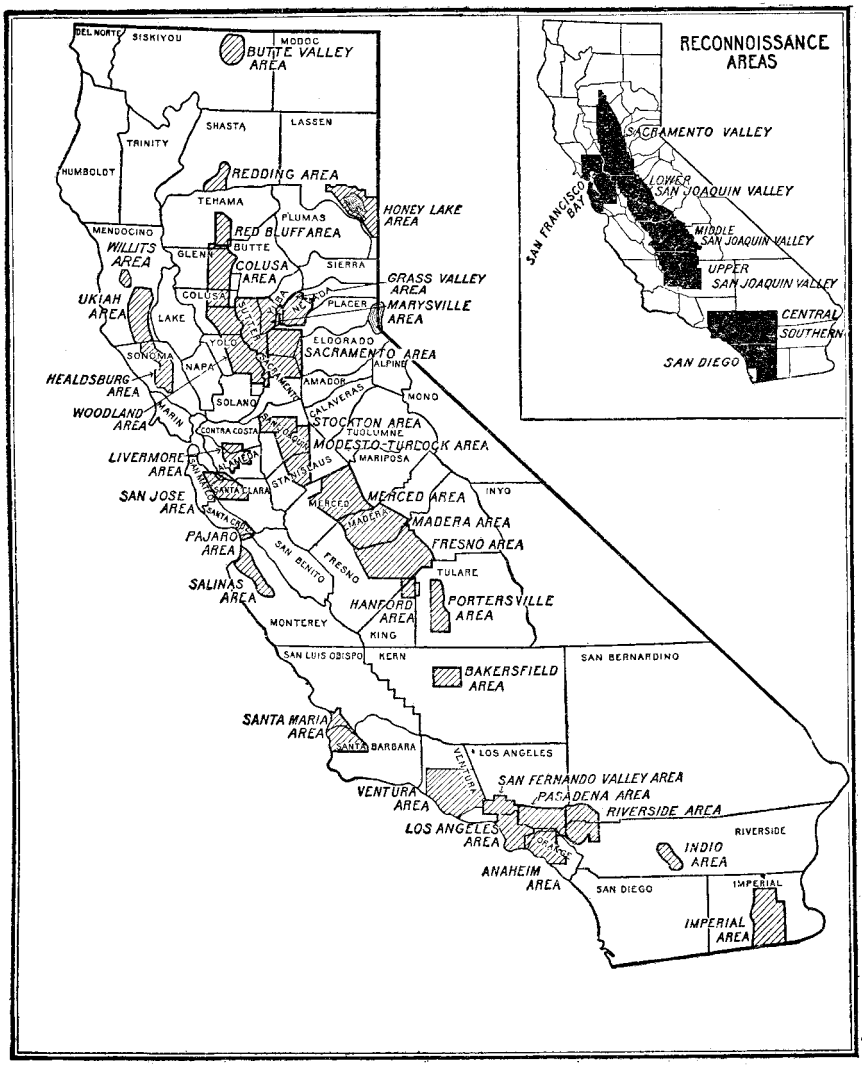
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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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