Series 1933, No. 26. Issued May 1939

Soil Survey

Contra Costa County California

By
E. J. CARPENTER
United States Department of Agriculture, in Charge
and
S. W. COSBY
University of California

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
In cooperation with the
University of California Agricultural Experiment Station

For sale by the SUPERINTENDENT OF DOCUMENTS, WASHINGTON, D. C. Price 75 cents

BUREAU OF CHEMISTRY AND SOILS

HENRY G. KNIGHT, *Chief*

SOIL SURVEY DIVISION

CHARLES E. KELLOGG, *Chief*
M. H. LAPHAM, *Inspector, District 5*
J. W. McKERICHER, *in Charge Map Drafting*

COOPERATION
UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION

C. B. HUTCHISON, *Director*
CHARLES F. SHAW, *in Charge Soil Survey*

CONTENTS

Series 1933, No. 26 Issued May 1939

SOIL SURVEY OF CONTRA COSTA COUNTY, CALIFORNIA

By E. J. CARPENTER, United States Department of Agriculture, in Charge, and S. W. COSBY, University of California

COUNTY SURVEYED

Contra Costa County is situated in the west-central part of California (fig. 1). The western part includes a small part of the industrial and thickly settled districts that center around Berkeley, Richmond, and other cities along the eastern shore of San Francisco Bay. On the north the county is bordered by San Pablo and Suisun Bays and connecting or tributary waterways, through which the waters of Sacramento and San Joaquin Rivers reach the Pacific Ocean.

FIGURE 1.—Sketch map showing location of Contra Costa County, Calif.

The county includes parts of the areas covered by previous soil surveys of the San Francisco Bay region (*1*),[1] the Sacramento Valley (*2*), the lower San Joaquin Valley (*5*), and the Livermore area (*7*). It embraces an area of 728 square miles, or 465,920 acres.

The dominant physiographic features of the county are a rolling to steeply sloping hilly area in the central and south-central parts culminating in Mount Diablo; a broad gently sloping valley plain

[1] Italic numbers in parentheses refer to Literature Cited, p. 82.

41674—39

forming the eastern part; a series of rolling, generally smooth, and gently to steeply sloping hills and ridges marginal to the western part and enclosing a number of comparatively narrow intervening stream valleys; and associated old alluvial-fan and coastal-plain terraces occurring at intervals along the northern coastal part.

Mount Diablo, with an elevation of 3,849 feet, is a prominent landmark and physiographic feature. The other hilly areas and ridges have an average elevation of about 1,000 feet. A few monoliths of igneous rocks associated with extreme faulting and folding of the sedimentary rocks forming most of the lower hilly areas have produced a variety of structural and topographic land forms.

The western hills have a general northwest-southeast trend parallel to San Francisco Bay and are separated from the Mount Diablo block by a valley of similar trend, about 12 miles inland, which roughly divides the hilly area into two parts. North of Mount Diablo the hill lands are rolling and have a general easterly trend with a slight dip to the south. South of Mount Diablo the hills are composed of soft sedimentary rocks of more recent geologic age, in which numerous streams have cut narrow valleys, all having a south or slightly southwest trend. The hill lands between the valleys are generally rolling and have smooth rounded crests.

The valley plain of the eastern part of the county has been built up by a series of alluvial fans deposited by intermittent streams having their sources in the hilly and mountainous central part. This plain merges on the east with the alluvial stream flood-plain and stream-delta deposits of the San Joaquin River and its distributaries. The stream courses are entrenched in the alluvium of the fans at the mouths of the canyons but lose their identity and spread out over the sediments a short distance beyond their emergence from the hills.

The low-lying river-delta lands, most of which have been reclaimed by protective dikes and drainageways, grade with gradually increasing slope into the alluvial valley plain. Large areas of wind-blown sand are developed on the valley plain where it is pinched out on the north by the delta lands of the river. The more elevated coastal-plain areas in the northwest are generally well dissected by minor flat-topped ridges and numerous rounded somewhat eroded ridges and slopes. In the softer sediments south of Mount Diablo, the stream courses cut across the structural formation; and the same condition exists, to a minor extent, in the hill lands that border Suisun Bay and the delta lands east of that point.

Except for a few small streamways draining west into San Francisco Bay, the drainage of the area enters San Joaquin River, San Pablo Bay, or Suisun Bay to the north and west. Marsh Creek has the largest drainage basin of any stream originating within the county. San Ramon and San Pablo Creeks are important drainageways. A number of creeks ramify all sections of the hilly and mountainous areas, affording complete drainage.

The river-delta and island districts, the surfaces of which are near sea level, have a high water table and poorly developed surface drainage.

A wide range of local climatic conditions and exposure to fog, sun, and wind have given rise to marked variation in vegetative cover in

different sections of the county. Various species of native oaks grow thickly in the southwestern part, especially on the northern and eastern slopes of the hills, which also support a dense growth of buckeye and other shrubs and species of brush; and in the Laguna De Los Palos Colorados numerous redwoods and ferns make a vigorous growth. In sharp contrast to this vegetative cover, the more exposed slopes are mainly grass covered (pl. 1, *A*); and the valley plains lying in the rain-shadow area of Mount Diablo in the southeast support a cover of salt-tolerant vegetation or vegetation typical of semiarid regions. Elsewhere scattered oaks and a ground cover of alfileria, bur-clover, and wild oats are the dominant vegetation.

The first permanent settlement in what is now Contra Costa County was made in 1823 with the issue of the Pinole grant to Ignacio Martinez and of the San Pablo grant to Francisco Castro. Prior to this time, hunters and trappers had passed through the country or plied their trade within the area and found it occupied only by Indians. The initial grants were followed by others in rapid succession until, by 1832, most of the more desirable lands were owned privately. The first American permanent resident was John Marsh, a Harvard graduate, who settled on his Los Meganos grant in 1837. Settlement progressed slowly until men returning from the gold fields in the eastern part of the State in the late fifties turned their attention to agriculture, and thereafter settlement was rapid for a number of years.

The county was formed in 1850, and Martinez was made the county seat. One of the original 27 counties into which the State was divided, this county originally comprised about 1,500 square miles, but in 1853 nearly one-half of its area was taken in the formation of Alameda County (*3*). The population is drawn principally from the Eastern and Central States. The Federal census for 1930 gives the total population of Contra Costa County as 78,608, of which 90.9 percent were native or foreign-born white persons. The remainder consisted mainly of Mexicans, Japanese, Negroes, Chinese, and East Indians (Hindoos and Sikhs), named in the order of their predominance. Of the total population, slightly more than 55 percent live in towns or cities of more than 2,500 inhabitants. The remaining 34,903 persons, or 45 percent of the total population, are classed as rural, of whom 9,182, or slightly less than 12 percent, live on farms.

The most thickly settled rural districts are in Clayton Valley, in Ygnacio Valley, and in San Ramon Valley to the south. The broad valley plain extending from Byron to the edge of the delta lands north of Oakley and Knightsen is also thickly settled. The industrial development bordering San Joaquin River from Martinez eastward has resulted in highly populated districts at intervals on the coastal plain. Throughout the mountainous and hilly sections, the population, in general, is sparse, except in localities developed as summer-home sites or country-club properties.

Richmond, having a population of 20,093, is the largest town, followed by Pittsburg with a population of 9,610 at the time of the 1930 census. Richmond is an important industrial center, the seat of extensive oil-refining operations and of a freight terminal and shops of the Atchison, Topeka & Santa Fe Railway. Fruit and fish

canneries; a large creamery; and steel, chemical, and other industrial enterprises are located at Pittsburg and employ a large proportion of the population. Martinez is the third largest town, with a population of 6,569. Oil refineries and other industrial developments give employment to many families there. A large paper-fiberboard mill and a cannery at Antioch, which had a population of 3,563 in 1930, assist in giving employment to the people of this town, and much of the trade from the rich agricultural districts to the south and east also centers here. Concord, with a population of 1,125, is in the thickly settled Ygnacio Valley and is supported largely by agricultural activities. A plant at Walnut Creek handles walnuts from 18 of the central counties, and much of the trade from the thickly settled lower San Ramon Valley and surrounding agricultural districts centers in this town. Byron, Brentwood, Oakley, and Knightsen in the eastern part of the county, are important shipping points for fruits, nuts, vegetables, grain, hay, and dairy products. San Pablo, Pinole, Crockett, and Rodeo are adjacent to San Pablo Bay and serve as trading points for the surrounding agricultural districts as well as for the industrial developments along the bay shore. San Ramon, Danville, and Alamo are trading points of local importance to the upper San Ramon Valley. In addition to the towns mentioned, numerous trading points, as Clayton, Nichols, Port Chicago, and Pacheco, afford schools and other conveniences for the surrounding agricultural or industrial developments. Numerous fruit-packing and shipping points are situated on the railways that traverse the county.

The county is well supplied with transportation facilities by the Southern Pacific Railroad, the Sacramento Northern (electric) Railway, and the Atchison, Topeka & Santa Fe Railway. In addition to these main lines, numerous branches penetrate to all the better developed agricultural sections. Facilities for transportation by water also are good. The shore line—including 70 or more miles fronting on navigable waterways—has numerous landings from which river boats pick up and discharge cargo.

Approximately one-half of the mileage of county highways, and the 105 miles of State highway within the county are paved. Other public roads generally can be traveled throughout the year. Rural and urban telephone service and electricity for lighting and power are available in all the more thickly settled sections. Schools, churches, and central meeting places are conveniently located to serve the needs of the urban as well as the rural population. Orchards and vineyards are well kept, and dairy and general farm equipment is modern and serviceable.

Manufacturing industries in the northern part include steel and rubber mills, chemical factories, ore smelters, paper mills, oil refineries, sugar refineries, lime plants, and various plants manufacturing building supplies and household necessities. A number of factories producing explosives are located at Hercules and Giant, on San Pablo Bay. The manufacturing industries are important factors in maintaining the population and thereby directly benefiting the farm population by making available a greater home market. Coal mining was once an important industry in the low range of hills bordering the bay shore south of Pittsburg and Antioch. These mines have been worked out, and the industry has almost disappeared.

CLIMATE

The climate of this county is typically Mediterranean, that is, it is characterized by warm dry summers and cool moist winters. Although this type of climate is general throughout the Pacific coast region, great variations in temperature and rainfall occur within the region and often within narrow limits. In most of Contra Costa County, summer temperatures are somewhat higher than those along the coast and appreciably lower than those in the interior valleys; and the rainfall, although slightly less than along the coast, is extremely variable.

Variations in temperature from one section of the county to another usually are the result either of proximity to the cooling fogs and breezes from the ocean and bays or of uneven relief. The prevailing wind movement during the summer is from the cool coastal section to the heated interior. The cool moist ocean breezes enter the area principally through the wind gap formed by the various tidal bays, and they become warmer and drier as they pass inland, with the result that in the southeastern part of the county summer temperatures are higher and winter temperatures lower than in other parts favored by the moderating influence of the bodies of water. The troughs of the valleys are colder in winter than the foothills and the upper alluvial-fan slopes. In that part of the county lying west of San Ramon and Ygnacio Valleys, the variation between winter and summer temperatures usually is not great, and in no section is it extreme. Frosts occur throughout the county, and on the higher elevations there is occasionally a light snowfall which generally remains on the ground only a few days.

Practically all the precipitation falls during the cooler months of the year. The rains normally begin in November and continue until late in March. April and October normally have more than one-half inch of rainfall, but during the late spring, summer, and early fall the precipitation ordinarily is not sufficient to be of value to crops or to have any harmful effect on harvested crops lying in the fields. Most of the rains come with the wind from the southwest and become progressively less as the wind passes eastward over the successive ranges of hills. In passing over Mount Diablo appreciable moisture is lost from the rain-bearing winds, and a pronounced rain-shadow area lies east of the mountain. The rainfall here is so light that most of the native vegetation is typical of semiarid regions.

In the western part the normal rainfall is about twice that in the eastern part. Such variations in rainfall are reflected in the agricultural practices and, to some extent, in the type of crops grown. In the eastern part grain crops are grown largely under dry-farm practices, the land being left fallow in alternate years, whereas under the more favorable moisture conditions in the western part grain or hay crops occupy the soils every year. Tree fruits are grown in the eastern part only under irrigation, whereas nearly all varieties of fruits and nuts can be grown successfully without irrigation in the areas of higher rainfall. In areas adjacent to the waterways along the northern boundary, where summer fogs are frequent, irrigation is even less necessary. Climatic conditions other than rainfall also play an important part in the distribution of crops. Apricots, peaches, plums,

prunes, nectarines, and figs are grown more largely in the eastern than in the western part. Almonds are grown on a large acreage in the vicinity of Oakley, where late spring frosts are rare. Apples and pears are grown largely in the western part. Although some crops are grown without irrigation even in the eastern part, provision for irrigation generally is desirable throughout the county, as the rainfall varies markedly from year to year. The rainfall for the driest year on record at Antioch was 4.92 inches, for the wettest year it was 20.95 inches, and the normal rainfall is 12.02 inches.

During the winter, cover crops are grown successfully in all sections of the county, and the more hardy vegetable crops are grown in many localities least subject to frost. Farm operations can be carried on during any season of the year, although cultural operations and the pasturing of livestock are limited at times by the wetness of the soils during the rainy season. The average date of the last killing frost at Antioch is February 17, and that of the first is November 27, giving an average frost-free season of 283 days. Frosts have been recorded, however, as late as April 23 and as early as October 24. In the western part the growing season is 15 to 20 days longer than in the eastern part. Late spring frosts do appreciable damage to fruit crops, and some provision is made for heating the orchards, except in the thermal belts. Early fall frosts are destructive of late vegetable, melon, or hay crops.

Table 1 gives the normal monthly, seasonal, and annual temperature and precipitation, as recorded at the United States Weather Bureau station at Antioch, in the northeastern part at an elevation of 46 feet.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Antioch, Contra Costa County, Calif.*

[Elevation, 46 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1898)	Total amount for the wettest year (1889)
	°F	°F	°F.	*Inches*	*Inches*	*Inches*
December	48 2	79	21	2 14	0 72	6 54
January	47 1	88	23	2 73	79	.95
February	51 3	83	28	2 24	1.32	.52
Winter	48 9	88	21	7 11	2 83	8.01
March	55 7	91	32	1 74	.45	4 81
April	61 1	94	35	58	15	.46
May	66 0	104	39	.39	40	1 07
Spring	60 9	104	32	2 71	1 00	6.34
June	73 2	109	43	.10	10	(1)
July	76 6	112	48	.01	00	.00
August	75 2	109	45	02	00	.00
Summer	75 0	112	43	13	10	(1)
September	71 9	109	43	34	15	.00
October	64 4	104	32	53	84	4.51
November	54 7	90	29	1 20	.00	2.09
Fall	63 7	109	29	2 07	.99	6.60
Year	62 1	112	21	12 02	4 92	20.95

[1] Trace

AGRICULTURAL HISTORY AND STATISTICS [2]

In the early settlements, although staple foodstuffs could be obtained, of course, at the trading posts, fresh fruits, vegetables, and other perishable foodstuffs were not available. It was but natural, therefore, that fruit trees and vines should have been planted by the first settlers soon after their grants were received. In addition to foodstuffs for the home, some grain was grown as feed for livestock. It is reported that John Marsh was the first settler who grew wheat in the county and that he first planted this grain in 1868 on his Los Meganos grant (*3*).

Table 2, compiled from the reports of the Federal census, gives the acreages devoted to the principal crops in 1879, 1889, 1899, 1909, 1919, 1929, and 1934.

TABLE 2.—*Extent of principal crops in Contra Costa County, Calif., in stated years*

Crop	1879	1889	1899	1909	1919	1929	1934
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Wheat	71,870	42,744	46,916	2,443	17,257	5,322	7,170
Barley	19,674	15,343	25,441	18,665	20,181	21,008	21,071
Oats	1,280	753	8,205	1,112	3,100	671	644
Corn	55	335	435	263	8,513	4,677	2,735
Hay	29,566	50,247	70,725	88,915	60,721	40,902	35,769
	Trees [1]	*Trees*	*Trees*	*Trees*	*Trees*	*Trees*	*Trees*
Apples	----------	18,045	22,191	13,429	21,489	19,401	7,054
Apricots	----------	16,443	70,108	38,812	21,814	228,015	(1)
Cherries	----------	3,228	18,771	7,258	(1)	16,239	8,515
Peaches	----------	19,082	66,341	39,461	43,364	98,130	77,488
Pears	----------	18,685	106,633	68,088	87,138	267,337	309,829
Plums and prunes	----------	13,995	118,527	58,177	61,497	142,970	121,655
Walnuts	----------	(1)	(1)	6,148	39,493	115,382	(1)
	Vines [1]	*Vines* [1]	*Vines*	*Vines*	*Vines*	*Vines*	*Vines*
Grapes	----------	----------	2,400,257	2,972,130	1,710,451	2,835,432	2,519,902

[1] Not reported.

The culture of wheat expanded rapidly, and the Federal census for 1880 reports 71,870 acres devoted to it in 1879. The next crop in order of importance was hay, which was grown on 29,566 acres in the same year. Barley occupied 19,674 acres, oats 1,280 acres, and corn 55 acres.

The next decade saw a falling off in the acreage of wheat, oats, and barley, a slight increase in the corn acreage, and a very material increase in the acreage devoted to the production of hay. Peaches, pears, apples, apricots, plums and prunes, and cherries were planted. There were not more than 90,000 fruit trees in the county, however, at that time.

The 1900 Federal census reports the acreage of cereals to be only slightly higher in 1889 than that in the previous decade, but the acreage devoted to hay crops continued to increase, more than 70,000 acres of grain cut green for hay and smaller acreages of other kinds of hay and forage crops being reported. The acreage devoted to fruits also increased markedly, with the exception of apples, which showed a very

[2] Many of the statistical data in this section were furnished by V. G. Stevens, Contra Costa County horticultural commissioner, and Ray Goble, Contra Costa County farm adviser.

slight increase during the decade. In this census, grapes are reported for the first time, although their culture dates back to the earliest settlement. There were 2,400,257 grapevines in the county in 1889.

The most significant changes in the agriculture in the next decade were the big drop in the acreage devoted to cereal crops and the continued increase in the acreage devoted to hay. The census for 1910 reports less than 23,000 acres devoted to grain crops and almost 89,000 acres devoted to hay in 1909. The large urban districts centering around San Francisco Bay created a good market for dairy products. All fruits except grapes showed a drop in acreage, although numerous nut and subtropical fruit trees were planted during this period.

Agriculture showed little or no significant change in the next two decades. It might be marked, perhaps, by an increase in the number of walnut, apricot, pear, and plum and prune trees, by a material decrease in the number of grapevines in 1919 and a return in 1929 to approximately the 1909 figure, and by a steady decrease in the acreage of hay. Approximately three-eighths of the grapes grown are varieties of wine grapes. The total acreage in fruit orchards, vineyards, and nut trees was 31,120 acres in 1934. The falling off in acreage of the hay crop was due largely to the gradual replacement of horses by automobiles and trucks in the urban centers.

The acreage devoted to vegetables has increased enormously in the last few years and is continuing to increase. The principal vegetables produced, named in about the order of their relative acreages, are tomatoes, asparagus, potatoes, lettuce, beans, cucumbers, peas, cabbage, cauliflower, and onions. In 1934, 6,360 acres were devoted to the production of tomatoes. With the exception of tomatoes, which are produced throughout the county, vegetables are grown mostly on the valley-plain and the river-delta lands.

The present-day agriculture consists of the production of fruits, nuts, and vegetables on the flatter valley plains; the production of grain, hay, and forage on the foothills; and the grazing of cattle and sheep over the pasture lands of the valleys and the steeper uncultivated hill and mountain lands. The value of all agricultural products in 1929 was $10,174,729.

Table 3, compiled from the reports of the Federal census, gives the number of the principal domestic animals and poultry on farms in 1880, 1890, 1900, 1910, 1920, 1930, and 1935.

TABLE 3.—*Number of principal domestic animals and poultry on farms in Contra Costa County, Calif., in stated years*

Livestock	1880	1890	1900	1910	1920	1930	1935
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Horses	7,612	10,433	10,879	11,233	8,418	4,373	3,864
Mules	549	257	701	651	423	294	172
Cattle	9,030	15,468	20,738	26,529	28,564	34,305	33,202
Sheep	7,629	7,415	19,766	19,595	27,068	70,748	33,079
Swine	9,471	11,473	8,303	6,941	14,415	11,594	10,563
Chickens	[1] 38,160	68,094	[1] 120,067	[2] 118,944	127,436	143,491	126,773

[1] All poultry.

[2] Including guinea fowls.

Dairying is one of the more important agricultural activities, both in value of its products and the number of persons employed. In

1930, 144 farms were deriving their income largely from dairying. Most of these farms are on the valley plain in the eastern part of the county, where it is possible to grow alfalfa under irrigation, and a few are on the valley lands in the central part. In 1929, 5,372 milk cows were on dairy ranches and an additional 3,176 were kept for home use or for supplementing other farm incomes. In the same year the value of all dairy products sold, including dairy cattle and calves, amounted to $1,114,843. In 1929, 5,360,002 gallons of milk were produced, slightly less than 65 percent of which was disposed of as whole milk in the bay cities. Most of the remainder was sold as butterfat.

The dairy cattle are fed a few pounds of dry hay in the morning, are allowed to run on alfalfa pasture during the day, and in the evening after removal from pasture generally are fed a few pounds of rolled barley or some other concentrate. The fields are fenced into small units, and the pasturing is rotated over the different units. The larger areas are set aside for the production of sufficient hay for feed during stormy weather when the fields are too wet to be pastured. The general plan is to have at least an acre of alfalfa to each animal.

The dairy ranches average about 250 acres in size; about two-thirds of them embrace more than 100 acres and less than 1,000 acres. The average dairy herd includes from 50 to 60 milk cows, but on a few ranches more than 100 milk cows are kept. Most of the herds are tuberculin tested, and the milk is produced under sufficiently sanitary conditions to meet the requirements of raw market milk. The production of milk from cows kept on dairy ranches averaged 688 gallons per cow in 1929, and that of cows kept for home use or to supplement other farm incomes averaged 523 gallons. These yields are very good when compared to an average production of only 440 gallons a cow for the United States and 630 gallons for California, in 1924. Average yields can be improved still further, however, by keeping systematic production records and culling out unprofitable producers. Most of the dairy cattle are of the Holstein-Friesian breed, but some pure-blooded Jersey and Guernsey herds supply certified milk to cities of the bay region.

In addition to dairy cattle, a few goats are kept for the production of milk. One farm in lower San Ramon Valley specializes in goat's milk for sale in the cities.

Poultry raising ranks high in importance, and 136 farms derive most of their income from poultry products. At the time of the 1930 census, 81,974 chickens were on poultry ranches, and an additional 61,517 were on other ranches, supplementing incomes from other farm operations or supplying home needs. The chickens kept on the poultry ranches are given good care and are culled and fed for egg production. This is well reflected in their average production as compared to the production of hens on ranches not devoted exclusively to poultry raising. In 1929, the poultry ranches produced 933,734 dozens of eggs, an average of 137 eggs a hen, and the hens on other than poultry ranches produced 402,740 dozens of eggs, an average of 79 eggs per hen. The value of all poultry products produced in the county in 1929 was $722,941.

The poultry ranches are scattered throughout the county, the greater number centering around Lafayette and various towns of the San

Ramon Valley. Most of them are situated on well-drained sunny exposures, and the flocks are confined within fenced enclosures that allow plenty of room for exercise. The hen houses in general are modern and afford ample protection from the elements as well as provide sanitary laying conditions.

The majority of poultrymen buy their chicks from commercial hatcheries; 289 farms reported the purchase of 129,106 baby chicks in 1929. The commercial flocks are almost exclusively of the White Leghorn breed, but various heavier breeds are preferred on most of the ranches producing poultry for home consumption. Few of the commercial poultry plants produce their own feed. The feeds are purchased and the eggs are sold largely through a cooperative association.

In addition to chickens, a number of turkeys are raised, largely on ranches devoted to general farm crops. Numerous waterfowl are raised for sale throughout the county, but no ranches are devoted exclusively to this business. Squabs are raised commercially on several ranches, but nowhere are they the major source of income.

In the proportion of capital invested in livestock, land, and buildings, the raising of livestock outranks any other agricultural pursuit in the county. In 1930, 100 ranchers derived their income largely from livestock operations. The value of land and buildings on livestock ranches at that time was $6,145,890, and the value of livestock and livestock products sold or traded from livestock ranches was $771,054.

The livestock ranches are in the hilly and mountainous sections, and the owners specialize largely in the raising of sheep and beef cattle. The ranches average about 1,500 acres in size, and more than 30 percent of them embrace between 1,000 and 5,000 acres. In addition to the ranches on which the income is derived largely from livestock, sheep or cattle are kept on most of the grain ranches to graze over uncultivated areas or on stubble and fallow lands. The number of cows and heifers kept mainly for beef on the livestock farms in 1930 was 5,205, and all other cattle, including steers, of which 1,579 were 2 or more years old, numbered 8,760. In the same year, 39,131 sheep were on 39 of the livestock ranches in the county.

Sheep and cattle are run on the range throughout the year and in normal years are given no supplemental feed. In dry years or when the range is overstocked, ewes are fed some hay and concentrates at lambing time. The general plan is to have lambs dropped in the fall as soon as grass for feeding may normally be expected. They are marketed in the spring directly from grass without additional feeding, when they weigh about 60 or 70 pounds. Most of the beef cattle, when 2 years old, are marketed in the spring before the grass begins to dry. They usually are in good condition at that time and require no additional feed for fattening.

Beef cattle, as a rule, are not transferred from winter to summer grazing grounds as is the practice in many other sections of the State, but they are kept on the ranch of the owner or on rented grazing land throughout the year. The fields are fenced and generally are grazed in rotation, a field being left ungrazed at least every third or fourth year. In the fall many sheepmen transfer their flocks to the harvested corn-

fields of the delta or to grain-stubble land, in order to insure that the ewes may be in good condition at lambing time. On the grain ranches of the eastern part of the county sheep are used to advantage in keeping down the growth of weeds on fallow land.

Most of the beef cattle are of mixed breeds, but the inclusion of Hereford bulls of good breeding is bringing about a predominance of that blood in most of the herds.

In 1935, 10,563 swine were on the farms. They are kept almost exclusively to be fed the byproducts of the ranches or to be run on grain or corn stubble. They supplement the income from other farm operations and seldom constitute the major source of farm income.

Horse breeding is not important, although 912 farms reported having horses or mules at the time of the 1935 census, and one ranch is devoted exclusively to the breeding of gaited horses. Of the 3,864 horses and 172 mules in the county in 1935, practically all are kept for draft purposes in connection with grain-farm operations. Work horses, most of which are of Percheron blood, are generally of medium weight.

In 1880, 885 farms averaged 314.3 acres of improved land, or a total of 278,155.5 acres. The 1935 census shows 207,621 acres of improved land, including cropland and plowable pasture, divided among 2,299 farms, an average of 90.3 acres of improved land a farm. The data would indicate a reversion to grazing land of part of the area formerly plowed and used for the production of cereals or hay. The better land remaining under cultivation has been divided into smaller units, principally for the production of fruits or nuts. The average size of the farms is 161.6 acres; that of ranches devoted to the production of fruits or nuts is about 60 acres; that of ranches devoted to the production of grain or hay and grazing is about 800 acres; and that of livestock ranches is about 1,500 acres. The average value of land and buildings in 1935 was $18,462 a farm as compared with $7,141 in 1880.

In 1930, 82 farms reported the purchase of fertilizers at an average cost of $460.70 a farm. The soil amendments used are barnyard manure or ready-mixed commercial fertilizer. The hire of labor was reported on 1,354 farms at an average cost of $1,483.99 a farm. Most of the laborers employed on the dairy farms are American born, whereas those who work on fruit ranches and harvest vegetable crops are largely Filipinos or Mexicans. Work in the orchards and the harvesting of vegetable crops generally is handled under contract, and in 1933 day labor was paid about $2. On the smaller fruit ranches, exchange of labor is a common practice.

Of the 2,299 farms in 1935, 1,762 were operated by owners, 55 by managers, and 482 by tenants, some of whom rented on a cash basis and others on a share-crop basis. The tenants renting grain ranches on a share-crop basis generally furnish everything necessary, and the owner receives as his share one-fourth of the crop delivered in the warehouse; the owner of a truck or fruit ranch generally receives one-fifth of the crop.

Most of the farmhouses are modern and are equipped with telephones, running water, electricity where available, and, especially in the warmer sections, with natural gas for cooking. On the larger

poultry ranches, well-built modern hen houses shelter the flocks, but, in general, barns and shelters for poultry and livestock are cheaply built although serviceable under existing climatic conditions. Many farm homes are equipped with radios, and automobiles and trucks are in general use. Tractors are used on most farms, the size of the tractor depending on individual requirements. The light- or medium-weight tractor is the most common.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers or horizons called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil[3] and its content of lime and salts are determined by simple tests.[4] The drainage, both internal and external, and other external features, such as the relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, special emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics, soils are grouped into mapping units. The three principal ones are (1) series, (2) type, and (3) phase. Areas of land, such as coastal beach or bare rocky mountainsides that have no true soil, are called (4) miscellaneous land types.

The most important of these groups is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Thus, Hugo, Altamont, Zamora, and Yolo are names of soil series.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to

[3] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality; higher values, alkalinity; and lower values, acidity.

[4] The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthlein solution is used to detect a strong alkaline reaction.

give the complete name of the soil type. For example, Hugo clay loam and Hugo clay are soil types within the Hugo series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is generally the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within the type which differs from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of accelerated erosion frequently are shown as phases. For example, within the normal range of relief for a soil type, there may be parts which are adapted to the use of machinery and the growth of cultivated crops and other parts that are not. Even though there may be no important differences in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such an instance the more sloping parts of the soil type may be segregated on the map as a sloping or hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS

Contra Costa County is dominated by hilly and mountainous relief, with minor drainageways deeply entrenched and bordered by narrow strips of alluvium. The eastern part is formed by a broad valley plain sloping gently toward and merging with the delta lands of San Joaquin River. This plain is about 3 miles wide in the southeastern part of the county and gradually broadens to a maximum width of about 10 miles on the north.

The soils of the valley plain are varied in character, but some of the largest continuous bodies of the soil types mapped are in this section. The delta lands consist largely of organic deposits, together with various quantities of mineral sediments. Bordering the delta deposits are long narrow belts of mineral soils laid down by and paralleling San Joaquin River and its associated sloughs and distributaries. Streams issuing from the hilly lands to the west have built large alluvial fans in the central part of the valley plain, which completely cover the underlying materials and encroach on the mineral soils that border the organic deposits of the delta. The northern part of the valley plain is occupied by wind-blown sandy deposits, around which the alluvial materials are being deposited.

In the valleys in other parts of the county the individual bodies of soil are small, and because of differences in drainage, local climatic conditions, and parent materials, numerous series and types of soils are intermingled. The most uniformly dark-colored soils are in San Ramon Valley and smaller valleys to the west.

In the hilly parts of the county, the different parent rocks have given rise to a number of different soils developed in place. Here, the soils occur as more or less continuous bands broken by steep nonagricultural areas and drainageways.

The climatic and biologic environment is an extremely important factor in the development of the soils. It is perhaps the most important factor in determining the chemical and physical composition of the soils in different parts of the county. In the western part, where the rainfall is relatively heavy and the winds sweeping inland from the ocean and bays are cool and moist, the soils are leached of lime and are comparatively dark colored because of an accumulation of organic matter. The rainfall becomes gradually lighter and the prevailing winds warmer and drier toward the east. The youthful hill soils of the western part retain lime in the subsoil and are dark gray or black; in the eastern part, they are dull gray or dull brownish gray and contain free lime in both the surface soil and the subsoil. The valley soils in the western part are dark colored and leached of lime; in the eastern part they are dull brown or rich brown and are invariably calcareous in the subsoil. Some of the soils in the eastern part contain an accumulation of mineral salts and support a vegetation typical of semiarid sections, whereas the soils in the western part are leached of salts and in part are wooded with oaks. Ferns, trees, and brush grow thickly in the more shaded canyons.

The relative age, or stage in development, of the soils in each climatic zone has given rise also to a number of different soil series and types. The soils on the elevated terraces generally are well matured and are characterized by pronounced accumulations of clay in the subsoils. In some soils a tight, compact claypan, that effectively influences the penetration of moisture and roots, has been developed. In general, the soils of the alluvial fans and stream bottoms represent a youthful stage in development, which is favorable to their agricultural use. The soils on the hill lands are, for the most part, comparatively shallow and immature, as a result of erosion and soil creep.

On the river delta soils, principally on the organic soils, potatoes, asparagus, sugar beets, onions, celery, barley, corn, and milo yield abundantly. All these are cash crops produced commercially.

The sandy soils of the northeastern plains are utilized largely in the production of almonds. A smaller acreage is in grapes chiefly of the wine, or juice, varieties. Some fruits are grown commercially, but yields are not such as to encourage an expansion of the acreage in fruit orchards. The farmers of this district depend largely on cash crops. Poultry products and a few vegetables are produced for home use.

The soils of the eastern plains, other than the sandy deposits, are largely irrigated and are used to produce a wide range of crops. Apricots, prunes, peaches, and grapes occupy more than 70 percent of the acreage devoted to tree and vine crops. Plums, pears, cherries, figs, walnuts, and nectarines occupy smaller acreages but are nevertheless cash crops grown on a commercial scale. The fruit ranchers generally produce some poultry and garden truck for home use and

depend largely on neighboring ranches for other agricultural products. Most of the alfalfa produced is grown on the soils of the eastern plains and is fed to dairy cattle. A good quality of alfalfa seed is produced in the Byron district, and a variable acreage is utilized for this purpose each year, depending on the relative profit that can be derived from hay or seed. The acreage in melons, lettuce, tomatoes, and various other vegetable crops is increasing on the soils of this district.

In Ygnacio, Clayton, and San Ramon Valleys, walnuts, for which this district is especially noted, almonds, pears, grapes, and prunes are the principal cash crops. Peaches, plums, cherries, quinces, and apples also are produced here on a commercial scale, but they seldom constitute the sole cash crop of an individual rancher. Tomatoes, lettuce, and other vegetables are grown commercially.

The soils of the hills and mountain slopes in the western and higher central parts are wooded with oaks that have value only as fuel or fence posts. Large areas in the eastern part and elsewhere throughout the county are open and covered with grass, and, although they are too steep for cultivation, many of them are valued highly as grazing land for sheep and cattle. In the south-central part several thousand acres are devoted to grain hay. In the north-central part and elsewhere, the more gently sloping soils of the hilly areas are used for the production of wheat or barley or for grain hay when the season or economic conditions warrant.

The soils of this county are classified in four main groups, as follows: (1) Soils of the hilly and mountainous areas, (2) soils of the valley and coastal-plain areas, (3) organic soils of the river-delta area, and (4) miscellaneous land types. The soils of the valley and coastal-plain areas are further separated into (*a*) older soils of advanced profile development and (*b*) younger soils of undeveloped or young profile. This separation recognizes that under normal conditions of environment soils pass through definite stages corresponding to infancy, youth, maturity, and old age, which are determined by processes of soil development rather than by the time element and which are reflected in the development of natural layers or horizons in the soil profile, accompanied by definite mineral, chemical, and physical characteristics. Some of these soils represent stages in development that are transitional or intermediate between the older and the younger soils. They, therefore, occupy a somewhat debatable position in the classification.

The soils range in color from light gray and light brown or rich reddish brown to dark dull brown and black, although, with the exception of a few, they are predominantly dark in comparison with the soils of most of the areas that have been mapped in previous surveys in the State.

In the following pages the soils are described in detail, and their agricultural importance is discussed; their distribution is shown on the accompanying soil map; and their acreage and proportionate extent are given in table 4.

TABLE 4.—*Acreage and proportionate extent of the soils mapped in Contra Costa County, Calif.*[1]

Soil type	Acres	Percent	Soil type	Acres	Percent
Nacimiento clay loam	704	0 2	Denverton adobe clay	448	0 1
Linne adobe clay	2,368	.5	Sacramento adobe clay	5,312	1.1
Arnold sandy loam	4,224	.9	Marcuse loam	2,560	.5
Hugo clay loam	2,752	.6	Marcuse clay	3,968	.9
Hugo clay	16,064	3 5	Sorrento clay loam	1,920	.4
Hugo clay, steep phase	18,176	3.9	Sorrento clay	1,472	.3
Altamont clay loam	27,456	5.9	Yolo loam	2,304	5
Altamont clay loam, steep phase	31,104	6.7	Brentwood clay loam	11,712	2 5
Altamont adobe clay	9,856	2.1	Brentwood sandy clay loam	1,984	4
Los Osos clay loam	4,864	1.0	Brentwood clay	7,104	1.5
Los Osos clay loam, shallow phase	640	.1	Oakley sand	8,256	1 8
Los Osos adobe clay	14,016	3 0	Salinas clay loam	2,944	.6
Los Osos adobe clay, steep phase	41,664	9 0	Botella clay loam	448	.1
Contra Costa sandy loam	2,944	.6	Botella clay	13,824	3.0
Contra Costa clay	1,984	.4	Danville clay loam	2,688	.6
Contra Costa clay, steep phase	8,512	1.8	Dublin adobe clay	2,304	.5
Sobrante stony clay loam	3,520	.8	Dublin adobe clay, overwash phase	1,024	.2
Diablo adobe clay	29,568	6.4	Dublin adobe clay loam	1,472	3
Diablo adobe clay, steep phase	5,056	1.1	Clear Lake adobe clay	15,552	3 3
Cayucos loam	7,808	1.7	Clear Lake clay loam	1,792	4
Cayucos adobe clay	8,128	1.7	Columbia loam	512	.1
Rincon clay loam	3,712	.8	Alviso clay	1,920	4
Rincon clay	6,784	1.5	Piper fine sandy loam	3,200	7
Zamora loam	2,432	.5	Egbert clay loam	6,208	1 3
Zamora clay loam	4,736	1.0	Ryde clay loam	2,816	.6
Antioch loam	2,176	.5	Peat	24,896	5 3
Ambrose clay loam	10,624	2 3	Piper fine sandy loam, Egbert clay loam, and peat, undifferentiated	1,344	.3
Ambrose adobe clay	1,536	.3	Made land	896	2
Tierra loam	6,784	1.5	Rough broken land	4,864	1 0
Olcott loam	1,472	.3	Rough stony land	8,704	1 9
Herdlyn loam	2,240	.5	Tidal marsh	8,192	1 8
Solano silty clay	3,776	.8	Unclassified city land	12,224	2 6
Manzanita gravelly clay loam	1,536	.3			
Corning gravelly clay loam	1,792	.4			
Cowell clay loam	2,560	.5			
Antone clay loam	5,376	1.2	Total	465,920	
Montezuma adobe clay	2,112	.5			

[1] In this survey, because of much greater detail in mapping, data accumulated in several years of field study, and development in the science of soil classification since the date of the earlier surveys (mainly of a broader reconnaissance character), many changes from the older surveys have been made in soil names, resulting in apparent conflicts. The more important of these are noted in the text.

SOILS OF THE HILLY AND MOUNTAINOUS AREAS[2]

The soils of the hilly and mountainous areas comprise the Nacimiento, Linne, and Arnold soils, which have predominantly gray or grayish-brown surface soils; the Hugo soils, which are dull brown; the Altamont and Los Osos soils, which are brown or dull dark brown; the Contra Costa and Sobrante soils, which are reddish brown; and the Diablo and Cayucos soils, which are black. All these soils are developed from the underlying weathered rock and are comparatively shallow.

These soils are used for pasture and for the production of grain and hay. The larger areas are steep, and the soils are shallow. They are utilized for grazing in connection with dairy farms and livestock ranches. Wheat and barley, much of which is cut green and cured for hay, are grown extensively on the smoother and more gentle slopes.

The 7- to 12-inch surface soils of members of the Nacimiento series are brownish gray or yellowish gray, granular, friable, and

[2] For the purpose of avoiding unnecessary repetition, some of the more general or less important characteristics common to the soil series described under the main soil groups are eliminated from descriptions of the individual soil types.

calcareous. They grade into slightly compact light brownish-gray highly calcareous material of about the same texture. Both surface soils and subsoils are permeated with interlacing root cavities. Most of the older cavities in the subsoil have been filled with lime carbonate. When disturbed, the subsoils break into coarse clods that crumble readily to a fine granular structure. The subsoils rest on parent bedrock of calcareous shale at a depth ranging from 20 to 40 inches, depending on the degree of soil creep and erosion to which the soils are subject. Native grasses formed the vegetal cover under virgin conditions. Nacimiento clay loam is the only type of this series mapped in this county. It is developed in the eastern part of the hilly section under comparatively low rainfall. In the earlier reconnaissance surveys it was included with the Altamont and Diablo soils.

The surface soils of types in the Linne series are dull-gray or dull brownish-gray calcareous material that is granular and friable, though generally of heavy texture. In most places the surface soils are about 10 or 12 inches thick, and they grade into brownish-gray slightly compact highly calcareous material that rests on parent bedrock of calcareous shale at a depth ranging from 30 to 45 inches, except on the steeper slopes or other areas subject to erosion where the soil covering over bedrock is shallow. Although the soil mass is calcareous throughout, the lime carbonate in the lower part of the subsoil is somewhat concentrated in interlacing root cavities, giving an appearance of mycelia. Under virgin conditions these soils are grass-covered. Only the adobe clay member of the series occurs in this county. Like Nacimiento clay loam, it is developed in the eastern part under comparatively low rainfall. In the earlier reconnaissance surveys it, also, was included with the Altamont and Diablo soils.

The Arnold series comprises soil types having dull-gray or dull dark brownish-gray surface soils to a depth ranging from 7 to 10 inches. The upper part of the subsoil, to a depth ranging from 18 to 26 inches, is typically slightly heavier textured than the surface soils and of a dull dark-gray or dark brownish-gray color. The material is only slightly compact and breaks readily to a fine granular structure. Slightly dull brown or dark-brown colloidal staining is apparent in root cavities in this layer. The lower part of the subsoil is dull gray or light brownish gray, and in areas of typical development is of about the same texture as the surface soils. It contains little colloidal material and crumbles readily to a fine granular structure. In the flatter areas, covering probably nearly one-half of the total area, the material in this layer is tight compact sandy clay. The depth to the parent bedrock of gray sandstone varies within short distances, owing to the removal of soil material by erosion, but in the more typical areas it ranges from 30 to 36 inches. Arnold sandy loam is the only type of this series mapped. It supports a scattered growth of oaks and grasses under virgin conditions and has an undulating or hilly relief. Because of its erosibility, low productivity, and low water-holding capacity, only a small part of the soil, which occurs only in the northern part of the county, is cultivated.

Soils of the Hugo series are characterized by dull grayish-brown surface soils tinged with yellow, extending to a depth ranging from 7 to 10 inches. The upper part of the subsoil, to a depth ranging from

18 to 24 inches, consists of dull grayish-brown or dull yellowish-brown slightly compact material which is heavier textured than the overlying layer and has a cloddy structure. The insides of the older root cavities and the outside surfaces of the structural aggregates are somewhat coated with dull yellowish-brown colloidal stains. When crushed, however, the color is similar to that of the surface soils. The lower part of the subsoil is light gray or dull yellowish gray and generally is lighter textured than the material in the surface soil. It contains an appreciable quantity of partly decomposed sandstone or shale fragments. The substratum of parent bedrock, which is generally noncalcareous, is reached, in most places, at a depth ranging from 20 to 45 inches. The lighter textured soils of this series are somewhat shallower and have a lower water-holding capacity than the heavier textured types. Under virgin conditions these soils support a scattered growth of oaks, together with a fair stand of grasses. They are developed in areas of hilly or rolling relief, in which the slopes for the most part are smooth, although many are steep. The surface soil and subsoil materials generally are slightly acid. As mapped in this county, the soils of the Hugo series are somewhat darker than those in areas previously surveyed. This is perhaps due to the more frequent fogs and decreased oxidation of organic matter. The series includes Hugo clay, Hugo clay loam, and Hugo clay, steep phase. These soils occur in the northern part of the county. They are of moderate extent but of little agricultural importance, although areas of favorable depth and slope are utilized for the growing of grapes. At the time of the earlier reconnaissance survey of the San Francisco Bay region (*1*), these soils were included with soils of the Altamont series.

The surface soils of members of the Altamont series are brown or dull brown and range from 6 to 12 inches in thickness. They grade into dull grayish-brown or dark grayish-brown slightly more compact material that is typically somewhat heavier textured than the surface soils. The subsoil breaks into coarse clods, stained on the outside with dull-brown colloidal material, that are easily reduced to a granular structure under moderate pressure. At a depth ranging from 20 to 30 inches, the upper part of the subsoil grades into the dull-brown or dull grayish-brown calcareous lower subsoil layer which contains disseminated lime with only slight evidence of segregation and is of about the same texture as or slightly lighter texture than the surface soils. Numerous fragments of parent calcareous shale or sandstone bedrock occur in the lower part of the subsoil which grades into partly weathered bedrock at a depth ranging from 30 to 45 inches. These soils occupy hilly relief, and they were largely grass-covered under virgin conditions. The surface soils generally are neutral in reaction, and the subsoils are alkaline. Altamont clay loam; Altamont clay loam, steep phase; and Altamont adobe clay are mapped.

As developed in this county, the Altamont soils in many places are somewhat darker than is typical of soils of this series elsewhere, and they include variations which approach the darker soils of the Diablo series, although, under moist field conditions, the brown color of the Altamont soils becomes more pronounced, in contrast with the associated Diablo soils. The Altamont soils, together with the

associated Los Osos, Cayucos, and Diablo soils, are extensive and are the more important grain- and hay-producing soils of the hilly areas.

Soils of the Los Osos series have brown or dull-brown surface soils from 7 to 10 inches thick. They are of coarse cloddy structure and, under favorable conditions of moisture content and cultivation, crumble readily to a granular condition. The upper subsoil layers, which extend to a depth ranging from 16 to 24 inches, are dull brown or brownish drab, slightly compact, somewhat heavier textured than the surface soils, and contain partly weathered rock fragments. They are without definite structural development but break into coarse clods that are reduced to a coarse granular structure under moderate pressure. Root cavities and faces of parting planes are coated with dark-brown colloidal stains. The lower subsoil layers, which extend to a depth ranging from 36 to 45 inches, consist of light-brown or light yellowish-brown material of about the same texture as the surface soils. With depth, these layers contain increasing quantities of sandstone or shale rock fragments which are in different stages of weathering and give rise to rust-brown and gray mottlings. The root cavities in places are stained with yellowish-brown colloidal deposition. Both surface soils and subsoils are noncalcareous, although here and there the parent bedrock contains some lime. These soils support a native vegetation of various species of oaks, together with grasses and herbaceous plants. The relief is hilly, and the slopes range from gentle to steep.

The surface soils and subsoils of members of the Contra Costa series are pale reddish brown, rich brown, or rich light brown. The surface soils are of low organic-matter content but in general are friable or moderately friable. The transition from surface soils to subsoils is gradual. The subsoils are moderately compact and, except in the sandier types, break into irregular clods without definite structural form. The soil aggregates are but feebly coated with colloidal material and rest on light-colored sandstone, conglomerate, or shaly parent bedrock which in most places occurs at a depth ranging from 20 to 30 inches, depending on the angle of slope and degree of erosion to which the soil has been subjected. The soils are developed on rolling to hilly relief, and the slopes range from smooth and gentle to steep. Drainage is excessive, and the soils are of low moisture-holding capacity and, therefore, subject to drought. With the exception of sheltered slopes, on which scattered oaks grow, they are grass-covered. They have been developed under low rainfall and are utilized for the production of dry-farmed grain and for pasture. Contra Costa sandy loam, Contra Costa clay, and Contra Costa clay, steep phase, are mapped. These soils occur in the eastern part of the county, and in the earlier reconnaissance surveys they were included with the Altamont soils, to which they are related.

The 10- to 14-inch surface soils of members of the Sobrante series are brown or dull reddish brown. They are friable and of low or moderate organic-matter content. The surface soils grade into dull reddish-brown somewhat heavier textured slightly compact subsoils which become slightly lighter in color directly overlying the parent bedrock which lies at a depth ranging from 20 to 45 inches. The bedrock typically consists of basic igneous rocks, although in this county rhyolite and some serpentine, as well as more acid rocks, have

entered into the composition of the parent soil material. Under virgin conditions the soils supported a fair to good growth of oaks and brush depending on the depth of soil, exposure, and other factors that affect the water-holding capacity. The relief ranges from hilly to mountainous. Although moderately developed in the Mount Diablo section, very little of the total area of these soils is used for cultivated crops. In the earlier reconnaissance surveys, the soil mapped as Sobrante stony clay loam in this county was included with soils of the Olympic series, to which it is closely related in origin and character, but it has developed under a lower rainfall.

The 8- or 10-inch surface soils of members of the Diablo series are dark gray, dark brownish gray, or black and generally of heavy texture and difficult to handle under cultivation, if not in favorable moisture condition or until reduced through natural processes of exposure to a small-cloddy and granular structure. The upper part of the subsoil, to a depth ranging from 20 to 32 inches, is moderately compact dark-gray or black material which typically is of somewhat heavier texture than the surface soil. This material breaks along well-defined parting planes into elongated clods or blocks of irregular or rough prismatic shapes. The faces of the parting planes and the insides of cavities are coated with very dark brown colloidal stains. The structural aggregates and parting planes become less pronounced in the lower part of the upper subsoil layer as it grades into dull brownish-gray lighter textured less compact material resting on parent shale or sandstone bedrock at an average depth of about 40 inches. The lower part of the subsoil contains free lime carbonate disseminated through the soil mass and with some tendency toward mycelialike segregation. The parent bedrock ranges from moderately to highly calcareous. Under virgin conditions these soils support a scattered growth of oaks and are carpeted with grasses and herbaceous plants during the winter. Diablo adobe clay and Diablo adobe clay, steep phase, are mapped. They occur on rolling to steeply sloping hills or mountains.

The surface soils of members of the Cayucos series range in thickness from 7 to 10 inches, and they are dark gray, dark brownish gray, or black. The upper part of the subsoil, which extends to a depth ranging from 20 to 25 inches, is moderately compact and of somewhat heavier texture than the surface soils. It is slightly darker and contains dark brownish-gray colloidal stains that coat the insides of cavities and faces of structural units. The material breaks into coarse irregularly shaped clods along parting planes that are well defined in the upper part of the subsoil but become less well developed in the lower part. The upper subsoil layer grades with depth into material that is less compact and of somewhat lighter texture. It is dull brown, dark brown, or dark grayish brown and rests on parent sandstone or shale bedrock at a depth ranging from 26 to 48 inches. The material in this layer is without definite structural form and breaks into coarse clods that, although firm, are more readily reduced to a small-cloddy structure than the overlying material. The surface soil and subsoil materials are without free lime carbonate, but the underlying bedrock contains some lime in places. These soils occupy gently to steeply sloping hilly relief. During the winter they support a herbaceous growth that carpets the ground under a scattered growth of oaks.

Cayucos loam and Cayucos adobe clay are mapped. The Cayucos soils formerly were included with the Diablo soils and with the darker colored areas of the Altamont soils. They are closely related to the Diablo soils but have developed under a heavier rainfall and have been leached of lime.

Nacimiento clay loam.—The 7- to 12-inch surface soil of Nacimiento clay loam is brownish-gray or yellowish-gray granular friable calcareous clay loam which is easily handled in cultural operations. The subsoil is brownish gray, of about the same texture as, but slightly more compact than, the surface soil, and highly calcareous. There are many interlacing root cavities which, in the subsoil are filled with lime carbonate. The subsoil is of coarse cloddy structure that crumbles to a fine granular structure when disturbed. Parent bedrock of calcareous shale occurs at a depth ranging from 20 to 40 inches.

The soil is subject to considerable erosion and the activity of rodents, and it contains but little organic matter. The soil in many areas is shallow, especially along the crests of the hills, where it contains more or less angular chips of the parent calcareous bedrock.

This soil is developed in only two bodies in the foothills of the eastern part of the county—one just north of the place where Briones Valley passes into the alluvial plain and the other just south of the entrance to Lone Tree Valley.

Some of the land is used for the production of grain and grain-hay crops which yield well in favorable seasons, but the greater part has never been cultivated. Although native grasses wither in the hot dry summer, they make a good growth during the wetter months and furnish appreciable quantities of feed. This soil is valued for the grazing of livestock, but the prevailingly low rainfall limits its agricultural value.

Linne adobe clay.—The 10- to 12-inch dull-gray or brownish-gray surface soil of Linne adobe clay is of heavy texture, but, because of its high lime content and adobe structure, it is granular and is easily cultivated. It grades into a dull-gray slightly compact subsoil which has a high lime content. The subsoil rests on calcareous shale bedrock at a depth ranging from 30 to 45 inches.

In some areas, the surface soil is noncalcareous, and in such places the soil is darker and is not so friable and granular as the typical soil. Such inclusions represent undifferentiated areas of Diablo adobe clay.

Rodents are very active in Linne adobe clay, and they damage crops unless measures of control are taken. Angular chips of the parent bedrock are numerous in the surface soil, especially on the steeper slopes or in areas where the soil is shallow as a result of erosion or where rodents are especially active.

This soil occurs entirely in the foothills of the eastern part of the county. It is especially well developed west of Byron and in numerous small bodies south and southeast of Byron Hot Springs. A number of areas are northwest of Brentwood.

About 30 percent of the soil is dry-farmed and is used in the production of wheat and barley. The rest supports a good stand of native grasses during the wetter months and is used as pasture for sheep and cattle. Wheat and barley return good yields in favorable sea-

sons, but in dry years the grain crops are frequently more profitable if cut for hay.

Arnold sandy loam.—The dull dark-gray surface soil of Arnold sandy loam, which is about 8 inches thick, is loose and friable under cultivation but tends to bake when uncultivated. The subsoil typically is loose and friable to bedrock of gray sandstone, on which it rests at a depth ranging from 30 to 36 inches; but in many areas, especially in swales and near the lower slopes of the hills, it is heavy sandy clay that is not particularly favorable to the development of plant roots. Slight dull-brown or dark-brown colloidal stains are apparent in root cavities in the upper part of the subsoil. The soil generally is thin and has low water-holding capacity. The presence of shallow impervious bedrock at a slight depth limits the rooting zone of plants and causes the soil to be better adapted to shallow-rooted crops than to deep-rooted crops. The surface soil and upper part of the subsoil are mildly acid in reaction.

This soil occurs only in the northern part of the county, particularly in the vicinity of Pinole. An area embracing slightly more than a square mile borders Horse Valley, and a few smaller areas are in the hill lands south and southwest of Martinez.

About 5 percent of the land is under cultivation, and the rest is sparsely wooded with oaks or is open. This soil is not well suited to the production of grain, but it is used to some extent for this purpose in connection with other soils. Grapes are grown on a small acreage and produce fair yields of a good-quality fruit. The soil is not particularly fertile, and its agricultural value is further limited by its low water-holding capacity.

Hugo clay loam.—The 7- to 10-inch surface soil of Hugo clay loam is rather dull grayish-brown granular friable clay loam which is easily maintained in good tilth. It is low in organic matter but absorbs moisture readily and retains it well. This layer grades into a grayish-brown or yellowish-brown slightly more compact or heavier textured subsoil. Both surface soil and subsoil materials are noncalcareous. The lower part of the subsoil contains partly decomposed sandstone or shale rock fragments. The soil is comparatively shallow, averaging about 24 inches in thickness. An impervious parent sandstone or shale bedrock, which is noncalcareous in most places, limits the rooting zone of plants and, to some extent, the water-holding capacity of the soil.

Hugo clay loam occurs only in the northwestern part of the county southeast of Martinez, on hilly land bordering and partly enclosing lower lying rolling or undulating areas of Cayucos soils.

About 15 percent of the land is under cultivation, and the largest acreage is devoted to grapes. Some grain is grown, but yields are generally low. Small acreages devoted to prunes and other tree fruits return fair yields but not sufficiently good to warrant extension of the acreage under present economic conditions.

Hugo clay.—Except for the heavier texture of its surface soil, Hugo clay is similar to Hugo clay loam. The surface soil is easily handled, however, and can be worked under a wide range of moisture conditions. The soil has good moisture-holding capacity, which is somewhat limited, however, by the occurrence of parent bedrock at a depth ranging from 30 to 45 inches. Some of the steeper cultivated

areas tend to erode severely during heavy rains. On the more northern and northeastern slopes, which are protected from the sun, the surface soil in many places is darker than typical.

Hugo clay is developed, for the most part, in the northwestern and south-central parts of the county and, although it is comparatively extensive, it is not very important agriculturally. Large areas are south and west of Martinez and south and east of Mount Diablo.

About 15 percent of the land is under cultivation, and the rest is used largely for grazing. The scattered oak trees are utilized for fuel. Practically all the cultivated areas are devoted to the production of wheat and barley or grain hay. Yields of wheat average nine sacks [6] an acre, and of barley slightly more. A few vineyards on this soil return yields ranging from 2 to 4 tons of grapes an acre. Fruit trees in home orchards give rather poor yields.

Hugo clay, steep phase.—The steep phase of Hugo clay is similar to the typical soil, but it occupies areas of steeper relief. Most areas of this soil are somewhat eroded, and the soil is shallower than the typical soil, as bedrock, in most places, lies within a depth of 24 inches. Because of the tendency of the soil to erode and of the difficulties attendant on cultural operations on the steep slopes, none of the land is under cultivation, and none is likely to be of any future agricultural value other than for grazing. Scattered oak trees grow over a large part of the land, with grasses occupying the open spaces between the trees.

Altamont clay loam.—Altamont clay loam is brown, dull-brown, or dark grayish-brown friable clay loam to a depth ranging from 6 to 12 inches. It grades into dull grayish-brown or dark grayish-brown somewhat heavier textured slightly compact material containing noticeable quantities of dull-brown colloidal material which breaks into coarse clods that are easily broken down under moderate pressure to a granular structure. At a depth ranging from 20 to 30 inches the upper part of the subsoil grades into dull-brown or dull grayish-brown calcareous material of about the same or slightly lighter texture than that of the surface soil and containing fragments of the parent bedrock of calcareous shale or sandstone in the lower part. Lime is disseminated throughout this lower layer.

As mapped, this soil includes some areas in which the soil is slightly heavier textured than typical. Such soil occurs in swales or is derived from fine-grained shale. Bordering Briones Valley in the eastern part of the county, the soil is richer brown than is typical. It is very similar in color to the soils of the Contra Costa series, but it differs from those soils in that it has a calcareous subsoil.

Altamont clay loam is developed in a wide belt extending southeastward across the central part of the county from Martinez to the southern boundary west of Herdlyn.

This soil is easily cultivated, retentive of moisture, and productive. About 40 percent of the land is under cultivation, and the rest is used as grazing land for sheep and cattle. Virgin areas are heavily carpeted with alfileria, bur-clover, wild oats, and native grasses during the wetter months. Wheat and barley are the principal cultivated

[6] The capacity of grain sacks in the different markets in California ranges from 100 to 125 pounds, but the average is about 2 bushels.

crops. Yields of grain are slightly less than those obtained on Diablo adobe clay.

Altamont clay loam, steep phase.—The steep phase of Altamont clay loam is more subject to soil creep, slides, and erosion than is the typical soil; for this reason the soil texture varies somewhat, the soil covering is shallower, and bedrock outcrops in some areas. The soil occurs in steeply sloping areas which are more or less dissected by drainageways and on which cultural operations are difficult and hazardous.

This soil is very prominently developed in the range of hills which borders Clayton Valley on the north and continues southeastward to the valley plain of San Joaquin River in the southeastern corner of the county.

Most of the soil is covered with grass, together with a few oaks and patches of chamiso or other brush. The grasses afford good grazing, and the land is best suited to this use.

Altamont adobe clay.—The surface soil of Altamont adobe clay is somewhat darker than that of Altamont clay loam, and it has a tendency to assume naturally a fine-granular structure, which aids materially in cultivation. It is, nevertheless, much more difficult to plow and cultivate than are the lighter textured soils of this series, and in dry seasons crop failures are more common than on the lighter textured soils that give up moisture more rapidly to roots. Along the southeastern boundary of the county, some areas have a richer brown color than is typical, and in some places in this section the soil has a lime-free subsoil and represents an inclusion of the Los Osos soils.

Altamont adobe clay is extensively developed along the southern county line and in the eastern part of the county around the headwaters of Kellogg Creek. Smaller areas are near the upper end of Briones Valley and southwest of Clayton. A few areas are associated with other hilly land, particularly in the eastern foothill section.

About one-half of this soil is under cultivation, and the rest is used as grazing land. Wheat and barley return good yields in favorable seasons. The soil is best adapted to grain and hay crops or to grazing.

Los Osos clay loam.—The surface soil of Los Osos clay loam is brown or dark dull-brown friable clay loam, about 8 or 9 inches thick, moderately well supplied with organic matter, and easily reduced to a granular structure favorable to the preparation of a mellow seedbed. It is underlain by a dull-brown slightly heavier textured and somewhat more dense subsoil. The material in the upper part of the subsoil contains partly weathered rock fragments that, in some places, impart rust-brown mottlings. It breaks into coarse clods that are reduced under moderate pressure to a coarse-granular structure. The lower part of the subsoil consists of light-brown or light yellowish-brown material of about the same texture as the surface soil, and it contains sandstone or shale rock fragments, in various stages of decomposition, which produce rust-brown and gray mottlings. Parent bedrock lies at a depth ranging from 3 to 4 feet. Both surface soil and subsoil materials are leached of lime.

This soil is developed principally in the foothills bordering San Ramon Valley in the vicinity of Walnut Creek. Other areas of importance border Pinole and Rodeo Creeks in the northwestern part of the county.

Because of its comparatively low moisture-holding capacity, the soil is not considered of high agricultural value. About 10 percent is under cultivation, and the remainder is, in part, wooded with oaks and, in part, open and covered with grass. The cultivated areas are used largely for the production of grain or grain hay, and most ranchers on this soil depend on poultry products for supplemental income. Grasses wither soon after the rains cease in the spring. Some fruits are grown, but the yields are lower than those obtained on the deeper valley soils.

Los Osos clay loam, shallow phase.—The shallow phase of Los Osos clay loam is variable in color and texture; some areas on the crests of the hills are lighter colored and lighter textured than is typical of the phase, whereas other areas subject to seepage in the swales are darker colored and heavier textured. The soil is shallow over the parent bedrock, and it has a low moisture-holding capacity.

This shallow soil is mapped only on the northern point of Shell Ridge east and northeast of Walnut Creek. It is used largely as grazing land. The grain planted in small areas is generally harvested for hay.

Los Osos adobe clay.—The soil materials of Los Osos adobe clay are somewhat darker and of heavier texture than those of Los Osos clay loam. The surface soil is heavy clay of pronounced adobe structure, which, when wet, is too plastic to be tilled, and, when dry, shrinks, cracks, and checks into large irregular blocks. In places the larger cracks extend to a depth ranging from 2 to 3 feet. The blocks are further subdivided by smaller checks, which eventually develop a rather coarse granular structure. The fragments are of irregular shapes and very hard when dry. This promotes a friable condition not developed in soils of equally heavy texture, in which the adobe structure is lacking. During rainy periods in winter, the soil, which contains a high proportion of colloidal clay materials, absorbs moisture, the individual blocks and soil aggregates swell, and the cracks close. The soil is capable of absorbing and retaining a large quantity of moisture, it is comparatively deep, and the subsoil is readily penetrated by plant roots.

As mapped, this soil includes fairly large areas of approximately clay loam texture, that could not be differentiated readily. In general, such areas occur on the crests of the ridges and as small bodies originating from coarser textured sandstone rocks. The lighter textured soil is more easily cultivated than the typical soil and has as high a moisture-holding capacity. The color of the soil varies somewhat from place to place, as the result of drainage conditions, and some small internally poorly drained areas are much darker than the typical soil.

Los Osos adobe clay occurs only in the western and central parts of the county. It is the dominant soil in the hilly lands south and west of Lafayette and on the lower hills north of Lafayette. In the central part most of the soil is developed on the foothills north of Mount Diablo.

About 40 percent of the land is cultivated and used almost exclusively for the production of wheat and barley. Wheat yields about 10 or 12 sacks an acre, and barley from 13 to 16 sacks. Some small orchards of apples, prunes, or apricots are planted on this soil, and

yields are fairly good. Some grain hay is harvested each year, and in seasons of low rainfall most of the grain crops are cut for hay. In other parts of the State, beans and peas are valuable crops on this soil. The yield of grain following a clean-cultivated leguminous crop is materially increased.

Los Osos adobe clay, steep phase.—The steep phase of Los Osos adobe clay differs from the typical soil chiefly in the steeper and more broken character of the slopes on which the steeper soil occurs, and, in most places, the soil covering over bedrock ranges from 10 to 20 inches thinner than that of the typical soil.

This is the dominant soil in the hilly land west of San Ramon Valley. It also occurs in a number of places east of that valley. Large bodies border Wildcat and San Pablo Creeks in the northwestern part of the county. No important bodies are east of Mount Diablo.

None of the land is under cultivation, and it is not likely to be cultivated in the future, owing to the susceptibility of the steeper lands to erosion and the difficulties and hazards attendant on cultural operations over the steep and broken surfaces. The shaded northeastern slopes are largely wooded with oaks, which are cut for fuel and marketed in nearby cities; and the sunny southwestern slopes support a treeless grass cover which is utilized as pasture (pl. 1, *A*). Sheep and cattle are grazed over the land, and the more open areas afford almost as good grazing as the less steeply sloping areas of typical Los Osos adobe clay.

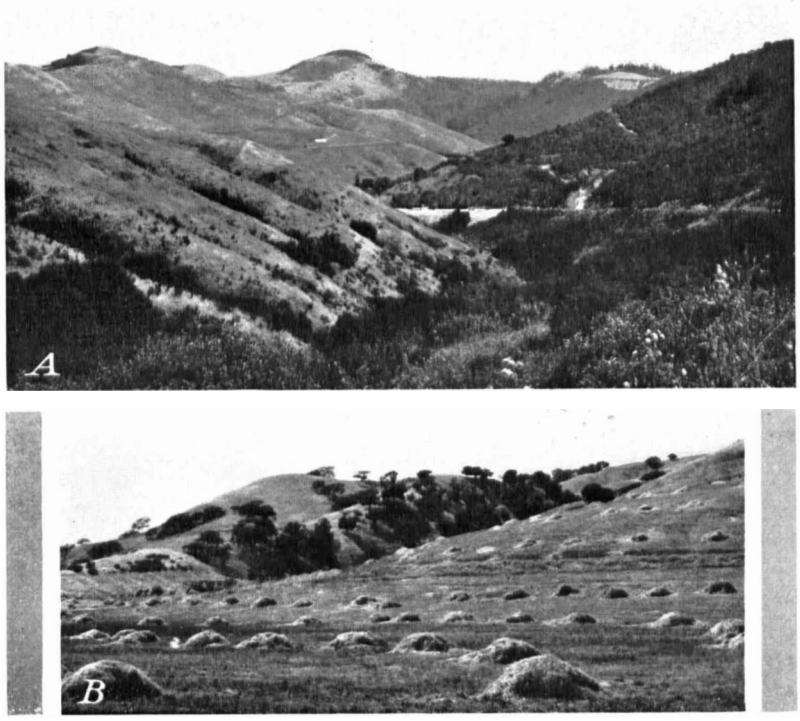
Contra Costa sandy loam.—The surface soil of Contra Costa sandy loam is light reddish-brown or pale reddish-brown friable sandy loam, 8 or 10 inches thick. It gives way very gradually to a light reddish-brown slightly or moderately compact subsoil which contains very small quantities of colloidal material. When disturbed, the subsoil breaks into irregularly shaped clods. At a depth ranging from 20 to 30 inches, the pinkish-gray sandstone or conglomerate bedrock is reached. The depth to bedrock depends largely on the angle of slope and on the degree of erosion to which the soil has been subjected. Bedrock outcrops in a few places on hill crests where erosion has been most active. The soil is neutral or slightly acid and has a low water-holding capacity.

This is not an extensive soil. It occurs only in the eastern part of the county. It occupies a low range of hills west and northwest of Byron where a tilted sedimentary rock formation exposes noncalcareous strata.

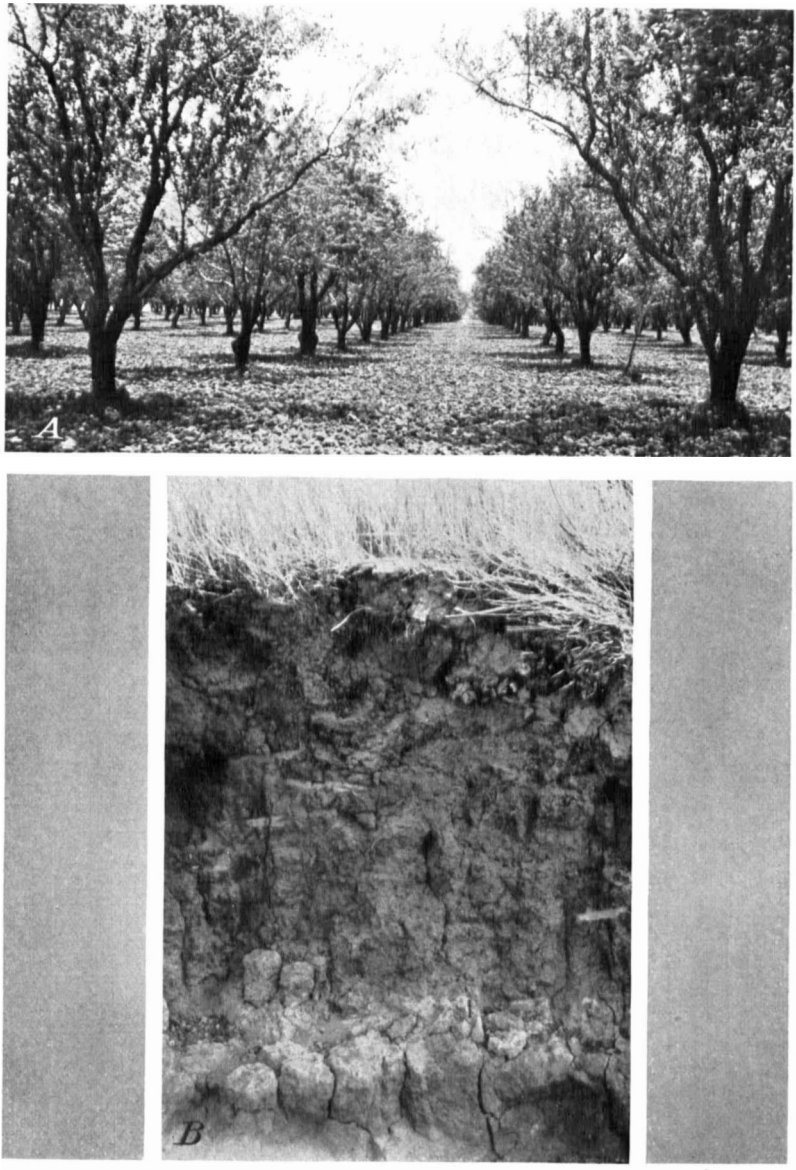
Inclusions are made in mapping of closely associated areas which are slightly heavier textured and more retentive of moisture than the typical soil. A few such areas lie near the lower end of Deer Valley.

A small proportion of the land is cultivated in connection with other soils, but yields of grain or hay are poor. The uncultivated areas are open, covered with grass, and utilized for grazing.

Contra Costa clay.—The 8- or 10-inch surface soil of Contra Costa clay consists of rich-brown clay. It is underlain by a dull-brown moderately compact subsoil. The soil is of more pronounced reddish-brown color than Contra Costa sandy loam. It has good water-holding capacity, is fairly easy to cultivate, and may be worked readily to a granular structure. Parent bedrock is reached, in most places, at a depth ranging from 3 to 4 feet.



A, View down a stream valley in the hills in the northwestern part of the county, occupied by Los Osos adobe clay, steep phase. The shaded northeastern slopes are covered with grass and trees, and the sunny southwestern slopes support a grass cover only. *B*, Barley hay on Diablo adobe clay near Lafayette.



A, A clean-cultivated almond orchard on Zamora loam; *B*, profile of Antioch loam showing solonetzlike structure.

This soil occurs only in the eastern part of the county and is most typically and extensively developed on the edge of Round Valley and around the headwaters of Kellogg Creek. A number of typical bodies border Marsh Creek in the vicinity of Hog Canyon.

About 10 percent of the land is cultivated, and it returns slightly smaller yields of wheat and barley than does Los Osos adobe clay. Patches of oak trees are scattered over the shaded canyon slopes, but the more exposed slopes are open, support a good growth of grasses, and furnish desirable pasture.

Contra Costa clay, steep phase.—Contra Costa clay, steep phase, is shallower over bedrock than is the typical soil, and it occupies steeper and more broken slopes. In the large body lying south and west of Mount Diablo the soil varies greatly in color, texture, and structure, owing to variations in the parent materials. In places the soil is deep red intermixed with gray and brown. The texture varies also within short distances, from clay loam to clay. Some igneous rocks have entered into the formation of the soil in this body. Large bodies of the steeper soil border Marsh Creek in the vicinity of Hog Canyon. Due to the steep, broken character of the slopes on which this soil occurs, the possibility of agricultural utilization other than for grazing is remote. A good growth of grass carpets the soil, and a few oaks, buckeyes, and brush grow on the more shaded slopes.

Sobrante stony clay loam.—Sobrante stony clay loam, to a depth ranging from 10 to 14 inches, consists of rich dull reddish-brown clay loam containing large quantities of stone. It grades into a dull reddish-brown subsoil of similar or slightly heavier texture, in which angular stone fragments are present. Parent bedrock underlies the soil at a depth ranging from 20 to 45 inches. In this county Sobrante stony clay loam is developed typically on andesitic and basaltic rock, but the parent materials and soils are somewhat variable, and the underlying rocks, both igneous and metamorphic, are more acidic in places, especially in the areas along the western boundary. Several bodies of this soil are developed on and near Mount Diablo.

Sobrante stony clay loam absorbs water readily, has a comparatively high water-holding capacity despite its relatively slight depth, and contains appreciable quantities of well-decayed organic matter. It is a noncalcareous soil. The content of angular rock fragments varies from place to place but is sufficiently large in most places to interfere with cultural operations, and, in some places, the soil cannot be worked until the stones have been removed. In the areas containing fewer stones, the soil is friable, granular, and is easily maintained in good tilth.

The relief of Sobrante stony clay loam ranges from hilly to mountainous. Although extensively developed in the Mount Diablo section, very little of this soil is cultivated. The cultivated areas are used largely with other soils in the production of fruit and grain. Grapes and small fruits do well on the deeper soil areas. The virgin soil supports a growth largely of oaks and brush, and it affords poor grazing although grass grows well in the more open areas.

Diablo adobe clay.—The surface soil of Diablo adobe clay, to a depth of 8 or 10 inches, is dark brownish-gray or black clay of adobe structure. It is well supplied with organic matter and is rather easily handled if worked under proper moisture conditions, despite its heavy texture. If plowed when slightly moist, it crumbles naturally to a

fine- or medium-granular structure favorable to the preparation of a mellow seedbed. The soil retains moisture well but, owing to its heavy texture, gives it up slowly to crops. The upper part of the subsoil, to a depth ranging from 20 to 32 inches, is moderately compact dark-gray or black heavy-textured material. This breaks into roughly prismatic clods coated with very dark brown colloidal stains. The upper subsoil layer grades into dull brownish-gray lighter textured and less compact material. Free lime carbonate is disseminated throughout the lower subsoil layer, but it tends toward a myceliumlike segregation or toward mottlings, particularly in the grayer inclusions. The moderately to highly calcareous parent bedrock is reached at an average depth of 40 inches.

Included are variations, in which the soil is more gray and contains somewhat less organic matter than is typical. Many of the included areas occupy the crests of the ridges and slopes subject to erosion. An area of clay loam 1¼ miles west of San Ramon also is included because of its small extent.

This soil is extensively developed in the low rolling foothills bordering the upper San Ramon and Amador Valleys. It occurs also in numerous areas of variable size throughout the western part of the county, and in the northeastern part near Antioch.

From 50 to 60 percent of the land is under cultivation, and the rest, which supports a good growth of grass, is used as grazing land for sheep and cattle. Most of the cultivated land is used in the production of grain hay (pl. 1, *B*). A good quality of grain hay is grown, and the soil has been used for this purpose for many years. The cultivated acreage is somewhat smaller now than it was when the demand for hay for horses was good in the bay cities. The average yield of wheat hay is about 1½ tons an acre, but yields of 3 tons have been reported. Yields of wheat and barley for grain are also very good, but they vary greatly, depending on the rainfall. Wheat yields an average of about 12 sacks an acre and barley about 15 sacks. In dry years, the grain crops are commonly cut for hay, and in unusually good years yields of grain are higher on well-prepared land than those given above.

Diablo adobe clay, steep phase.—The steep phase of Diablo adobe clay is similar to the typical soil except that it is in general somewhat more shallow over bedrock and slightly lighter gray. It occupies broken steep slopes, over most of which cultural operations are extremely difficult and hazardous. Erosion would be very active if the land were cultivated. This steep soil occurs only in the south-central part of the county, principally along the base of the Black Hills. Areas of this soil are open, covered with grass, and used as grazing land for sheep and cattle, for which purpose the land has about as high a value as the less steep areas of typical Diablo adobe clay.

Cayucos loam.—The surface soil of Cayucos loam ranges from 7 to 10 inches in thickness and is dark gray, dark brownish gray, or black, the black color becoming intensified when the soil is wet. It is easily cultivated and worked up to a tilth favorable to the germination of seed and plant growth. The upper part of the subsoil is moderately compact. It is heavier textured and slightly darker than the surface soil, breaks up cloddy, and contains appreciable quantities of dark-brown colloidal material that coats the insides of cavities

and the faces of structural units. The material in the lower part of the subsoil is less compact and lighter textured than that in the upper part. It is dull brown, dark brown, or dark grayish drab, has no definite structural form, and breaks into coarse clods that are firm but are more readily reduced to a fine-cloddy structure than is the overlying material. The soil is shallow, averaging 26 inches in depth to the parent bedrock of sandstone or shale, and in places is even shallower. No free lime carbonate is present in the soil materials, but in places the underlying bedrock contains some lime. The soil has a good water-holding capacity considering its shallowness, but moisture is lost quickly in uncultivated areas.

In many of the swales and other areas subject to seepage the surface soil is heavier textured than is typical, and the subsoil is tighter and more compact. The parent materials of the soil in the foothills south of Antioch in the eastern part of the county are somewhat mixed in origin. Here the sedimentary rocks from which the soil is derived are uptilted, and thin strata, which are calcareous in places, give rise to inclusions of small bands or areas of soils of the Diablo series, containing more or less lime.

Cayucos loam is typically and extensively developed on a low range of rolling to undulating hills extending southeast from Martinez. An area lies southwest of Crockett.

Areas of this soil are open and covered with grass under virgin conditions, and the land supports a few oaks on the shaded hill slopes. About 7 percent of the soil is cultivated and is used very largely for the production of grapes, with smaller acreages devoted to other fruits or grain crops. Grapes return fair yields, but the deeper rooted tree fruits or grain return fairly low yields. Most areas of this soil are better adapted to grazing than to cultivated crops.

Cayucos adobe clay.—The surface soil of Cayucos adobe clay is dark-colored clay of adobe structure, which has the desirable property of developing a fine-granular structure under alternate wetting and drying. The soil is difficult to plow when dry and breaks into coarse lumps that break down after the first rains to a structure favorable to the germination of seeds and to the growth of plants. The range of moisture conditions under which the soil can be worked effectively is narrow, as the desirable structure is destroyed if the ground is worked when too wet. This soil has a high water-holding capacity, but it gives up moisture slowly to plants, so that crops wither and die during prolonged dry periods. The texture of the surface soil varies somewhat from place to place, and on many of the ridge crests it is loam or clay loam. These areas are too small to be differentiated on the adopted scale of mapping.

The largest body of this soil lies about 1½ miles southwest of Pinole. A slightly smaller area is in the northeastern part of the county southeast of Antioch. Numerous smaller areas occupy the lower slopes of the higher hills east and west of Tassajero, and others are associated with other residual soils in the western part.

From 40 to 50 percent of the land has been under cultivation, but a large part of the formerly cultivated area is now used as pasture. Approximately 20 percent of the land is devoted to the production of grain or grain hay, of which the yields in general are less than those obtained on Diablo adobe clay. Virgin areas support a few oak

trees, and the intervening spaces are carpeted with grasses. During the dry season the grasses wither, cure, and furnish nourishing pasturage.

SOILS OF THE VALLEY AND COASTAL-PLAIN AREAS

OLDER SOILS

The older soils are developed mainly on the more elevated alluvial-fan slopes and stream and coastal-plain terraces. They represent conditions in profile development identified with compacted and heavy-textured subsoils and horizons of accumulated lime and colloidal materials and the development of a certain structure, which generally are indicative of moderately mature or mature stages in soil development. The mature or more markedly developed soils have heavy-textured tough subsoils which are less permeable to deep-rooted crops than the younger soils of the valleys and coastal-plain areas.

Within the group of older soils are members of the Rincon, Zamora, Antioch, Ambrose, Tierra, Olcott, Herdlyn, Solano, Manzanita, Corning, Cowell, Antone, Montezuma, Denverton, Marcuse, and Sacramento series, which differ widely in color, thickness of surface soil, microrelief, moisture-holding capacity, response to cultural treatment, productiveness, and utilization.

The Rincon series comprises soils having dull-brown or dark dull-brown surface soils extending to a depth of 8 or 10 inches. They are of moderate organic-matter content, of favorable structure, and are friable under effective methods of cultivation. The surface soils grade into darker, heavier textured, and moderately compact upper subsoil layers that extend to a depth ranging from 30 to 40 inches. When disturbed this material breaks into coarse clods along imperfectly defined jointing planes. Root channels are numerous, and the insides of the openings as well as the faces of structural units are coated with dark-brown colloidal stains which penetrate the structural units to some extent. When crushed the material of the soil aggregates is lighter grayish brown. The lower part of the subsoil, which extends to a depth of more than 6 feet, is more friable light grayish-brown or light brownish-gray calcareous material of about the same texture as the surface soil. The lime carbonate in this zone is disseminated mainly through the soil mass, but it has some tendency toward segregation in root cavities and as mycelialike accumulations. The Rincon soils are developed on alluvial fans and stream bottoms no longer subject to overflow. They are well drained. They are good farm soils and are important in the production of fruits, nuts, tomatoes, lettuce, and other special crops. Rincon clay loam and Rincon clay occur in this county. These soils were included in the Yolo series of soils in the earlier and less detailed reconnaissance surveys.

The 10- or 12-inch surface soils of members of the Zamora series consist of dull grayish-brown or dark grayish-brown material having a moderate organic-matter content. The surface soils pass gradually into dull grayish-brown or dark grayish-brown moderately compact material which typically, but not in all areas, is of slightly heavier texture. This breaks up to coarse clods, in which the insides of root cavities and the faces of the structural aggregates are coated with dark-brown colloidal stains. When crushed the material form-

ing the soil aggregates becomes much lighter in color than the undisturbed material. At a depth ranging from 40 to 45 inches, the upper subsoil layer grades into light grayish-brown more friable material of about the same texture as the surface soils. No free lime carbonate occurs in any part of the soil profile. Under virgin conditions the soils were mainly grass-covered. Numerous oaks grow in many areas. These soils occur on well-drained terraces and alluvial fans no longer subject to overflow. Zamora loam and Zamora clay loam are mapped. They include some of the most desirable soil areas of the county and are utilized to an important extent for orchards. At the time of the earlier reconnaissance surveys, the Zamora series had not been recognized, and the soils were included with the associated Antioch, Yolo, and Dublin soils.

The surface soils of members of the Antioch series are dull grayish brown or dark brown, and they range from 15 to 20 inches in thickness. The surface soils are underlain abruptly by dark-brown or dull grayish-brown dense compact clay which continues to a depth ranging from 26 to 40 inches. This layer is of columnar structure, and the tops of the columns are rounded and coated with gray siliceous material. The structural units are coated with dark-brown colloidal stains. This columnar layer grades into a lighter brownish gray lower subsoil layer which, in most places, extends to a depth below 6 feet. The material in this horizon breaks into structural units of cubical shape and contains lime carbonate in soft segregations. The content of lime decreases with depth and generally disappears within a depth of 5 feet. Antioch loam, the only member of the series mapped in this county, is utilized mainly for the production of grain and grain hay.

Typically developed soils of the Ambrose series have dull-brown or dark-brown surface soils extending to an average depth of 8 or 10 inches. They are moderately well supplied with organic matter and although of heavy texture respond well to cultural operations. The surface soils are underlain rather abruptly by compact tight heavy-textured dark-brown material which extends to a depth ranging from 36 to 40 inches. This material in general is of prismatic structure and, when disturbed, breaks into cubical fragments. The structural units are coated with dark-brown colloidal stains. Roots penetrate the material with difficulty, and there are few root cavities or animal or insect burrows in this horizon. This dark heavy-textured material becomes somewhat lighter colored and more friable in the lower part and gives way to light brownish-gray or light grayish-brown calcareous material of clay loam or clay texture. The material in this layer is firm in the upper part and contains segregations of lime carbonate, which fill seams or cracks. When disturbed, the material of this layer breaks into irregularly shaped clods without structural form. The Ambrose soils are developed mainly on old alluvial fans or terraces. Some areas occur in stream valleys having deeply entrenched drainage courses. Like the Antioch soils which they resemble, the Ambrose soils are best adapted to the production of grains and other shallow-rooted crops, and they are utilized mainly for this purpose. The Ambrose soils are recognized in this survey as representing a distinct series of soils. They are closely associated in occurrence with soils of the Antioch series and in earlier surveys were included with the Antioch and Yolo soils.

The surface soils of members of the Tierra series are dark dull grayish brown and generally are loose and friable to a depth ranging from 16 to 20 inches. The lower part of the layer is grayer and is mottled with gray and rust brown. Abruptly underlying the surface soils is dull yellowish-brown tight compact clay which breaks to a columnar structure when disturbed. The tops of the columns are rounded and thinly coated with light-gray siliceous material. This horizon is 6 or 7 inches thick and grades into lighter colored yellowish-brown material of slightly lighter texture and less tough character, that breaks into cubelike fragments. This material is underlain, at a depth ranging from 40 to 50 inches, by yellowish-gray partly consolidated sandy clay or clay loam materials which continue to a depth below 6 feet. In general the soil materials are leached of lime, but in some places lime carbonate is segregated in seams or lenses in the lower part of the subsoil. Under virgin conditions, these soils support grasses and a scattered growth of trees. They occupy old terraces, in which surface drainage generally is well developed, but in most places subdrainage is restricted by the heavy and comparatively impervious subsoils. Tierra loam is the only member of this series mapped in this county. Small areas are planted to orchards, grapes, and gardens, because of their favorable location with respect to markets rather than because the soils are suitable for such purposes.

Soils of the Olcott series have dull-brown or dull grayish-brown surface soils extending to a depth of 10 or 12 inches and grading into slightly lighter colored material which continues to a depth ranging from 20 to 24 inches. This material is underlain abruptly by tight compact dull reddish-brown clay of columnar structure, in which the tops of the columns are rounded and coated with a thin layer of gray siliceous material. The faces of the parting planes are coated with dark colloidal stains which penetrate with diminishing intensity the structural units. This horizon is underlain, at a depth between 30 and 34 inches, by light reddish-gray clay which is only slightly less tight and compact than the material in the layer above and breaks into cubes that are coated with dull yellowish-gray stains. This lower subsoil layer rests on light yellowish-gray softly consolidated material at a depth ranging from 40 to 50 inches. In a few places lime carbonate occurs in the lower part of the subsoil and in the substratum, but typically the soils of this series are without free lime. The soils are developed on old elevated terraces dominated by a grass cover. Olcott loam is mapped in this county. It is not a particularly desirable soil and is utilized mainly for the production of grain, with small plantings of prunes, apricots, and grapes. The Olcott series of soils is one of the series recognized and established in more recent surveys. In the older reconnaissance surveys the Olcott soils were included with soils of the Antioch and Yolo series.

Soils of the Herdlyn series have light-brown surface soils ranging from 7 to 14 inches in thickness. In most places the soil material is deflocculated and becomes very hard and baked when dry but is rather friable when moist. This layer is underlain abruptly by dull yellowish-brown compact clay, in which a prismatic structure is developed when dry. When disturbed, the clay breaks into coarse or medium-sized cubes. In places the material has a definite solonetzlike structure, but such areas are of irregular distribution. This clay

layer grades into pale reddish-brown less compact and slightly calcareous material at a depth ranging from 18 to 24 inches, and this material, in turn, continues to a depth between 40 and 45 inches. It also breaks up into cubical aggregates. Lime carbonate occurs in soft segregations in root cavities or other openings in the soil. The underlying deeper material consists of pale yellowish-brown or light brownish-gray intermittently calcareous more friable material. Herdlyn loam is mapped in Contra Costa County. It occurs on old terraces and alluvial fans no longer subject to overflow. The soil has been developed under a grass cover and is of minor agricultural importance. It represents a newly recognized series of soils which were included with associated soils in the earlier reconnaissance surveys.

Soils of the Solano series are characterized by gray or dull brownish-gray surface soils ranging from 5 to 10 inches in thickness. They contain more or less soluble salts and are deflocculated. They become baked and hard when dry but are friable when moist. The surface soils are underlain abruptly by dark-brown columnar clay of tight compact consistence, extending to a depth of 15 or 18 inches. This material is of solonetzlike structure. The tops of the columns are rounded and thinly coated with gray siliceous material. Dark-brown colloidal stains cover and penetrate well into the structural units. The upper part of the subsoil grades into dull-brown or dull grayish-brown calcareous material of uniform character to a depth ranging from 26 to 42 inches. This material is of about the same texture as the overlying material, but it is less compact and breaks into cubical aggregates when disturbed. Lime carbonate occurs in soft nodules in cavities and along the parting planes of structural aggregates. Some dark-brown colloidal material coats the soil aggregates but does not penetrate the structural units to any degree. The deeper material, to a depth of 6 or more feet, consists of light grayish-brown material, in which the lime carbonate is present in both segregated and disseminated form. This material is dense and moderately compact. The Solano soils border the poorly drained island district. They have poorly developed surface drainage and subdrainage, and under virgin conditions they support a rather scattered and stunted growth of grasses. The surface soils are neutral or slightly alkaline in reaction, and the subsoils are distinctly alkaline. Solano silty clay, the only member of the series occurring in this county, is of minor agricultural importance and is utilized mainly for pasture. At the time of the earlier reconnaissance surveys, the Solano soils were included with the associated soils, mainly of the Antioch and Yolo series.

The 8- or 10-inch surface soils of members of the Manzanita series are brownish red or dull reddish brown and in most places gravelly. They pass through a gradual transitional layer into the upper subsoil layers which consist of brownish-red somewhat compact gravelly heavy-textured material to a depth ranging from 18 to 30 inches. When disturbed this material breaks into coarse clods that may be reduced to a granular structure under moderate pressure. Dull reddish-brown colloidal stains coat and penetrate well into the structural units. The material in the upper part of the subsoil gives way abruptly to a dark brownish-red or dark reddish-brown compact tight

41674—39——3

gravelly and stony lower subsoil layer of clay texture, that continues to a depth ranging from 48 to 54 inches with little change in color or texture. This material is of massive character and has a large proportion of stone and gravel, which typically are rather soft and partly weathered. This layer, in turn, grades into lighter reddish-brown and less compact material which becomes yellowish red with depth. Gravelly and stony materials constitute a large proportion of the soil mass of this layer also. The gravel are largely of basic igneous origin, and there are some quartzite and other rocks. In many places they are well weathered and may be chopped through with a sharp instrument. Manzanita gravelly clay loam is mapped in this county. It is developed on terraces lying at an elevation of several feet above the surrounding soils, and it is utilized for the production of grapes, prunes, and other fruits and for general farming. The surface soils typically are somewhat acid, and the lower subsoil layers are neutral in reaction.

The surface soils of members of the Corning series are pale reddish brown or pale red, the red tint being more pronounced under moist field conditions. In most places they contain more or less gravel and are friable when moist but, unless cultivated, become hard and baked during periods of drought. They are low in content of organic matter and in water-holding capacity. They grade rather abruptly into tight compact red, light brownish-red, or yellowish-red gravelly clay loam or clay material that continues to a depth ranging from 45 to 50 inches. The lower subsoil layer, which extends to a depth of 6 feet or more, consists of pale reddish-brown gravelly material that is somewhat more friable than the overlying material. The subsoil materials are without well-defined structural form and break into coarse clods. Reddish-brown colloidal material in the upper part of the subsoil, and of a lighter yellowish-brown tint in the lower part, stains the soil aggregates and the outsides of the gravel. Gravel of quartzite and other rocks make up a large proportion of the soil mass. Corning gravelly clay loam mapped in this county occupies elevated alluvial terraces and valley plains, which are frequently subject to excessive surface drainage. Together with its darker colored inclusions, which are not typical of the Corning series, this soil is used for the production of grain and hay and for pasture.

The surface soils of soil types in the Cowell series are of dark rich-brown or dark reddish-brown color and generally are of moderate organic-matter content. They grade, at a depth ranging from 9 to 12 inches, into dark rich-brown compact material of somewhat heavier texture and of coarse cloddy structure. Dark-brown colloidal stains coat the outsides and penetrate well into the structural units. At a depth ranging from 42 to 48 inches, the upper part of the subsoil gives way to pale reddish-brown slightly compact lighter textured material that continues uniform in character to a depth of more than 6 feet. Numerous gravelly seams and lenses occur in the lower part of the subsoil. Cowell clay loam mapped in this county occupies alluvial fans or stream bottoms, no longer subject to overflow. The soil appears to have been developed on outwash materials derived from areas of Manzanita gravelly clay loam, and it is utilized for similar purposes as that soil. The Cowell is a recently established

series of soils which formerly were included with the Antioch soils.

The 6- to 9-inch surface layers of members of the Antone series are dull brownish gray. In general they are deflocculated and become baked and hard when dry. The subsurface material, which extends to a depth ranging from 14 to 18 inches, is slightly darker colored and in most places somewhat heavier textured. It is penetrated by numerous root cavities and, under moderate pressure, breaks to a granular or small-cloddy condition. It grades into dull brownish-gray compact slightly calcareous heavy-textured material which breaks into coarse clods. This material becomes darker and very tight and compact as depth increases, and it includes seams, soft nodules, and other segregations of lime carbonate and gypsum. Below this, the soil, to a depth of 6 feet or more, consists of dull brownish-gray moderately compact calcareous material of about the same texture as the surface soil, and it contains both disseminated and segregated lime. Antone clay loam is mapped in this county. It is developed in local stream-valley bottoms no longer subject to overflow, most of which are entrenched by stream courses. Subdrainage is retarded, and here and there accumulations of saline salts occur. This soil is of low productivity and is utilized mainly for pasture. The Antone is a newly recognized series of soils previously included with the Dublin.

The 9- or 10-inch surface soils of members of the Montezuma series consist of dark-gray or black heavy-textured materials having an adobe structure. The upper part of the subsoil, to a depth ranging from 29 to 32 inches, is similar in color to the surface soils, is compact, but lacks the well-developed adobe structure of the surface soils. The material in this layer grades into dull-brown or dark brownish-gray calcareous fine-textured material that continues without definite change in color or texture to a depth ranging from 43 to 48 inches. The lime carbonate occurs in soft segregations in root cavities and in cracks between structural units. When disturbed the material breaks into coarse clods of medium size. The underlying material, to a depth of 6 or more feet, consists of light brownish-gray partly consolidated calcareous materials of somewhat lighter texture. Lime carbonate occurs throughout this horizon and has a tendency toward segregation in cavities and openings in the material. Under virgin conditions, the Montezuma soils were grass-covered and were well drained. They occupy terraces and alluvial fans. Montezuma adobe clay, the only type mapped in this county, is a productive soil highly valued for the production of grain and for pasture.

The surface soils of soils of the Denverton series are dark brown or dark dull grayish brown. They have a heavy texture and an adobe structure. The subsoils and parent soil materials are similar to the corresponding layers of the Montezuma soils, with which the Denverton soils are associated and from which they are distinguished by the browner color of the surface soil. The Denverton series is represented in this county by Denverton adobe clay, an inextensive but productive soil which closely resembles Montezuma adobe clay in soil character, occurrence, and relief.

Soils of the Sacramento series have dark brownish-gray, dark-gray, or black surface soils from 4 to 10 inches thick. In the heavier textured types, the surface soils generally are mottled with partly oxidized organic matter. The upper part of the subsoil, to a depth rang-

ing from 40 to 50 inches, consists typically of dark-gray or dull-gray slightly compact material mottled with iron stains and having about the same texture as the surface soils. The lower part of the subsoil, which continues to a depth ranging from 6 to 8 feet, is dark grayish-drab mottled calcareous clay. The Sacramento soils as a rule are neutral in reaction in the surface soils and distinctly alkaline in the subsoil which in most places contains seams and nodules of lime carbonate in the lower part. Sacramento adobe clay in Contra Costa County occupies poorly drained nearly flat areas bordering the highly organic soils of the island and basin district. Most of the land is utilized for pasture and the rest for the production of milo, barley, and asparagus.

Soils of the Marcuse series occurring in this county represent a rather wide range in profile development and in agricultural value. The surface soils are dull brownish gray, granular, and friable in the lighter textured types, but they are deflocculated, cloddy, and difficult to cultivate in the heavier textured types. They are underlain, at a depth ranging from 15 to 20 inches, by lighter colored subsoils which, in the lighter textured types, are friable and stratified but, in the heavier textured types, are of heavy texture, cloddy, compact, and stained with dark-colored colloids, representing a somewhat older stage in soil development. The subsoils contain lime carbonate. Marcuse loam and Marcuse clay are mapped in this county. These soils border the poorly drained island district and are subject to poor drainage and an accumulation of saline salts. Under virgin conditions, the better drained areas support a scanty growth of grasses, and, in the areas having an accumulation of salt, saltgrass, pickleweed, greasewood, and other salt-tolerant plants grow.

Rincon clay loam.—The 10-inch surface soil of Rincon clay loam is easily cultivated and maintained in good tilth, notwithstanding its moderately heavy texture. The material in the upper part of the subsoil is somewhat more dense and when disturbed breaks into coarse clods. The insides of the numerous root cavities, as well as the faces of the better-defined jointing planes, are coated with dark-brown colloidal material, but when crushed the soil aggregates are of a lighter brown color. The lower subsoil layer, beginning at a depth ranging from 30 to 40 inches and continuing to a depth of 6 or more feet below the surface, is more friable lighter brown or light brownish-gray calcareous material of about the same texture as the surface soil. Lime carbonate is disseminated throughout this layer, with some tendency toward segregation in root cavities and cracks, giving the layer a myceliumlike appearance. In a few places, due to imperfect internal drainage, the lower part of the subsoil is slightly mottled with iron stains.

The parent material of this soil is derived largely from sedimentary rocks. The soil is well drained, absorbs moisture readily, and has a high water-holding capacity. The moisture is readily available to plant roots. The surface soil is neutral or slightly alkaline, and the subsoil is distinctly alkaline.

This soil is extensively developed in Lone Tree Valley and on the alluvial fan where the valley empties onto the plain. A large more or less continuous body borders the poorly drained soils adjacent to

the delta lands at Bixler. A small body lies on the stream terrace at Antioch.

About 80 percent of the land is under cultivation, mostly to specialized crops. The uncultivated areas are open, covered with grass, and used for grazing. Apricots and prunes, of which the average yields from mature trees are 4 tons and 1½ tons an acre, respectively, are the principal specialized crops grown on this soil. Large acreages are used for peaches, plums, grapes, and other fruits. Yields of peaches range from 5 to 20 tons an acre, depending on the age of the trees and the care taken of them, and yields of grapes average 5 tons. Tomatoes and lettuce return good yields, and the acreage devoted to these crops is expanding. Alfalfa is grown successfully in connection with dairying, and it produces 4 or 5 tons an acre when cut for hay. A small acreage is used for the production of grain.

This is a productive soil and when properly managed returns better-than-average yields of most fruit and general farm crops. The turning under of cover crops is a very desirable practice and must be followed for the continued successful upkeep of orchards. The growing of intertilled leguminous crops, such as beans or peas, increases the yields from vegetable crops that follow in the rotation. The soil is especially well adapted to alfalfa.

Rincon clay.—Except for the texture of its surface soil and its slightly darker color, Rincon clay has the same profile characteristics as Rincon clay loam. As mapped in this county, it is somewhat variable in clay content, in density of consistence and structure, and in relation to tillage. The more friable areas, which occur mainly in the eastern part of the county on the slopes of the Marsh Creek fan, have a high water-holding capacity and are favorable to the penetration of plant roots, air, and moisture. They resemble a lighter textured soil. The heavier textured areas, developed in Lone Tree Valley and in the lower ends of Clayton and Ygnacio Valleys, are more difficult to manage under cultivation. They take up moisture more slowly and give it up to plants less readily.

Under virgin conditions this soil was heavily carpeted with grass, but now most of it is under cultivation.

Zamora loam.—The 10- or 12-inch surface soil of Zamora loam is dull grayish-brown or dark grayish-brown loam. In dry uncultivated fields it is hard and baked, but if cultivated when in favorable moisture condition it is generally of granular structure. The soil has a fair supply of organic matter but rather low water-holding capacity. When the soil is dry, moisture or plant roots penetrate the plow sole, which often forms, only with difficulty. The subsoil, in most places, is sandy loam which breaks up into coarse clods. At a depth ranging from 40 to 45 inches the upper subsoil layer grades into light grayish-brown or dull grayish-brown more friable material that is of about the same texture as the surface soil. The lower subsoil layer continues uniform to a depth exceeding 6 feet. No free lime carbonate occurs in any part of the soil profile.

This soil is developed mainly in the northeastern part of the county in the vicinity of the sand hills. One of the largest bodies lies near the Lone Tree Valley drainage course southeast of Antioch. Small bodies are associated with the sand hills, particularly near and south

of Knightsen. An area at the mouth of Kellogg Creek is much richer in color than is typical. A few small scattered bodies of more yellowish-brown or grayish-brown color than typical occupy valley terraces bordering Bear Creek north of Orinda, and two very small bodies are about a mile south of Moraga.

Nearly all of the land is cultivated and is used mostly for the production of almonds (pl. 2, *A*), yields of which range from 500 to 1,200 pounds an acre, depending on the season and the age and care of the orchard. Although yields of almonds are slightly better on this soil than on Oakley sand, the trees are more subject to frost. Some prunes, apricots, and other fruits are grown, and they return fair yields of good-quality and early-maturing fruit. Smaller areas are devoted to grain and pasture.

Subsoiling to break up the plow sole which develops on this land under continued cultivation is very desirable. When this has been done, care should be exercised not to plow the soil when wet. Occasional deep plowing will break up any plow sole which is beginning to form.

Zamora clay loam.—The surface soil of Zamora clay loam is dull-brown clay loam of moderately heavy texture which is not so easily cultivated as is Zamora loam. The soil is moderately well supplied with organic matter and has a high water-holding capacity. The subsoil is somewhat variable; in most places it is moderately compact and of heavier texture than the surface soil, but some areas have gravelly and sandy lower subsoil layers. Plant roots, air, and moisture, however, penetrate the subsoil readily. A number of bodies containing from 15 to 50 percent or more of gravel, which are therefore of less agricultural value than the typical soil, are indicated on the soil map by gravel symbols. The presence of gravel interferes with cultural operations and materially reduces the water-holding capacity of the soil, especially in the more gravelly areas. These areas require lighter and more frequent applications of water under irrigation than the typical gravel-free soil.

This soil occurs almost exclusively in the Ygnacio and Clayton Valleys. It is especially well developed in the vicinity of Oak Grove School. Practically all of the land is under cultivation and is used largely in the production of tree fruits and nuts. Walnuts probably are grown on a larger acreage than any other crop. Prunes, grapes, and pears are also important crops, and plums, cherries, and peaches occupy smaller acreages. A few vegetables are grown, and very small acreages are in grain, hay, or other general farm crops.

The walnut groves on this land are vigorous and productive. Yields of walnuts range from 500 to 2,400 pounds an acre and average about 1,500 pounds. Late spring frosts occasionally reduce the yields very materially. Prunes return an average yield of 1½ tons of dried fruit an acre and pears from 5 to 10 tons or more, depending on the age of the trees and other factors. Other crops produced on the gravel-free areas return slightly better than average yields.

This soil is well farmed, and recognition is given to the desirability of cover crops for continued successful crop production. Adequate provision for orchard heating, as well as for irrigation, is desirable.

Antioch loam.—To a depth ranging from 15 to 20 inches, the sur-

face soil of Antioch loam is dark-brown loam which, in many places, is tinged with gray and mottled with gray or rusty brown in the lower part. It is granular and friable and is easily handled and maintained in good tilth favorable to the germination of seed and the development of plant roots. The subsoil is dark grayish-brown or dull grayish-brown clay which is so heavy and tight that roots penetrate it with difficulty, and the movement of air and moisture through the soil is slow. The clay layer is of columnar structure with the tops of the columns rounded and coated with a thin deposit of gray siliceous material (pl. 2, *B*). Dark-brown colloids coat the outsides of the columns and penetrate well into the structural units. This upper subsoil layer continues without change, except to a lighter color, to a depth ranging from 36 to 40 inches where it gradually gives way to the light brownish-gray material of the lower subsoil layer that extends to undetermined depths below 6 feet. The upper part of the lower subsoil layer generally breaks to a cubical structure and contains more or less lime carbonate in soft segregations. Lime is less evident in the lower part of the subsoil and in most places disappears entirely within a depth of 5 feet. In this county many bodies are underlain by a compact substratum of old sedimentary materials at a depth ranging from 60 to 70 inches.

Antioch loam is developed principally along the coastal plain from a point near West Pittsburg to Port Chicago. A few bodies are on the outer margin of the Clayton Valley and elsewhere on stream terraces.

Nearly all the land is under cultivation and is devoted almost exclusively to grain. A few areas are in pasture or are used for residential purposes, and a very small acreage is in grapes or prunes. Yields of grapes are fairly good, but yields from deep-rooted tree crops are low. Wheat yields an average of 7 sacks an acre, and barley 10 to 12 sacks. In good seasons these yields are exceeded, but in dry years it is frequently necessary to cut the crops for hay. In wet years subdrainage is impaired and the soil is boggy, consequently crops drown out on the flatter areas. The soil is best adapted to early-maturing grains and shallow-rooted fruit crops.

Ambrose clay loam.—The 8- to 10-inch surface soil of Ambrose clay loam is dark dull-brown moderately friable clay loam which can be worked to a granular structure fairly easily. The soil has a fair content of organic matter and is absorptive and retentive of moisture. The subsoil, however, is heavy textured and compact, and plant roots find their way into it with difficulty. The material in this layer generally is prismatic in structure and breaks, when disturbed, to a medium cubical structure. The structural units are coated with a dark-brown colloidal deposition that stains with diminishing intensity the insides of the structural units. A few root cavities and animal or insect burrows occur in this layer. The material becomes somewhat lighter colored and lighter textured in the lower part of the layer and gives way, at a depth ranging from 36 to 40 inches, to light brownish-gray or light grayish-brown calcareous clay loam or clay, that continues to a depth of 6 or more feet. The upper part of this material is firmer than the material below, and it constitutes the zone of greatest concentration of lime carbonate. When disturbed, it breaks into irregularly shaped clods. The density of the soil material varies, and,

in places, the material in the upper part of the subsoil suggests a solonetz structure. In general, the surface soil is neutral in reaction and the subsoil distinctly alkaline.

Ambrose clay loam is one of the more extensive soil types developed on the alluvial fans and coastal plain, that extend from Nichols east to the sand hills just east of Antioch. It also occurs on the terraces of many of the creeks that drain the hilly lands in the north-central part of the county.

The greater part of the land is under cultivation, and approximately 25 percent is used for grazing or for building sites. In favorable seasons wheat yields an average of about 10 sacks an acre and barley 14 sacks. In dry years it is frequently desirable to cut the grain for hay, especially from late-planted fields. Grains are sown on dry soil shortly before the first fall rains may reasonably be expected. The rains cause the grain to sprout, and it makes a good growth before cooler winter weather begins. Early-sown grain is much more likely to produce a crop than that sown later, which matures several weeks after the rains have ceased.

Included with Ambrose clay loam on the map are two small bodies situated northwest of Clayton, which are more gray than the typical soil. One of these areas contains considerable gravel. The surface soil of the included areas, to a depth of 3 or 4 inches, is generally calcareous, due to the settling of lime dust from a nearby lime plant. The included areas are used largely for the production of prunes and grapes, and a few other kinds of fruit are grown to some extent. Yields of grapes are fairly good, and the quality of fruit is high; deeper rooted fruit trees return low yields. The soil is much better adapted to shallow- than to deep-rooted crops.

Ambrose adobe clay.—Ambrose adobe clay is characterized by a dark-brown heavy clay surface soil that is difficult to work and absorbs moisture slowly. The adobe structure is rather poorly developed, although the soil cracks badly to a depth ranging from 2 to 3 feet when dry. The cracks form large blocks that break down with difficulty to a granular structure. Except for its adobe structure and somewhat darker color, this soil resembles Ambrose clay loam.

This is not an extensive soil. It is developed only on the alluvial fans south and southeast of Pittsburg.

About 40 percent of the land is cultivated, and the rest is in pasture or is used for building sites. The cultivated areas are devoted exclusively to the production of grain and grain-hay crops. Yields are similar to those obtained on Ambrose clay loam in years of favorable moisture supply, but in dry years they are appreciably lower. In general the soil is well farmed and utilized to good advantage.

Tierra loam.—The surface soil of Tierra loam is dark grayish-brown loam about 18 inches thick. It is granular and friable and is easily handled. When not cultivated, the soil has a decided tendency to bake, and it loses moisture quickly. The surface soil changes abruptly to dull yellowish-brown tight compact columnar clay. This columnar layer is, in most places, about 6 or 7 inches thick. It gradually gives way to lighter colored slightly lighter textured yellowish-brown or yellow material with a cubical structure. At a depth ranging from 40 to 50 inches, the subsoil rests on light yellowish-gray softly consolidated sandy clay or clay loam, which continues to undeter-

mined depths below 6 feet with little change in color, structure, or texture.

This soil is developed on materials occupying elevated terraces that probably are of marine origin. The surface soil is neutral or slightly acid, whereas the subsoil is generally acid, but in places some lime carbonate is present in seams or lenses in the lower subsoil layer.

As mapped, the soil includes a few small somewhat eroded areas along the lower margin of the terrace lands west of Walnut Creek. The surface soil in most of these bodies is clay loam. In many other places the subsoil is not so tight and compact as typical, and the abrupt transition from surface soil to subsoil is not so marked. Such areas generally occupy the hilly slopes and other places subject to erosion.

Tierra loam is extensively developed on the terrace lands in the vicinity of Walnut Creek and along the upper western margin of the Ygnacio Valley. An area embracing about 4 square miles lies north of San Pablo. Numerous bodies border San Pablo Bay and Carquinez Strait in the northwestern part of the county.

About 20 percent of the land is cultivated, and the rest supports a fair stand of grass that affords some pasturage. The cultivated areas are used largely for the production of grapes, although some prunes, apricots, pears, and other fruits are grown. Grapes yield an average of about 3 tons of fruit an acre, but tree fruits yield rather poorly. Wheat and barley produced in this soil return fair yields in good seasons; but the crops are frequently drowned out in wet seasons and in dry years must be cut for hay.

This soil probably is best adapted to grazing and the production of grain or shallow-rooted fruit crops. Of the deeper rooted fruit crops, pears and prunes are best adapted. The limiting factor in successful crop production on these soils is the presence of the tight compact clay layer of the subsoil. Blasting to loosen up the clay layer is not advisable, as the material soon runs together again.

Olcott loam.—The 10- or 12-inch surface layer of Olcott loam is dull grayish-brown loam which is friable and richly colored when moist, but which becomes hard and baked when dry. It is low in organic matter, and when baked and dry it absorbs moisture slowly until fairly wet. The subsurface layer, extending to a depth of 20 or 24 inches, is slightly lighter colored than the surface layer and is slightly mottled with gray, especially in the lower part where it rests on the upper subsoil layer. The friable light-textured surface soil materials pass abruptly into tight compact dull reddish-brown clay of columnar structure. At a depth ranging from 30 to 34 inches, the material in the upper part of the subsoil grades into a pale reddish-brown clay that is only slightly less tight and compact than the overlying material. The material in this layer breaks into small or medium-sized cubes coated with dull yellowish-gray colloids. This lower subsoil layer rests, at a depth ranging from 40 to 50 inches, on a pale yellowish-gray softly consolidated substratum composed of sediments similar to the overlying material. In a few places lime is present in the lower part of the subsoil and in the substratum. The subsoil offers appreciable resistance to the penetration of plant roots and moisture, and the surface soil becomes boggy following heavy rains.

This soil is distributed in numerous small bodies throughout the north-central part of the county. Some of the largest are near Pleasant Hill School and along the upper slopes of Clayton Valley. Several occupy the upper fan slopes between Port Chicago and Shell Point.

About 40 percent of the land is cultivated and is used largely for the production of grain. Small acreages are in prunes, grapes, and apricots. Grapes yield from 3 to 5 tons an acre, and prunes yield an average of slightly less than a ton of dried fruit. The yield of grain on this soil is similar to that obtained on the related Antioch loam.

The addition of organic matter through the turning under of leguminous cover crops or barnyard manure would be beneficial to this soil, which is better adapted to the production of shallow-rooted fruit crops than to deep-rooted crops.

Herdlyn loam.—The 7- to 14-inch surface soil of Herdlyn loam is light brown, poor in organic matter, and becomes hard and baked when dry. It is slow in taking up moisture when dry, but, when once wet, it absorbs moisture readily, is friable, and assumes a richer color. The dull yellowish-brown clay subsoil is very tight and compact, and it distinctly limits root penetration. Moisture moves slowly through it. It has a prismatic structure when dry, and when disturbed it breaks into coarse or medium-sized cubes, the larger ones breaking from the top of the column or prism. In most places this clay layer extends to a depth ranging from 18 to 24 inches, and the material changes gradually to pale reddish-brown or dull yellowish-brown less compact slightly calcareous material that extends to a depth ranging from 40 to 45 inches. The soil in this layer also breaks, when disturbed, into small cubes. The lime occurs in soft segregations in root cavities or small chambers in the soil. Below this layer and extending to a depth of 6 or more feet, is pale yellowish-brown or light brownish-gray friable intermittently calcareous material. The surface soil is slightly acid and the subsoil alkaline.

Herdlyn loam occurs mainly on the terraces in the southeastern part of the county. A small area lies along the headwaters of Kellogg Creek. As mapped, the soil includes some areas, especially in the vicinity of Herdlyn, of agriculturally more valuable soil, in which the subsoil is not so tight and compact.

About 10 percent of the land, consisting of the better areas, is cultivated and used exclusively for the production of grain or grain hay, yields of which are fair. The rest of the land is open, covered with grass, and used for pasture, to which purpose it is best adapted. Aside from the areas already cultivated, the soil has little potential value for the production of cultivated crops.

Solano silty clay.—Solano silty clay has a dull brownish-gray surface soil, from 5 to 10 inches thick, which is friable when wet but is deflocculated and baked when dry. The subsoil is dark-brown columnar tight compact clay to a depth of 15 or 18 inches. This layer resists the penetration of plant roots or the absorption of moisture. The upper subsoil layer changes gradually to dull grayish-brown calcareous material which continues to a depth ranging from 36 to 42 inches. This material is less compact, has a cubical structure, but is otherwise similar in texture to the overlying material. Lime carbonate is segregated in soft nodules. The deeper material is light

brownish-gray dense moderately compact material in which are both segregated and disseminated lime carbonate.

This soil has a hummocky microrelief. The cost of preparing the land for irrigation and its general unsuitability to irrigation practices render the soil of little potential value for agriculture. Internal drainage is poor. The reaction of the surface soil is neutral or slightly alkaline and that of the subsoil distinctly alkaline.

Solano silty clay occurs only in the southeastern part of the county in the vicinity of Byron Hot Springs station, bordering poorly drained areas. The soil has an appreciable salt content, and the grass growth on it is generally of poor quality for grazing and not very plentiful. The land is used only for grazing purposes, to which it is best adapted.

Manzanita gravelly clay loam.—The 8- or 10-inch surface soil of Manzanita gravelly clay loam is dull red or reddish brown. It contains little organic matter and tends to bake unless cultivated, but it is friable under cultivation. A gradual transitional layer marks the change from the surface soil to the upper part of the subsoil which, to a depth ranging from 18 to 30 inches, consists of brownish-red slightly compact heavy-textured gravelly material. When disturbed, this material breaks into rather soft coarse clods. The upper subsoil layer gives way abruptly to the dark brownish-red or dark reddish-brown extremely tight compact gravelly and stony clay lower subsoil layer. The material in this layer, which is dense and massive, continues to a depth ranging from 48 to 54 inches. Dull-red colloids permeate the soil material and coat the stone and gravel. This lower subsoil layer grades into lighter reddish brown or dark-red less compact material that extends to a depth exceeding 6 feet. In the lower part of this layer a yellowish-red color is developed, and stone and gravel constitute more than 60 percent of the soil mass. Most of the gravel in the lower subsoil layer are well weathered and soft.

Gravel constitutes 25 percent or more of the soil mass in the surface soil and an even higher proportion of that in the subsoil. The gravel interferes to some extent with cultural operations and reduces the water-holding capacity of the soil.

Notwithstanding its moderately heavy texture, the less gravelly areas may be handled almost like a loam, and some undifferentiated areas of loam texture along the crests of ridges are included in mapping. In such areas the surface soil generally is acid in reaction, and the lower part of the subsoil is neutral, although lime dust from a nearby cement plant modifies the reaction in some areas.

Manzanita gravelly clay loam occurs principally in the vicinity of Clayton. Small areas occupy knolls in Clayton Valley and the upper margins of valley slopes.

About 80 percent of the land is used for the production of crops, principally grapes and prunes. Prunes yield more than a ton of dried fruit an acre, and grapes from 2 to 8 tons, depending on the age of the vines and the care given them. Small acreages are in other fruits. As this is a poor soil for grain, very little is grown. The tight heavy-textured subsoil limits, to some extent, the penetration of plant roots, and the soil is better adapted to shallow-rooted fruit crops. The uncultivated areas have a slight value for grazing. The soil is well farmed and utilized. Plowing under leguminous cover crops is especially desirable on this soil because of its naturally low content of organic matter.

Corning gravelly clay loam.—In its typical development, the 12-inch surface soil of Corning gravelly clay loam is pale-red or pale reddish-brown clay loam containing a small supply of organic matter and a moderate to large quantity of small water-worn gravel derived from a variety of rocks but largely of quartz and quartzitic materials. The subsoil is dense tight yellowish-red or brownish-red clay or clay loam, of high gravel content. At a depth ranging from 45 to 50 inches, the upper part of the subsoil gives way to paler red and more friable gravelly material which continues to a depth exceeding 6 feet. The subsoil is without structural form and breaks into coarse clods. The reaction of the surface soil is slightly acid, whereas that of the subsoil is neutral in most places. The surface soil absorbs moisture slowly until once wet, after which water penetrates it readily. Plant roots, air, and moisture penetrate the subsoil only with difficulty. Gravel and a small quantity of cobblestones constitute from 40 to 50 percent or more of the soil mass. They interfere materially with cultural operations and limit the water-holding capacity of the soil.

Typical Corning gravelly clay loam is developed only in the east-central part of the county north of the junction of Marsh Creek and the valley plain. About 5 percent of this land was at one time under irrigation and cultivated, but at present none of it is cultivated. It supports a scant growth of grass and is used as pasture.

An area of dark-colored soil, which occupies a low range of hills 2 miles northeast of Concord, is included. This soil differs widely from the typical Corning material. It is a complex, in which a wide range in both color and character of soil material is represented. The surface soil is dark-brown or dark grayish-brown gravelly clay loam, the color gradually changing to dull reddish brown on the ridge crests. The upper part of the subsoil is dark reddish-brown compact heavy-textured gravelly and stony clay resting on a variable material which consists, in some places, of fine-textured calcareous sediments and in others of dark reddish-brown compact gravelly clay. The soil material has been deposited over an older sedimentary deposit, and subsequent erosion has exposed the underlying material in many places so that the surface soil and subsoil materials are extremely variable. In many places the surface soil is of clay or clay loam texture and almost free from gravel. The many variations are too inextensive and irregular to be separated on a map of the scale used.

The soil is largely cultivated, principally to grain and grain hay. Yields are lower than those obtained on most of the other hilly lands of this section.

Cowell clay loam.—The surface soil of Cowell clay loam is dark rich-brown or reddish-brown clay loam which generally is well supplied with organic matter and somewhat difficult to cultivate, although it can be reduced to a friable condition under effective cultivation. It is underlain, at a depth of about 10 inches, by dark rich-brown cloddy somewhat more dense material which is paler red and more friable below a depth ranging from 42 to 48 inches. This material continues to a depth of 6 or more feet. Gravel seams and lenses are present in the lower part of the subsoil. The soil retains moisture well but gives it up slowly, so that plants suffer in hot weather. The compact subsoil hinders the penetration of plant roots.

Included are a few areas of clay texture, which are less easily cultivated than the typical soil but otherwise are similar. A few gravelly areas are also included and are indicated on the map by gravel symbols. Gravel constitutes from 30 to 50 percent or more of the soil mass in these areas, interferes with cultural operations, and reduces the water-holding capacity of the soil. A third variation from the typical soil comprises a few very small areas of clay texture and adobe structure, in which the subsoil overlies calcareous sedimentary materials.

Cowell clay loam occurs almost exclusively in the Clayton Valley, especially in the southern part. The areas underlain by calcareous material are in the eastern part of the county, southwest of Byron Hot Springs School.

This soil is utilized principally in the production of prunes, grapes, and pears. A number of other fruits, as well as walnuts, are grown. Prunes yield an average of slightly more than a ton of dried fruit an acre, pears yield from 4 to 5 tons, and grapes yield from 3 to more than 5 tons. Some tomatoes grown for canning return very good yields. Due to the tight heavy-textured subsoil of this soil, shallow-rooted crops do better than the deeper rooted crops.

Antone clay loam.—The 6- to 9-inch surface soil of Antone clay loam is dull brownish gray or dull gray. In uneroded areas a thin coating of light-textured lighter gray material overlies the surface soil. The material in the surface layer generally is deflocculated, baked, and somewhat difficult to cultivate when dry. The lower part of the surface soil, extending to a depth ranging from 14 to 18 inches, is slightly darker colored and heavier textured than the upper part. The material in this layer is moderately compact, but, owing to the presence of numerous root cavities, it breaks up granular under moderate pressure. It gives way gradually to dark dull brownish-gray compact slightly calcareous material that in general has a clay texture. This layer also is deflocculated and breaks into coarse clods reducible under pressure to a medium nut structure. At a depth ranging from 32 to 36 inches, the upper subsoil layer grades into dark-gray or black very tight and compact material that continues to a depth of 45 or 50 inches. Lime carbonate occurs in seams and soft nodules in this layer. Below this and extending to a depth exceeding 6 feet, is dull brownish-gray moderately compact calcareous material of about the same texture as the surface soil. Lime carbonate is disseminated throughout this layer and also is segregated in soft nodules and seams. Exposed cuts appear to be encrusted with small nodules. Internal drainage is slow, and surface drainage, in places, is poorly developed. Saline salts affect the soil in places.

As mapped, the soil includes a few small areas in the Amador Valley south of San Ramon and scattered through the eastern and central parts of the county, which are heavier textured, more difficult to handle, and even less well adapted to agricultural utilization than the typical soil. These areas are valued only for the small amount of grazing they afford.

The typical soil occurs in a number of small bodies developed on the low terraces and bottoms of streams draining the hilly sections of the county, especially in the eastern and northwestern parts. One of the largest is along Rodeo Creek. The soil also is prominently developed in the Amador Valley along the county boundary.

This land is not used for field crops, except in connection with other soils for the production of grain and hay. Yields generally are unsatisfactory, and the main use of the land is for pasture. Virgin areas support some species of saltgrass and some more nutritious grasses, but the stands are poor.

Montezuma adobe clay.—The 9- or 10-inch surface soil of Montezuma adobe clay is dark-gray or black heavy adobe clay that is difficult to plow. It breaks into coarse lumps that reduce naturally, by progressive checking, to a granular structure, after which cultural operations are not so difficult. The subsoil is similar in color to the surface soil, but it does not have an adobe structure. It is moderately tight and compact, although apparently plants send their roots into it with little difficulty. At a depth ranging from 29 to 32 inches the upper subsoil layer grades into dull-brown or dark brownish-gray calcareous material, in which soft lime concretions are present in root cavities and between structural units. When disturbed, the material breaks into coarse clods. The lower part of the subsoil, beginning at a depth ranging from 43 to 48 inches and continuing to a depth below 6 feet, is light brownish-gray softly consolidated calcareous material which limits the rooting habits of plants and into which moisture penetrates slowly.

A large body of this soil lies west of Clyde, and smaller areas are nearby, adjacent to Port Chicago. Fairly large bodies are developed on the upper coastal plain to the south of Antioch and Pittsburg. An area including about 300 acres is situated 2 miles north of San Pablo. Numerous smaller bodies are associated with other terrace soils in the north-central part of the county.

Probably 70 percent or more of the land is under cultivation, and the rest supports a vigorous stand of native grasses and is valued highly for grazing. The cultivated areas are used almost exclusively for the production of grain. The few areas devoted to pears and prunes return fairly heavy crops. Wheat yields from 5 to 17 sacks of grain an acre, depending on the season and the care taken in the preparation of the land; yields of barley range from 5 to more than 20 sacks.

Care must be exercised in the cultivation of this soil not to work it when too wet, as it puddles easily and the adobe structure, so desirable in clay soils, is lost.

Denverton adobe clay.—The surface soil of Denverton adobe clay is dark-brown or dark grayish-brown clay of adobe structure. The subsoil is similar to that of Montezuma adobe clay in texture, structure, and lime content, but the surface soil and subsoil are distinguished by their browner color. The rooting zone of plants is limited by a softly consolidated substratum.

Three small bodies of this soil lie just south of Clyde. All the land is cultivated and returns as good yields of wheat and barley as the Montezuma soil.

Sacramento adobe clay.—The surface soil of Sacramento adobe clay is a dark-colored clay of adobe structure, well supplied with organic matter and highly retentive of moisture. At a depth ranging from 4 to 10 inches, it is underlain by dark-gray or dull-gray slightly compact similarly textured material mottled with iron stains. The

lower subsoil layer, begining at a depth ranging from 40 to 50 inches and continuing below a depth of 6 feet, is drab-gray clay.

This soil occupies low, flat, and shallow basinlike areas, where drainage is poorly developed, and in most places the water table lies within a depth of 6 feet. The soil is difficult to plow, but under favorable moisture conditions it breaks down further to a small-cloddy and coarse-granular condition, favorable to subsequent tillage operations. The reaction of the surface soil is neutral in most places, and that of the subsoil is distinctly alkaline.

A long continuous band of this soil, ranging from one-half to 2 miles in width, borders the more highly organic soils of the river delta area in the eastern part of the county. It extends from the southern boundary line northward nearly to Dutch Slough.

About 30 percent of the land is cultivated, and the rest is used for pasture. The principal crops are milo, barley, and asparagus. Milo and barley return good yields, except on areas having a high salt content, but yields of asparagus are lower than those obtained on the nearby highly organic soils. The present cropping system is well adapted to this soil.

Marcuse loam.—The 15- to 20-inch surface soil of Marcuse loam is dull brownish-gray loam which is granular and friable and requires very little labor in its cultivation. This is underlain by light-colored stratified friable and highly calcareous materials which continue to a depth exceeding 6 feet. The soil can be worked under a very wide range in moisture conditions, owing, in part, to the rapidity with which moisture is absorbed. Both surface soil and subsoil are alkaline.

This soil is subject to overflow and is developed on highly stratified sediments. The surface soil varies widely within very short distances from fine sand to clay loam, although most of the variations are not extensive. The soil occupies several stream bottoms in the north-central and northwestern parts of the county where the streams empty into San Pablo Bay and other bodies of water. The largest area is about a mile northwest of Concord, and a large area is west of San Pablo.

Only 15 percent of the land is used for crops, mainly vegetables. The soil is somewhat spotted with accumulations of salts, and for this reason crop yields are slightly below average. The soil is probably better adapted to annual vegetable or grain crops than to other crops. The uncultivated areas are used as pasture.

Marcuse clay.—The surface soil of Marcuse clay is heavy and difficult to handle. It contains larger quantities of saline salts than does Marcuse loam and is hard and deflocculated when dry. It absorbs moisture slowly when dry, but, when once wet, moisture is absorbed as quickly as in other clay soils.

Included with this soil as mapped are some small areas, in which the surface soil is of silty clay loam or clay loam texture. Such areas are more easily handled than the typical soil, although they too are deflocculated. A small area lying 1 mile northeast of Byron is browner than the typical soil.

A long, narrow almost unbroken body of Marcuse clay parallels the delta soils in the eastern part of the county, extending from a point southeast of Byron to the point where the sandy Oakley soils encroach

on the delta lands east and northeast of Oakley. A few bodies lie north of Pacheco.

Less than 1 percent of the land is under cultivation, and the rest is covered with pickleweed, greasewood, saltgrass, and other more or less salt-tolerant plants. The few cultivated areas are used in the production of alfalfa and milo. Alfalfa does fairly well on the better areas which contain but little salts, but the soil is better adapted to milo. The uncultivated areas afford scant pasturage.

YOUNGER SOILS

The younger soils occupy the stream flood plains, lower recently built stream terraces, and lower slopes of the alluvial fans and valley plains, in which parent soil materials have been more recently accumulated. The most recent materials have given rise to soils, in which the soil profile is undeveloped and is dominated by layers of parent materials or geological stratification of alluvial materials. The less recent materials have given rise to soils, in which an incipient or youthful profile development is expressed. The soils of this subgroup are dominated by permeable subsoils and substrata. Drainage is not so well developed as in the older soils of the valleys and coastal-plain areas. Low-lying areas are subject to overflow at times, and some of the soils have high water tables and accumulated saline salts.

Members of the Sorrento series have light-brown or light grayish-brown surface soils which extend to a depth ranging from 10 to 20 inches. They are low in organic matter but in general are friable and easily handled under cultivation. The subsoil is typically friable. It is composed of calcareous stratified alluvial materials of about the same or slightly lighter color than the surface soils. The soil materials are of recent stream-laid deposition and in many places contain fragments of the sandstone or shale rock from which they are derived. In places the rock fragments in various stages of decay impart a slight mottling to the soil material. The lime is disseminated through the subsoil with no tendency toward segregation, but some areas of these soils, especially the heavier textured types, exhibit a slight evidence of profile development and have slightly heavier textured subsoils, in which there is evidence of incipient colloidal deposition. Sorrento clay loam and Sorrento clay occupy alluvial fans and stream bottoms periodically subject to overflow. The soils were grass-covered under virgin conditions, but at present all areas are under cultivation. The surface soils are neutral or slightly alkaline, and the subsoils are alkaline.

Soils of the Yolo series have brown or dull-brown surface soils ranging from 10 to 15 inches in thickness. They grade into subsoil materials that continue to a depth of 6 feet or more. The subsoils are of about the same color as the surface soils and generally consist of alluvial sediments that are appreciably stratified. The soil materials consist typically of recent unmodified alluvial materials, but here and there some development of a profile is indicated by the darker color of the upper subsoil layer and by a slight compaction and staining of the soil aggregates with colloids. Yolo loam is mapped in this county. It is of slightly darker color than typical Yolo loam developed in most of the areas previously surveyed. In the earlier sur-

veys some of it was included with the darker soils of the Dublin series. It occupies alluvial fans or stream bottoms that are subject to occasional overflow.

The 8- or 10-inch surface soils of members of the Brentwood series are brown or dark brown, and a rich reddish-brown tint is apparent on exposed surfaces under moist field conditions. Although friable or granular under cultivation, these soils have a tendency to form a plow sole. The surface soils grade into a dull-brown or dark-brown moderately compact and somewhat more dense upper subsoil layer that is uniform in character to a depth ranging from 36 to 44 inches. This layer contains an appreciable quantity of dark-brown colloidal material that stains the outsides of the structural aggregates. Root holes are very numerous in this horizon. The upper subsoil layer very gradually changes to material of lighter color and lighter texture, until, at a depth ranging from 50 to 60 inches, it is light yellowish brown or light brown and of about the same texture as the surface soils. Lime carbonate is disseminated throughout the lower part of the subsoil. The upper part of the subsoil is without definite structural arrangement and breaks into coarse irregularly shaped clods, but the lower part is friable and breaks up to a granular condition. Brentwood sandy clay loam, Brentwood clay loam, and Brentwood clay are mapped. They are developed on alluvial materials outwashed from areas of sedimentary rocks, and they were included with the Yolo soils in the earlier reconnaissance mapping. They are important soils for the production of fruits and vegetables.

The 10- to 14-inch surface soils of the Oakley series consist of brown or light-brown sandy material that is subject to movement by the wind. The subsoil, which extends to a depth ranging from 45 to 50 inches, is slightly compact light-brown or light grayish-brown material of about the same texture as the surface soils, and it contains only small quantities of colloidal material. The lower part of the subsoil, which extends to a depth of 6 feet or more, is light grayish-brown sandy material of loose character. The land has a hummocky or rolling relief, and drainage is somewhat excessive. Under virgin conditions this soil was covered with live oaks, grasses, and annual herbaceous plants. According to the La Motte test, the soils are neutral or slightly acid. Oakley sand is mapped. It is developed on river-beach or sand-bar deposits or sandy material blown inland and shifted about by the wind since its original deposition. Grapes and almonds are the principal crops grown.

Members of the Salinas series have surface soils of brown or dull-brown, in some places dull dark grayish-brown, friable material which extends to a depth ranging from 10 to 14 inches. They grade into moderately compact dull-brown, dark-brown, or dull dark grayish-brown upper subsoil layers that are of about the same or of slightly heavier texture. The material in the upper part of the subsoil breaks into coarse clods that may be reduced to a granular structure under moderate pressure. Dark-brown colloidal coatings cover the outsides of the structural units and the faces of the cleavage planes. At a depth ranging from 38 to 45 inches, the material in this layer grades into light grayish-brown or light brownish-gray calcareous material of about the same texture as the surface soils. The lime is disseminated

for the most part, but there is a slight tendency toward mycelialike segregation in root channels. The material of this horizon shows little colloidal staining. The parent soil materials are derived mainly from sedimentary rocks. The surface soils are neutral in reaction, and the subsoils are distinctly alkaline. The soils were mainly grass-covered under virgin conditions. Salinas clay loam occurs in this county. It is developed on well-drained alluvial fans and in stream bottoms no longer subject to overflow. It is utilized mainly for the production of grain. It is predominantly dark, and most of it was included with the Dublin soils in the earlier and less detailed surveys.

The Botella soils have dark dull-brown or very dark dull grayish-brown friable surface soils extending to a depth ranging from 8 to 12 inches. The upper subsoil layer, to a depth ranging from 40 to 45 inches, consists of dark-brown or dark dull grayish-brown moderately compact material that is of coarse-cloddy structure. The clods break from the soil mass along fairly well defined parting planes. The faces of the planes and structural aggregates are coated with dark-brown colloidal stains which penetrate the soil aggregates to an appreciable extent, but when crushed the material becomes lighter in color. The upper subsoil layer grades into light grayish-brown or dull brownish-gray lower subsoil material that extends to a depth of 6 feet or more. This material is of about the same texture as the surface soils. Dull yellowish-brown colloids coat the soil aggregates in this layer. The soils are without free lime carbonate in any part of the soil profile to a depth of 6 feet or more. They occupy gently sloping alluvial fans and stream bottoms, no longer subject to overflow. Under virgin conditions they support a good growth of grasses together with numerous oaks. The surface soils are neutral in reaction to the La Motte test, and the subsoils are slightly alkaline. Botella clay loam and Botella clay are mapped. In this county the parent materials are derived to less extent from highly siliceous shales than they are elsewhere. Walnuts do particularly well on these soils, and fruits and vegetables return good yields.

The surface soils of members of the Danville series consist of dark dull grayish-brown or dark brownish-gray friable material moderately well supplied with organic matter and ranging in thickness from 14 to 20 inches. The subsoil, which continues to a depth of more than 6 feet, consists of lighter brownish-gray or lighter grayish-brown stratified materials which in most places are of lighter texture than the surface soils. In a few areas the upper part of the subsoil is slightly compact and is lightly stained with light-brown colloids, indicating slight development of a profile. Typically the soil materials are noncalcareous, but in some places in this county, the materials are mildly calcareous at a depth of 54 or more inches. Danville clay loam is mapped. It occurs on well-drained alluvial fans and stream bottoms, slightly above the level of overflow. This soil was included with the closely related Dublin and Yolo soils in the earlier surveys. The soil supports excellent walnut groves, and it is productive of fruits, vegetables, and grains.

The surface soils of types in the Dublin series are dark gray or black. They range from 15 to 22 inches in thickness. They are generally of heavy texture and are in places somewhat mottled with rust

brown or yellow. The subsoil, to a depth of 6 feet or more, consists of dull grayish-brown or dark grayish-brown material of about the same texture as the surface soils. There is little or no colloidal accumulation in the subsoil or other evidence of profile development. The soil materials are without free lime carbonate to a depth of 6 feet or more. Dublin adobe clay, with an overwash phase, and Dublin adobe clay loam occur in this county. They occupy flat or basinlike areas, in which drainage is poorly developed, but they are productive soils and are utilized for the growing of sugar beets, peas, and other vegetables, and to some extent for tree fruits.

Soils of the Clear Lake series have dark-gray or black surface soils which range from 9 to 14 inches in thickness. In most places they are heavy textured and of an adobe structure. The upper subsoil layer, which continues to a depth ranging from 34 to 40 inches, is dark-gray or black material of about the same or slightly heavier texture than the surface soils. It is more dense, and the more friable, cloddy, and granular adobe structure is lacking. The material in this layer grades into dull brownish-gray calcareous sediments of lighter texture than the surface soils, and this material is uniform to a depth of 6 feet or more. The lime carbonate is disseminated throughout the lower part of the subsoil. These soils occupy low poorly drained basinlike areas and flats having a high water table and supporting a growth of grasses under virgin conditions. The Clear Lake adobe clay and Clear Lake clay loam occurring in this county are not so well drained as the Montezuma soils, but, owing to their more favorable position with respect to moisture supply and markets, they are utilized for a wider range of crops, including pears, prunes, and vegetables. At the time of the earlier surveys, the Clear Lake soils were included with the Dublin soils which they closely resemble and from which they have been differentiated because of the presence of accumulated lime in the subsoils.

The soils of the Columbia series have rather dull grayish-brown or dull yellowish-brown surface soils mottled with rust brown and gray. They are underlain by stratified subsoils of slightly lighter color in which the mottlings continue to a depth of more than 6 feet. The soils consist of recent river-laid deposits that border sloughs and channels in the islands and basins, in which the alluvial sediments have been deposited over the organic soils of this section. The surface materials characteristic of the Columbia series gradually thin out, and along the outer margins the areas are represented by only a few inches of Columbia material. Although originally subject to overflow, Columbia loam which occurs in this county has been reclaimed by dikes and drainage and is now highly productive of alfalfa, asparagus, pears, and other crops.

The 10- to 15-inch surface soils of members of the Alviso series consist of a dull brownish-gray material highly mottled with organic and iron stains. They grade into dull brownish-gray or dark brownish-gray highly mottled mucky claylike material which, in many places is thinly stratified with organic deposits. The series is represented in this survey by Alviso clay which occupies areas only slightly above tidal overflow, that are inundated during unusually high tides. In general it contains large quantities of saline salts. It has practically

no agricultural value and supports only a growth of saltgrass and other salt-tolerant vegetation. This growth sometimes affords a little pasture in the better-drained localities.

Sorrento clay loam.—The surface soil of Sorrento clay loam, to a depth ranging from 10 to 20 inches, is light-brown clay loam which is granular and friable and easily maintained in good tilth. The subsoil is composed of calcareous stratified alluvial sediments of the same color as the surface soil or slightly lighter. The material is friable, and plant roots, air, and moisture penetrate it very readily. Soft fragments of the shale or sandstone rock, from which the soil is developed, are present in places and impart a slight mottling. Lime is disseminated throughout the subsoil and not segregated. The soil has a lower water-holding capacity than soils of similar texture that have more compact and slightly heavier textured subsoils.

This soil occurs only in the eastern part of the county. A comparatively large area borders the Marsh Creek channel in its course down the alluvial fan, and a body embracing about a square mile is at the point where Sand Creek empties onto the alluvial plain.

All the land is cultivated and is used principally for the production of fruit and nuts. Yields average about the same as on Brentwood clay loam, except that cherries and walnuts return higher yields. The soil seems especially well adapted to cherries and walnuts, although all fruits and nuts yield well. The soil is better adapted to deep-rooted than to shallow-rooted crops.

Sorrento clay.—The surface soil of Sorrento clay works up granular and mellow under ordinary cultural practices, although more power is required for the operation of tillage implements than on Sorrento clay loam. Sorrento clay has the better water-holding capacity, however, of the two soils; otherwise they are similar. Plant roots, air, and moisture penetrate this soil very readily. In a few areas, especially on the lower slopes of alluvial fans, the subsoil is mottled with rusty brown and yellow, due to imperfect subdrainage.

Sorrento clay is developed in only one body which lies at the foot of the sand hills between Oakley and Knightsen. All the land is under cultivation, and the acreage is divided about equally among fruit, alfalfa, and vegetables, including tomatoes and asparagus. Alfalfa is produced in connection with the dairy industry, and only sufficient hay is cut, as a rule, to supply the needs of the dairy cattle for dry feed. Fruit crops include cherries, apricots, peaches, prunes, plums, and other tree fruits. A few acres are devoted to walnuts and almonds. Plums return yields of 3 or 4 tons an acre, cherries, 1½ tons, and asparagus an average of 3,000 pounds. Yields of other fruits and nuts are as good as those obtained on Brentwood clay loam.

Sorrento clay is fertile and generally well farmed. It is adapted to a wide range of crops and is especially well adapted to the production of deep-rooted tree fruits.

Yolo loam.—The 10- to 15-inch surface soil of Yolo loam is light grayish-brown, brown, or dull-brown friable loam which is absorptive of moisture, easily handled under cultivation, and in all other respects well adapted to agricultural utilization. The subsoil continues to a depth of 6 or more feet and, in most places, consists of somewhat stratified alluvial sediments. The material is friable and easily penetrated by plant roots, air, and moisture, although, in a

few places, the texture is somewhat coarse and the water-holding capacity restricted. A few small undifferentiated bodies of sandy loam are included with this soil on the map.

A number of comparatively large bodies are in the San Ramon and Ygnacio Valleys and in the section extending from the town of San Ramon northward to Hookston. Small bodies occur along minor drainage courses in the central and western parts of the county.

Yolo loam is used in the production of all crops common to this section of the State. Walnut groves on the soil return yields ranging from 1,000 to 2,000 pounds or more an acre from fully matured trees, cherries 1½ to slightly more than 2 tons, and other fruits slightly better than average yields. The soil is well adapted to crops requiring a deep friable soil for their most successful development.

Brentwood clay loam.—Brentwood clay loam has a brown or rich-brown neutral or slightly alkaline surface soil about 10 inches thick, which is friable and granular but tends to form a plow sole. It is underlain by a brown or dull-brown somewhat more dense and compact subsoil which continues to a depth ranging from 36 to 44 inches. The material in this layer becomes lighter in color, more friable, and contains disseminated lime carbonate in the lower part. It breaks into irregularly shaped clods. Dark-brown colloidal material stains the outsides of structural aggregates, and root holes are numerous. The upper subsoil layer gives way gradually to a lighter colored and lighter textured granular material which, at a depth ranging from 50 to 60 inches, is light yellowish brown or light brown and of the same texture as the surface soil. Lime carbonate is disseminated throughout the lower part of the subsoil.

Cultural operations on this soil are carried on easily, and a fine-granular structure, favorable to crop growth, is produced readily. The soil has a high water-holding capacity and gives up moisture readily to plants. The organic-matter content is not high, but the soil is fertile and returns good yields of all crops suited to local climatic conditions.

This soil occurs only in the eastern part of the county, mainly on the alluvial fan at the mouth of Marsh Creek. Extensive areas occupy the terraces bordering Kellogg and Marsh Creeks, Briones Valley, and smaller valleys.

With the exception of small areas along minor drainageways, all this land is cultivated. Where irrigated it is used mostly in the production of tree fruits, vegetables, and alfalfa. Areas not under irrigation are used in the production of grain and grain hay. Apricots are the principal tree fruit produced, although the acreage in prunes is nearly as large as that in apricots. Plums, cherries, peaches, figs, and walnuts also are grown commercially. Tomatoes and lettuce are the principal vegetables grown, followed by spinach, cauliflower, and carrots. Melons are grown to some extent. Most of the alfalfa produced on this soil is fed to dairy cattle on the ranch on which it is grown. Tomatoes yield from 4 to 12 tons an acre, depending on the variety, the length of the growing season, and cultural care; and lettuce, about 250 crates. The average yield of walnuts is about 900 pounds an acre, although higher yields are reported from vigorous fully matured trees. Other fruits and vegetables yield equally well, and the products of this soil are of good quality.

The soil is well farmed and well managed. Leguminous cover crops on orchard or vegetable lands will help to maintain the fertility of the soil.

Brentwood sandy clay loam.—The surface soil of Brentwood sandy clay loam is somewhat lighter textured, more loamy, and easier to cultivate than Brentwood clay loam. It has, however, a lower water-holding capacity, although the soil is not so droughty as soils with light-textured subsoils. The soil in an area bordering Deer Creek has a heavier textured subsoil than is typical, which somewhat limits the development of plant roots. Some of the areas in stream valleys between Pittsburg and Antioch, included with this soil on the map, are somewhat more gray than typical.

The more typical areas are developed in Kellogg Creek Valley, on the Marsh Creek fan about 2 miles northeast of Byron, and in small valleys in the eastern part of the county.

About 50 percent of the land is cultivated, and the rest, although capable of cultivation, at present is used as pasture. The cultivated areas are used largely for the production of grain, good yields of which are obtained.

Brentwood clay.—The surface soil of Brentwood clay is dark-brown or rich-brown heavy clay, but under cultivation it is easily reduced to a granular structure and in other ways seems more nearly like a soil of lighter texture. The soil takes moisture readily and has a high water-holding capacity. In other characteristics it resembles Brentwood clay loam.

The soil is developed on alluvial fans of Marsh, Kellogg, and Deer Creeks in the eastern part of the county. A small area at Byron and a larger one 1½ miles south of Concord are more gray than is typical.

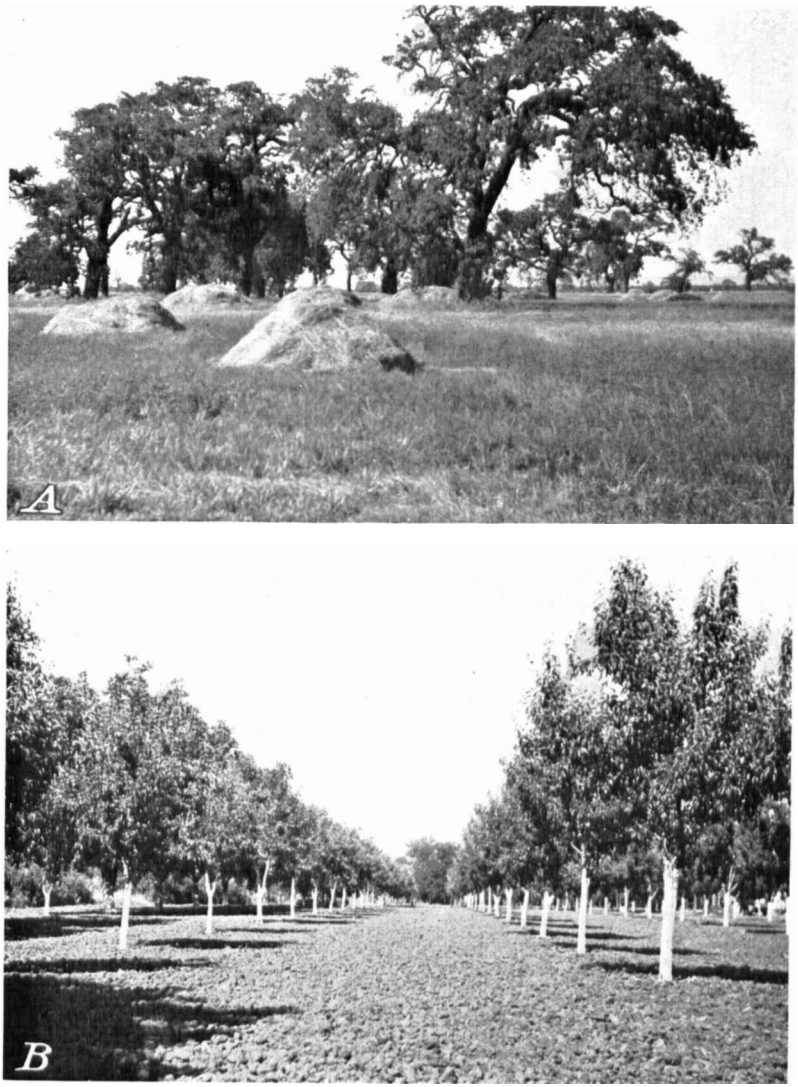
All the land is cultivated, and most of it is irrigated. The crops grown are similar to those grown on Brentwood clay loam, and yields are slightly less than yields returned by that soil. Apricots and prunes do especially well. Alfalfa stands generally are shorter lived than those on the lighter textured soils of the Brentwood series.

Oakley sand.—The 10- to 14-inch surface soil of Oakley sand is brown or light-brown sand. It is handled very easily. The soil is leachy and porous, and although moisture is absorbed readily, it is retained very poorly. The material in the surface soil is loose and incoherent and drifts badly during heavy winds. The upper part of the subsoil is slightly compact light grayish-brown material of about the same texture as the surface soil. It contains only a small quantity of colloidal material, and no iron-cemented seams or lenses are present as in the older soils developed on similar material. Beginning at a depth of 45 or 50 inches and extending below a depth of 6 feet is light grayish-brown loose friable material.

The relief is hummocky or rolling, and internal drainage is excessive. The reaction is neutral or slightly acid. The virgin soil supported live oaks, grasses, and an annual herbaceous growth.

This soil occurs only in the northeastern part of the county where it occupies an area of several square miles. Numerous small outlying areas are near the main body and in the delta lands, particularly in the Bethel tract.

About 90 percent of the land is under cultivation and is used largely in the production of grapes and almonds. Some prunes, apricots, and



A, Scattered native oaks in a field of barley hay on Salinas clay loam in Ygnacio Valley; *B*, young pear orchard on Dublin adobe clay. Note the small cloddy structure of the soil, developed under cultivation.

other early-maturing fruits are grown but return low yields. Almonds yield from 150 to 1,000 pounds an acre, depending on the age of the trees and various other factors. Grapes yield better than most other fruits, and the quality is good. The keeping of poultry on soil of this type makes for a better balanced farm income and plan of operation.

Salinas clay loam.—The 10- to 14-inch surface soil of Salinas clay loam is dull-brown or dull dark-brown clay loam. It is friable and granular under cultivation and contains a moderate amount of organic matter. It is underlain by a somewhat more compact and slightly heavier textured upper subsoil layer which grades into a lighter brown or grayish-brown lighter textured, more friable, and calcareous lower subsoil layer at a depth ranging from 38 to 45 inches. The material in the upper part of the subsoil breaks into coarse clods which are reducible to a granular structure under moderate pressure. Dark-brown colloids coat the outsides of the structural particles and cover the faces of cleavage planes. Lime is disseminated throughout the lower part of the subsoil, and a slight tendency toward segregation in root cavities imparts a mycelialike appearance. Colloidal stains are absent from this layer. The soil is absorptive and retentive of moisture, has a high water-holding capacity, and also in other respects is well suited to agricultural use. The reaction of the surface soil is neutral, whereas that of the subsoil is distinctly alkaline.

Included with this soil because of their small extent are a few areas which are slightly lighter in texture and which are cultivated more easily. These lighter textured areas border Tassajero Creek south of Tassajero. A number of bodies in Ygnacio Valley are somewhat darker than the typical soil, and the calcareous material of the subsoil lies at greater depths.

Typical areas of this soil also border Tassajero Creek and occur in Sycamore Valley to the southeast of Danville. Numerous small areas occupy creek bottoms in the hilly sections of the central and eastern parts of the county.

All the land is cultivable, but at present only about 70 percent of it is used for crops. Most of the cultivated area is used in connection with other soils for the production of grain without irrigation, and some fruits and vegetables are grown (pl. 3, *A*). The soil is well farmed and managed, and yields are good.

Botella clay loam.—The 10-inch surface soil of Botella clay loam is dull dark brown, friable, granular, and easily handled. It is well supplied with organic matter and absorbs moisture readily. The subsoil, to a depth of 40 or 45 inches, is dark grayish-brown slightly compact material which is readily permeable to plant roots or moisture. Coarse clods break from the soil mass along well-defined cleavage planes. This layer grades into the light grayish-brown or dull grayish-brown lower subsoil layer of about the same texture as the surface soil and continues to a depth below 6 feet. No free lime carbonate is present in the soil above a depth of 6 feet, but the surface soil is neutral and the subsoil slightly alkaline. Indicated on the soil map by gravel symbols are a few areas in Amador Valley near the county boundary, in which gravel constitute from 20 to 35 percent of the soil mass and reduce markedly the moisture retentiveness of the soil.

Botella clay loam is an inextensive but agriculturally valuable soil. The principal areas are southeast of San Ramon and east of Walnut Creek, and smaller ones are northwest of Cowell along the upper edge of Clayton Valley.

All the land is devoted to crops, principally walnuts. Some fruits and vegetables are grown, of which the yields are high and dependable except in seasons of late spring frost. The average yield of walnuts is about the same as that obtained on Botella clay.

Botella clay.—Botella clay is similar to Botella clay loam but is of heavier texture. Although of heavy texture, the soil is easily cultivated under favorable moisture conditions. Some areas of a slightly heavier texture than typical, which are somewhat more difficult to handle, are included on the map.

Botella clay is one of the more extensive soils in the San Ramon Valley. There are several areas in Ygnacio, Clayton, Amador, Arroyo del Hambre, and Las Trampas Valleys, and in most of the smaller valleys of the western part of the county. This soil also occupies a number of the creek bottoms in the south-central part.

As mapped this soil includes a small area just north of the town of San Pablo, which is not so well drained as the typical soil and in which the surface soil is slightly darker and the subsoil mottled with rusty brown, gray, and yellow. This area is used mainly for the production of vegetable crops and the yields are very good, but poor subdrainage limits its adaptation to the more shallow rooted crops.

Most of the land is under cultivation and is used for the production of nearly all crops commonly grown in this section, among which fruits and nuts dominate. It is used to a greater extent for the production of grain and hay than is Botella clay loam, largely because of the fact that small areas are associated with other soils devoted exclusively to these crops. A variable acreage is used for the production of vegetables and grains each year. Walnuts yield from 800 to 2,000 pounds an acre, depending on the age of the trees, the care given the crop, and the season. Frosts occasionally do considerable damage to the walnut crop, especially in the lower lying areas. Pears yield well on the soil and produce yields ranging from 5 to 12 tons an acre. Prunes, apples, apricots, and other tree fruits, as well as grapes, return better than average yields, and heavy yields of good-quality tomatoes are produced largely for canning, as well as for the local produce markets.

Botella clay is a fertile soil and generally is well farmed. The soil tends to form a plow sole which can be broken temporarily by deep plowing and subsoiling at intervals. For continued successful production of fruit, organic matter must be returned to the soil, preferably in the form of barnyard manure or as leguminous cover crops. Intertilled leguminous crops will aid in maintaining the fertility of vegetable and grain lands if worked into a 3- or 4-year rotation.

Danville clay loam.—The surface soil of Danville clay loam ranges from 14 to 20 inches in thickness. It is dull dark brown, friable, well supplied with organic matter, and rather easily cultivated. The surface soil is underlain by stratified materials which are lighter in color and texture, continuing to a depth exceeding 6 feet. In a few places the subsoil is slightly compact in the upper part and slightly stained with dark-brown colloids, indicating slight development of a

profile. In other places the subsoil is composed of sandy materials which reduce the typically good water-holding capacity of the soil.

As typically developed elsewhere, the Danville soils are noncalcareous, but within Contra Costa County the material in many places is mildly calcareous below a depth ranging from 54 to 60 inches. In the vicinity of Cowell a few areas are calcareous in the surface soil, owing to the deposition of dust from a nearby cement plant. The color of these areas is reddish brown instead of dull dark brown. Some small areas of loam, which could not be separated on a map of the scale used, also depart from the typical soil in color. They are light brown or light grayish brown.

Danville clay loam is developed on the bottoms of Tassajero and Alamo Creeks in the south-central part of the county, in Deer and Horse Valleys in the eastern part, and near Hookston, in San Ramon Valley, and on the bottoms of minor streams in the western part.

Practically all the land is used for the production of fruits, nuts, vegetables, and grains. Some of the better walnut groves are on this soil. Prunes yield from 1½ to 2 tons of dried fruit an acre, pears 6 to 10 tons in average seasons, and other crops yield well.

This is a productive soil and can be so maintained indefinitely through good cultural practices, such as plowing under cover crops in orchards and including an intertilled leguminous crop on land used in the production of vegetables and grains.

Dublin adobe clay.—The surface soil of Dublin adobe clay, which ranges from 15 to 22 inches in thickness, consists of very dark brownish-gray or black clay of pronounced adobe structure. It has a moderately high content of organic matter, is very sticky when wet, bakes and cracks deeply during prolonged dry periods, and breaks into large clods. Typically it is underlain by a dense heavy-textured subsoil which extends to a depth of 6 feet and is somewhat mottled with iron stains in most places. No accumulation of colloids or other evidence of the development of a profile is present in the subsoil. Free lime carbonate is lacking to a depth of more than 6 feet.

Dublin adobe clay is difficult to plow and can be effectively worked only under limited conditions of favorable moisture content. If plowed at a favorable moisture content, so that it does not puddle, the soil tends to slake down to a granular structure, after which further cultural operations are much less difficult. Moisture is retained very well, but it is absorbed and given up slowly.

The soil is distributed in numerous bodies throughout the western part of the county but is of small total extent. It is best developed at the lower end of San Pablo Creek. A number of bodies lie near Lafayette and Moraga and on the Amador and San Ramon Valley floors.

Dublin adobe clay is used for the production of fruit, sugar beets, vegetables, and hay. Uncultivated areas, constituting perhaps 20 percent of the land, are covered with a vigorous native growth of grasses and moist-land plants and are utilized for grazing. A few walnut groves are planted on areas of this soil closely associated with soils which are more suitable for this purpose. Pears are the principal tree fruit (pl. 3, *B*). Prunes and apricots are grown on smaller acreages. Tomatoes and lettuce are the principal vegetable crops. Sugar beets return yields ranging from 8 to 14 tons an acre and pears

an average yield of 7 tons. These crops are adapted to the soil and yield well, but, because of the difficulty of handling the soil, they cost more to produce on this soil than on lighter textured soils. Most vegetable crops yield well, but the heavy texture of the soil does not appeal to many truck farmers.

Dublin adobe clay, overwash phase.—The overwash phase of Dublin adobe clay represents a recent deposit, ranging from 24 to 45 inches in thickness, of variable dull grayish-brown, dull-brown, or dark-brown generally stratified material over typical Dublin adobe clay. Most of this surface layer is loam or clay loam in texture, but areas of fine sandy loam or silty clay loam are included. The soil is easily handled and reduces readily to a granular structure. The surface layer is penetrated easily by plant roots and moisture, but the underlying typical adobe clay is tight and compact, and plant roots penetrate it with difficulty.

A small total acreage of this soil is developed in the western part of the county, principally near the mouths of San Pablo and Wildcat Creeks.

About one-half of the land is under cultivation, and the rest is used for pasture or for building sites. The main crops are vegetables and fruits, yields of which are slightly higher than those obtained on typical Dublin adobe clay.

Dublin adobe clay loam.—The surface soil and subsoil of Dublin adobe clay loam are similar in color, structure, and behavior under cultivation to Dublin adobe clay but are of somewhat lighter texture. Dublin adobe clay loam can be cultivated more easily and worked under a slightly wider range of moisture conditions than the heavier textured soil. The clay loam also retains moisture better and releases it more readily.

Like Dublin adobe clay, this soil is distributed in numerous small bodies throughout the western part of the county. Its total extent is small. The largest bodies are in San Ramon Valley, particularly at San Ramon and Danville and north of Alamo. Small bodies occupy the bottoms of minor creeks west of San Ramon and Ygnacio Valleys.

Most of the land is under cultivation and is used principally for the production of fruits, nuts, and vegetables. It is better adapted and more extensively used for the production of walnuts than is Dublin adobe clay. It is also a good soil for pears which are the principal fruit grown. All vegetables do well. Yields of all crops on this soil exceed those obtained on Dublin adobe clay.

Clear Lake adobe clay.—The surface soil of Clear Lake adobe clay, to a depth ranging from 9 to 14 inches, is dark-gray or black heavy-textured clay of pronounced adobe structure, and it is difficult to plow. If worked when the moisture content is favorable, however, the soil material slakes to a small-cloddy and granular structure which is less unfavorable to tillage. The surface soil is underlain by dark-gray or black somewhat more dense material which lacks an adobe structure. At a depth ranging from 34 to 40 inches this material, in turn, gives way gradually to dull brownish-gray lighter textured material composed of calcareous sediments, which continues to a depth exceeding 6 feet. The soil is well supplied with organic matter and has good water-holding capacity. Subdrainage, however,

is restricted and this, together with the heavy texture, limits the agricultural utilization of the land. Included with this soil because of their small extent are some areas which are grayer than typical and which resemble Antone clay loam.

A number of large areas are in the upper San Ramon and Amador Valleys. This is also an important soil in the Ygnacio Valley and lower Clayton Valley. Comparatively large areas occupy the bottoms of Pinole and San Pablo Creeks, and bodies are distributed throughout the stream valleys in the hilly section of the county. The soil is especially well developed near Lafayette and Moraga and along the south-central boundary.

Most of the land is used to produce the crops commonly grown in this county. In the western part much of the land is devoted to fruit, and smaller acreages to vegetables. East of San Ramon and Amador Valleys, grain is the chief crop, and very small acreages are in vegetables. Pears and prunes are the principal fruits, and the soil probably is better adapted to their culture than to other kinds of fruits. Pears yield from 4 to 10 tons an acre, depending on the season and the age of the trees, and prunes average 1 ton of dried fruit. Other crops yield well in favorable seasons, but grains drown out in wet years and suffer from drought early in the season in dry years.

Clear Lake clay loam.—In most places the surface soil of Clear Lake clay loam is dark-gray or black clay loam. This soil resembles Clear Lake adobe clay in profile characteristics, but it is variable. Some areas have a gray color similar to that of Antone clay loam, and others have a clay texture and an adobe structure similar to that of Clear Lake adobe clay. These variations are too small and irregular to be differentiated on a map of the scale used.

This soil is scattered in numerous small bodies throughout the central and western parts of the county. Some of the larger areas are in Ygnacio Valley and in stream bottoms draining into San Pablo Bay; others are in Amador Valley and in small tributary stream valleys.

Approximately 50 percent of the land is under cultivation in connection with other soils, and the crops grown include most of those common to the county. The more typical areas are somewhat better adapted to agriculture and return slightly better yields than the included soils.

Columbia loam.—The 10- to 14-inch surface soil of Columbia loam is friable, granular, mottled brown or yellowish-brown loam which more nearly resembles a fine sandy loam in the manner in which it is handled. The subsoil consists of stratified, permeable river-laid sediments. Mottlings in the soil continue to a depth exceeding 6 feet. The soil is easily penetrated by plant roots, except in areas where the material is spread out as a very thin layer over the organic soils having a high water table. The water table in such areas limits the rooting habits of plants. The soil is, as a rule, slightly darker colored than typical Columbia loam developed in other parts of the State.

This soil is inextensive and occurs only east of Herdlyn in the extreme southeastern part of the county. It is largely under cultivation and is used for the production of alfalfa, asparagus, and such annual crops as milo, beans and other vegetables, or for grain crops. Alfalfa yields an average of about 5 tons an acre from good stands, and other crops return equally good yields.

Alviso clay.—The surface soil of Alviso clay varies somewhat in texture and includes areas of clay loam. It is dull brownish gray or drab, is much mottled with iron stains and organic matter, and is underlain, at a depth ranging from 10 to 15 inches, by fine-textured materials of high organic-matter content, which, in some places, are interstratified with layers of muck and peat. The soil contains saline salts and is subject to inundation at high tide by brackish tidal water.

Numerous bodies of this soil border San Pablo Bay and other tidal waterways along the northern shore line of the county.

None of the land is under cultivation, nor is it apt to be of agricultural value in the future, due to the high salt content, high water table, and the difficulty of drainage and reclamation. The cost of diking to prevent tidal overflow would, in most places, be prohibitive. The native vegetation is largely pickleweed and saltgrass, and the land has slight value for grazing. It has a little higher value for this purpose, however, than tidal marsh, with which it merges.

ORGANIC SOILS OF THE RIVER-DELTA AREA

The organic soils of the river delta have been formed by accumulations of roots, stems, and other remains of tules, sedges, and other aquatic plants in various stages of decay, together with an admixture of various quantities of mineral alluvial materials deposited from overflow waters of streams.

These soils, in which organic materials are dominant, occupy large areas of the island and stream-delta region, only a small part of which is included in this survey. Most of these soils, which lie only slightly above or, in some places, slightly below sea level, have been reclaimed from their original marshy condition by extensive dikes, drainageways, and pumping plants. They now form some of the most important agricultural soils of the State.

The organic soils include Piper fine sandy loam, Egbert clay loam, Ryde clay loam, peat, and areas in which the Piper and Egbert soils and peat are so intricately intermixed that they are not differentiated.

The surface soils of members of the Piper series are dark gray or dark brownish gray, and they have a high content of organic matter. They are loose, friable, and distinctly calcareous. They grade into a somewhat lighter subsurface layer or upper subsoil layer, of somewhat lower organic-matter content, which is highly calcareous, firm, and feebly cemented, but which breaks to soft lumpy aggregates. This material is penetrated by vertical root holes that are stained with iron and coated with lime carbonate. This horizon in general is high in saline salts. It is underlain by light-gray or yellowish-gray material of low organic-matter content and contains much accumulated lime carbonate in root holes. This layer, in turn, grades into a pale yellowish- and pale reddish-brown massive but soft sandy substratum of low organic-matter content, without lime segregation, and of neutral reaction. The soils of this series are developed on low mounds or ridges and are associated with the highly organic soils of the Sacramento-San Joaquin River delta region. The sandy subsoil and substratum appear to represent old aeolian and beach deposits which have been depressed and modified by a high water table and on which has been developed a surface soil of high organic-matter content.

The soils now are elevated above the associated areas of peat and highly organic soils, and drainage is well developed. The soils are of low water-holding capacity and are subject to drought.

The surface soils of the Egbert series, which are dark gray or dark brownish gray, extend to a depth ranging from 20 to 36 inches. They are high in organic-matter content and are loose and friable under cultivation. They are underlain to a depth of more than 6 feet by dark-gray or grayish-drab river sediments stratified to some extent with organic materials in various stages of decomposition. In some places these include tawny layers of undecomposed peat, locally known as "buckskin peat." The subsoil is highly mottled with yellow and rust brown. The Egbert soils occupy flat basinlike areas that generally lie several feet below sea level in the Sacramento-San Joaquin island delta region, where, in virgin condition, they support a growth of tules, reeds, and other water-loving plants. Egbert clay loam is mapped in this county. Most of the land has been reclaimed by diking and drainage, and it is utilized for the production of a variety of crops including asparagus, corn, milo, potatoes, and onions.

Soils of the Ryde series have dull-gray or dull brownish-gray heavy-textured surface soils, in which a high percentage of organic matter effectively masks the heavy texture. The organic matter is in various stages of decomposition, and the soil material is mottled with rust brown, yellow, and gray. The surface soils directly overlie dull brownish-gray or grayish-drab river sediments that are to some extent interstratified with layers of peat and muck. These soils are poorly drained, and in virgin condition and not diked and reclaimed they support a vigorous growth of tules, sedges, and other water-loving plants. Ryde clay loam occurs in this county. It is developed in the island and river-basin district, and most of it is several feet below sea level. Asparagus is the principal crop grown. The Ryde soils were included with the associated soils of the Sacramento series in the earlier reconnaissance surveys.

Piper fine sandy loam.—The surface soil of Piper fine sandy loam is dark gray or dark brownish gray, calcareous, highly organic, and friable. It absorbs moisture rapidly but has a rather low water-holding capacity and dries out quickly. The soil can be worked under a very wide range of moisture conditions. It is very spotted in occurrence, with small areas containing accumulations of saline salts, most of which are concentrated in the surface soil. The surface soil invariably is shallow, and the lighter gray subsoil is exposed in many areas that have been subject to erosion. The material in the upper part of the subsoil contains less organic matter than that in the surface soil and it is firm or feebly cemented but breaks to soft lumpy aggregates. It is penetrated by vertical root holes which are stained with iron and coated with lime carbonate. The pale-yellow or pale reddish-brown lower subsoil layer, in most places, is compact and softly consolidated sandy material containing little organic matter and no segregation of lime. The reaction of the material in this layer is neutral.

This soil is developed on low islands in the delta lands in the northeastern part of the county. It appears to be related to the sandy soils of the Oakley series, but it occurs on the lower areas of the river delta where it has been modified by organic deposits. The

very high water table, which existed before reclamation of the delta lands, favored the growth of a heavy vegetative cover and resulted in the development of the darker colored surface soil.

A very small proportion of the land is under cultivation in connection with other delta lands planted to asparagus, but yields are low. Saltgrass and other native grasses furnish fair grazing on the uncultivated areas. The soil has little potential value for agriculture.

Egbert clay loam.—The 20- to 36-inch surface soil of Egbert clay loam is dark gray or dark brownish gray. It is friable and granular, owing to a very high organic-matter content, and, when dry, the soil material is fluffy and blows about in the wind when disturbed by cultivation. The subsoil consists of dark-gray or drab-gray river sediments stratified to some extent with layers of peat and muck in various stages of decomposition. In places, tawny layers of undecomposed buckskin peat are present. This layer is highly mottled with yellow and rusty brown and extends below a depth of 6 feet. The material has a higher mineral content than the surface soil, but it is readily permeable to plant roots. A high water table, in most places occurring at a depth of about 3 feet below the surface, limits the root development of plants in the lower part of the subsoil.

The soil occurs only on the delta of San Joaquin River in the eastern part of the county. It is especially well developed along the upper margin of the peaty lands and in the Bethel tract.

With the exception of small areas, in which the concentration of saline salts is high, or those which are associated with large tracts of poorer soils, all the soil is under cultivation. It is used for the production of asparagus, corn, milo, potatoes, and onions. Asparagus yields range from 2,000 to 5,000 pounds an acre, depending on the age of the beds and the care given them; milo, from 3,000 to 5,000 pounds; and potatoes, from 100 to 300 sacks. Other crops do equally well.

The land, in general, is well farmed and is utilized for the crop to which it is best suited.

Ryde clay loam.—The surface soil of Ryde clay loam is dull gray, is rich in organic matter, and is very easily cultivated. It rests, at a variable depth below 10 inches, on mottled brown and gray river-laid sediments which extend to a depth below 6 feet and in some places include layers of peat and muck. The soil absorbs and retains moisture very well. The water table lies at a slight depth, and the rooting habits of plants are thereby limited.

This soil is inextensive. The largest areas are northeast of Herdlyn, and smaller areas are in the east-central and northeastern parts of the county. Practically all of the land is under cultivation and more than one-half is devoted to asparagus. The rest is used for the production of milo, alfalfa, barley, and other general farm crops. Alfalfa yields very well, although the stands generally are short lived and somewhat spotted. Asparagus yields are somewhat lower on this soil than on Egbert clay loam. Milo yields from 1½ to 3 tons an acre and barley from 20 to 35 or more sacks.

Peat.—Peat includes stratified organic materials containing more or less mineral soil, although this constitutes but a small proportion of the soil mass. As a rule, the surface soil materials are dark brownish gray, granular, and well decomposed. The subsoil, extending to a

depth of 6 or more feet, generally includes layers of tawny-colored undecomposed fibrous buckskin peat. As mapped in this county, some areas are included which contain a slightly higher proportion of mineral soil than is typical.

Peat is developed only in the delta of San Joaquin River in the eastern part of the county. It is one of the major soil classifications occurring in the islands and basins of this district.

About 70 percent of the land is under cultivation. Most of the rest is protected from overflow by dikes and is capable of cultivation, but, owing to the salty condition of the fields or other circumstances, it is not used for crops at present. The uncultivated and diked areas are grown up to cocklebur, cane, tules, and other moisture-loving plants. Areas that are not diked are covered with tules. Asparagus, potatoes, onions, celery, corn, milo, and various other vegetable or cereal crops are grown, and the yields are very similar to those obtained on Egbert clay loam. Barley and other light-stemmed cereal crops make a rank growth and lodge badly as the heads begin to fill. The land is subirrigated by controlling the height of the water table. It is well farmed and is utilized to good advantage.

Piper fine sandy loam, Egbert clay loam, and peat, undifferentiated.—It appears probable that in the northeastern part of the county the sandy soil materials similar to those occurring around Oakley formerly extended out into the lower delta lands of San Joaquin River. Remnants of this sandy area still remain in this section, and, in a number of places, they have been covered thinly with decomposed organic materials and river sediments. The decomposition varies greatly in depth within short distances, and, in many places, the sandy materials, covered with only a few inches of organic material, protrude above the surrounding deposits. The soils are so variable in character of material and in depth that it was impractical to differentiate accurately the individual soil areas on a map of the scale used. These heterogeneous soil areas therefore, have been shown on the soil map as undifferentiated areas of Piper fine sandy loam, Egbert clay loam, and peat, which they represent. Areas of all these types have been mapped in other parts of the county, and all are more or less typically developed in the undifferentiated bodies. An examination of the soils in these areas, to a depth of 6 feet, will disclose to which type the soils examined belong.

Areas on Jersey Island and on the Bethel tract consist of this undifferentiated material. About 15 percent of the land is under cultivation and used principally for the production of grain or milo. Yields are low. Uncultivated areas support some saltgrass and, in areas of low salt concentration, other native grasses. The chief value of the soil is for grazing or for the production of grain.

MISCELLANEOUS LAND TYPES

Associated with the arable soils which have been classified with respect to soil characteristics, a number of miscellaneous land types are shown on the map as made land, rough broken land, rough stony land, and tidal marsh.

Made land.—The areas designated as made land consist of materials removed by dredging for deep-water channels for shipping or for the purpose of building up adjacent low marshy areas for indus-

trial sites. They occur along tidal waterways in the northern part of the county. The dredged deposits are heterogeneous in character, ranging from sand to clay loam and are composed of raw, sedimentary, and, generally, very much stratified deposits.

Northwest of Pittsburg a small very sandy unstable body is being shifted about by the wind into dunes of various sizes. Bodies of made land have been built up along the shore line on either side of the town of Pittsburg, and others are north of Port Chicago and at Avon. In time the soil may have some value for grazing or for the growing of grain, but at present most of it is valued only as present or potential building and industrial sites.

Rough broken land.—Rough broken land embraces areas of steep and broken relief, in which the soil has restricted value even for forestry or grazing. Bedrock outcrops in many places, and the soil covering over rock everywhere is shallow. Erosion is more or less active. The land is so broken and irregular that livestock have difficulty in grazing, and the tree growth is scattered.

Rough broken land is mapped only on Rocky Ridge and Las Trampas Ridge in the southwestern part of the county and around the headwaters of Kellogg Creek in the eastern part. Other bodies of land of this character are included in mapping with some of the steep phases of the soil types.

None of the land is cultivated, nor is it likely to be in the future. The mountainous and hilly areas are partly timbered and partly open, and the more open areas afford fair grazing.

Rough stony land.—Stony and rough areas of shallow soil are mapped as rough stony land. This is distinguished from rough broken land by its greater content of stone which in most places is sufficient to make cultivation impossible, and the nonagricultural character of the land is emphasized by its steep and rough relief. The stone consists of loose stones and boulders lying on the surface and embedded in the shallow soil material or of ledges and outcrops of bedrock.

Land of this kind occurs only on Mount Diablo and in the Black Hills.

The soil is subject to erosion and has little potential value for agriculture, although there may be included a few small areas of more favorable relief and deeper soil covering, which are capable of some development in the future. Scattered oaks, used only for fuel, and brush cover the land which is of little value even for grazing.

Tidal marsh.—Land along the northern shore of the county, which is traversed by tidal sloughs and is wholly or in part subject to inundation at time of high tides, is classed as tidal marsh. Most of the soil material resembles Alviso clay, some of it is peaty, and the rest is stratified mucklike decomposed organic material and mineral soil.

Saline salts are highly concentrated in the soil and a salt-marsh vegetation, which has little potential value even for grazing, covers it. The expense of mapping these almost inaccessible areas in greater detail was unwarranted.

Areas of tidal marsh border Suisun Bay from Suisun Point eastward to Pittsburg, and they include Browns and Winter Islands northeast of that point. A few private toll roads lead to fishing grounds.

CLASSIFICATION OF SOIL TYPES ACCORDING TO PRODUCTIVITY

The soil types and phases of Contra Costa County have been rated on a percentage basis by means of the Storie index (*6*). This is obtained by evaluating such soil characteristics as depth, texture, chemical reaction, and density of the surface soil and subsoil, alkali content, drainage conditions, and slope. The most favorable or ideal soil conditions for plant growth are rated at 100 percent. The index rating is based solely on soil characteristics. The availability of irrigation water, rainfall, or other climatic conditions, distance from markets, and some other features, are not considered. The index, therefore, does not evaluate the land but rates the soils on their relative favorableness to the production of plants. Climatic conditions usually are reflected in the character of the soil itself, but minor variations in climate, which under California conditions frequently may determine the suitability of a particular location for special crops, rarely have an effect on the soil and are not recognized in this rating.

The index rating is given on a percentage basis in the third column of table 5.

TABLE 5.—*Classification of soils of Contra Costa County, Calif., arranged in descending order of their index rating*

Grade	Soil type	Index	Grade	Soil type	Index
		Percent			*Percent*
1	Yolo loam	100	3	Diablo adobe clay	46
	Brentwood sandy clay loam	100		Los Osos adobe clay	46
	Columbia loam	90		Altamont adobe clay	46
	Sorrento clay loam	90		Ambrose adobe clay	42
	Zamora loam	90		Manzanita gravelly clay loam	42
	Brentwood clay loam	85		Linne adobe clay	41
	Zamora clay loam	85		Tierra loam	38
	Botella clay loam	85		Cayucos adobe clay	38
	Danville clay loam	85		Hugo clay loam	36
	Dublin adobe clay loam	85		Contra Costa clay	36
	Clear Lake clay loam	85		Cayucos loam	35
	Salinas clay loam	81		Hugo clay	34
	Ryde clay loam	80		Nacimiento clay loam	34
	Egbert clay loam	80		Arnold sandy loam	33
	Peat [1]	80	4	Marcuse loam	32
2	Rincon clay loam	77		Corning gravelly clay loam	28
	Dublin adobe clay, overwash phase	77		Marcuse clay	24
	Cowell clay loam	70		Contra Costa sandy loam	23
	Sorrento clay	70		Los Osos clay loam, shallow phase	21
	Dublin adobe clay	63		Antone clay loam	21
	Brentwood clay	60		Altamont clay loam, steep phase	20
	Botella clay	60		Sobrante stony clay loam	20
3	Clear Lake adobe clay	56	5	Diablo adobe clay, steep phase	18
	Los Osos clay loam	55		Hugo clay, steep phase	15
	Altamont clay loam	55		Solano silty clay	15
	Rincon clay	54		Los Osos adobe clay, steep phase	14
	Oakley sand	54		Contra Costa clay, steep phase	14
	Antioch loam	54		Piper fine sandy loam	13
	Olcott loam	54		Made land	10
	Ambrose clay loam	51	6	Rough broken land	7
	Herdlyn loam	50		Alviso clay	6
	Sacramento adobe clay	50		Tidal marsh	6
	Montezuma adobe clay	49		Rough stony land	5
	Denverton adobe clay	49			
	Piper fine sandy loam, Egbert clay loam, and peat, undifferentiated	48			

[1] It should be understood that this rating refers only to peat in this county. In other areas where the material is coarser or the water table is not at a favorable depth, peat is not so desirable as it is here.

In addition to this rating, the soils have been grouped in six grades. Soils having an index rating ranging from 80 to 100 percent are placed in grade 1 and are considered to be of excellent quality, giving high yields, and suitable to a wide range of crops. Soils having an index rating from 60 to 79 percent are placed in grade 2. These soils are of good quality but for various reasons are less well suited to crop production than those in grade 1. Soils having an index rating between 40 and 59 percent are placed in grade 3. Their use is generally limited by extremes of texture, by variations in depth or density of certain profile horizons, or other soil factors. These soils are of fair quality only, except for occasional specialized crops. Soils having an index rating between 20 and 39 percent are placed in grade 4. These soils offer poor conditions for the growth of most crops. Some crops with special requirements, for instance, rice, might grow satisfactorily on some grade 4 soils perhaps better than on soils of a better grade; but in the main these soils are definitely poor and from the point of view of production of general farm crops, are considered by many farmers to be submarginal. Soils having an index rating between 10 and 19 percent are placed in grade 5 and in general are of very poor quality for any cultivated crop, owing to various unfavorable profile characteristics, shallowness, steeply sloping position, extremely coarse texture, or other soil factors. They are used mainly for pasture, and some areas are in brush or trees. Soils having an index rating of less than 10 percent are placed in grade 6 and are nonagricultural. They include rough stony land, tidal marsh, and badly eroded, gullied, and similar areas and are suitable only for pasturage, and this usually is of very poor quality. In the main these soils are covered with brush or trees and are of value only as a part of the watershed.

IRRIGATION AND DRAINAGE

In the eastern part of the county irrigation is essential for the successful production of many of the specialized crops grown. It is not so necessary in the western part where the rainfall is heavier, although many fields in Clayton and Ygnacio Valleys are irrigated by individual pumping units as the season or type of crop demands. In 1934, 437 farms reported the harvesting of crops from a total of 27,214 acres of irrigated land.

A number of irrigation districts organized in the eastern part of the county obtain water from various sloughs or distributaries of San Joaquin River. The Byron-Bethany irrigation district is reported to include 15,000 acres; the Brentwood irrigation district, 13,000 acres; the Lone Tree irrigation district, 2,100 acres; the Knightsen irrigation district, 10,000 acres; and the East Contra Costa irrigation district, 7,900 acres. The average cost per acre for maintenance and operation in 1929 was $4.63, and the average investment per acre for water in irrigation districts was $40.01.

In addition to the areas served by water pumped from the various sloughs or channels of San Joaquin River, water was pumped from 162 wells in 1930 for irrigation. Most of these wells were located in the central part of the county, particularly in the Clayton, Ygnacio, and San Ramon Valleys. Practically all the pumping equipment,

pumping water either from wells or from sloughs or channels, is electrically operated.

Over 90 percent of the delta land of San Joaquin River occurring in this county is reclaimed, and provision is made for irrigation. Water is obtained from the various sloughs or channels of San Joaquin River and carried over the levees by means of syphons. It is then conducted to the land in open ditches and distributed by means of shallow spud ditches between crop rows. The water table in the delta lands generally is at a depth of about 3 feet, and the application of irrigation water raises the water level to a point where drainage is essential. Deep, open drains are placed at intervals throughout the fields, and they empty into large deep drainage ditches from which the water is pumped when necessary back into the channels and sloughs.

Soils developed on the alluvial fans and plains, which are devoted to alfalfa, are irrigated by flooding between low borders that follow the natural slope of the fields, five or six times a season following harvest. Orchards generally are irrigated three or four times a season, depending on the crop and rainfall, by means of checks or basins, whereas land on which vegetables and melons are grown are frequently and lightly irrigated, generally by means of a furrow type of irrigation. The natural slope of the soils and the deep open ditches at the foot of the fan slopes provide drainage for the irrigated areas of the eastern part of the county.

ALKALI

Soil "alkali," in the commonly understood agricultural sense in this section, consists of an excess of soluble mineral salts in the soil. Most of the salts are, however, saline salts, incorrectly referred to as alkali salts, and in small quantities are not injurious to plants, and some of them are essential to plant growth. If soluble salts or minerals are present in sufficient quantity to increase the concentration of the soil solution beyond a certain point, however, most cultivated plants cannot take up plant nutrients in solution, and injury results. The injury resulting from a given quantity of soluble salts depends on a number of factors, such as the kind of salts present, the crop grown, climatic conditions, cultural practices, and the localization of the salts in the soil profile.

Sodium carbonate, or "black alkali," which is a true alkali, is the most injurious so-called alkali salt. Even a small quantity present in the soil generally results in injury to cultivated plants. In this county, salts of this character are found only rarely and in very small amounts.

The most common salt in the county is sodium chloride, or common salt. Sulphate salts, in combination with sodium, magnesium, or calcium are present in appreciable quantities in places and are generally regarded as less injurious to crops than is sodium chloride. Sodium bicarbonate also occurs in minor amounts, and this salt, under certain conditions, changes to sodium carbonate, or black alkali.

Some crops are much more tolerant of alkali than others. Of the cereal crops, barley, milo, and kafir are among the more tolerant. Sugar beets and asparagus also are tolerant of salts. Most legu-

minous crops are susceptible to injury by alkali and are not recommended for soils in which salt has accumulated, especially where it is localized in the upper part of the soil profile. Sweetclover, perhaps, is the most tolerant legume, although alfalfa will grow in soil containing an appreciable accumulation, if the salts are below the feeding zone of the plant roots during the seedling stage.

In cool moist weather crops are likely to grow more successfully on alkali soils than in hot dry weather when transpiration from the plants, evaporation, and the consequent concentration of salts in the surface soil proceeds at a rapid rate. It is the problem of the farm operator to keep the salts below the feeding zone of plant roots as much as possible, especially while the plants are in the seedling stage. A very low concentration of salts, if accumulated in the surface inch or two or soil, is much more injurious to crops than a much greater quantity of salts distributed throughout the soil profile or confined to the lower part of the subsoil.

In this county soils affected with salts are confined largely to land bordering the delta deposits of San Joaquin River and the tidal flats bordering the waterways in the northern part. These areas are indicated on the soil map. In mapping areas of alkali accumulation, soils in which the content of total salts averages 0.2 percent or more in the uppermost 6 feet, are recognized as having sufficient concentration of salt to be injurious to crops. The location of the soil samples taken to determine the salt concentration is shown by symbol on the accompanying soil map, and the analysis of total salts in air-dry soil is indicated in the form of a fraction, of which the numerator indicates the quantity of salts in the surface soil to a depth of 1 foot and the denominator the average concentration in the uppermost 6 feet of soil. Soils with an average of less than 0.2 percent of salts in the first 6 feet are regarded as free from salts in sufficient quantity to cause injury to most cultivated crops.

Two types of alkali-affected soils are shown on the soil map: Areas enclosed in broken red lines and lettered "A" in red are those in which the soil generally contains 0.2 percent or more of salts; and areas enclosed in broken red lines and lettered "S" in red are those in which the soils contain a variable and generally smaller quantity but sufficient in spots to cause injury to cultivated crops. Areas which are adjacent to or within alkali-affected areas, and in which the salt content is less than 0.2 percent, are indicated by the letter "F." In the areas indicated by the letter "S," the water table generally is high, and the salts, although of low average concentration for the uppermost 6 feet, are localized largely in the topmost inch or two of soil. Even in the areas indicated by the letter "A" the salt concentration in most places ranges from low to medium, although for the most part the soils are poorly drained, resulting in a concentration of salts in the surface soil, rendering their utilization more difficult. Some of the soils of the Antone series, although not indicated as containing injurious quantities of salts, are accompanied by sufficient salts and unfavorable structural characteristics to render them of low agricultural value.

In seasons of light rainfall the run-off in summer from the drainage basins of Sacramento and San Joaquin Rivers is not sufficient to prevent the salty or brackish waters of the bays from backing

up into the lower channels and distributaries of the rivers. Inundation of the tidal flats and the use of brackish waters for irrigation leave varying quantities of sodium chloride and other salts in the soil. Under existing conditions this situation is beyond control, and the reclamation of such areas is dependent on obtaining a supply of fresh water with which to leach the salts from the soils. Even if fresh water were available, the removal of the salts would be a very slow process, largely because the high water table prevents thorough flushing of the soil. The permeability of the organic soils, on the other hand, is a favorable factor, since water would move rapidly through them. The reclamation of mineral soil is largely dependent on good drainage, for, without it, sufficient water cannot be moved through the soil to leach it of soluble salts. Poor drainage is also conducive to the evaporation of moisture from the surface soil, and this increases the concentration of salts. Plowing under cover crops promotes internal drainage by increasing the content of organic matter. In this county, most areas of salt-affected soils would be very difficult and expensive to reclaim, owing to the prohibitive cost of providing adequate drainage under existing economic conditions.

Results of laboratory determinations showing the quantity and chemical character of salts in a few representative samples of salt-affected soils are given in table 6.

TABLE 6.—*Salt content of samples of soils from Contra Costa County, Calif.*

Sample No	Location	Vegetation and character of land	Kind of soil	Horizon	CO_3	HCO_3	Cl	Effervescence with HCL	Ca	SO_4	Na [1]	Total salts	Average in 6-foot section
					Parts per million	*Parts per million*	*Parts per million*		*Parts per million*	*Parts per million*	*Parts per million*	*Percent*	*Percent*
1	2½ miles southeast of Byron Hot Springs.	Saltgrass, occasional clumps of pickleweed.	Loam	A	1.2	35.4	810	None		200	250	0.25	0.20
			Clay	B		17.08	410	Vigorous		(2)	100	.14	
			Clay loam	C		39.1	110	Slight		160	50		
2	1½ miles southeast of Byron Hot Springs	Spots of milo and pickleweed.	Loam	A		17.08	4,480	do	1,000	300	1,000	1.00	1.49
			Clay loam	B		14.64	5,280	do	4,000	600	1,000	.96	
			do	C		12.2	10,460	None	850	600	1,000	2.50	
3	2¾ miles southeast of Byron Hot Springs	Bare spots, pickleweed, salt sage.	Clay	A		2.44	3,150	do	8,500	700	1,000	.88	.86
			do	B		7.32	810	do	2,000	300	1,000	1.16	
			do	C		7.32	930	do	800	800	500	.55	
4	¾ mile east of Byron Hot Springs.	Greasewood, bare spots.	Loam	A		17.08	7,480	do	8,000	(2)	1,000	1.16	1.16
			Clay	B		12.2	7,480	Strong	800	(2)	1,000	1.18	
			do	C		12.2	5,410	Vigorous	700	(2)	500	1.14	
5	1½ miles east of Byron	do	Loam	A		51.3	2,650	None	300	4,000	500	.60	.78
			Clay	B		24.4	2,770	do	2,000	10,000	800	.95	
			Clay loam	C		75.6	585	Slight		2,000	500		
6	2 miles northeast of Byron.	Greasewood and pickleweed.	Clay	A		34.2	160	None		(2)	50	.075	.34
			do	B		26.9	1,470	Slight	(2)	800	500	.60	
			Silty clay loam	C		53.6	1,070	do	(2)	1,250	500		
7	1¼ miles east of Knightsen.	Saltgrass	Clay	A		26.9	520	None		300	200	.225	.44
			do	B	4.8	31.8	540	do		700	250	.775	
			do	C	4.8	29.3	180	do		1,500	75	.31	
8	1 mile east of Iron House School	Asparagus. Slight evidence of alkali.	do	A		24.4	870	Strong		750	100	.36	.24
			do	B		12.2	250	do		300	50	.18	
			do	C		29.3	460	Vigorous			50	.18	
9	South-central part of Bethel tract.	No evidence of alkali grass.	Loamy sand	A		51.3	60	Slight	(2)		(2)	.02	.02
			Sand	B		29.3	30	Vigorous			(2)	.02	
			do	C	2.4	217.16	40	do			(2)	.02	

[1] Sodium (Na) readings determined only to 1,000 parts per million; many above this amount.
[2] Trace.

MORPHOLOGY AND GENESIS OF SOILS

Contra Costa County lies in and adjacent to the coast ranges of west-central California. The climate is characterized by cool moist winters and warm dry summers. The native grasses begin to grow with the first fall rains and make a good growth during the fall, early winter, and spring. By the middle of May the rains cease, and normally less than 1 inch of rain falls between the middle of May and late October. Under such conditions the grass withers, and its growth ceases.

The amount of rainfall varies widely in different parts of the county, and the areas having the higher rainfall are favored with summer fogs or by cooler and moister winds than the areas having less rainfall. These climatic conditions are reflected in soil development. The moisture to which the soils are subject is determined largely by local relief and proximity to the coast. The moisture-bearing winds invariably blow inland in an easterly direction from the ocean, and, in passing over the higher hills in the western part of the county, the greater part of the moisture is lost. Mount Diablo is favored by a moderately good rainfall, but east of this mountain there is a very marked rain shadow where the precipitation probably is only about one-fifth of that in the western valleys. This rain shadow continues over the valley lands of the eastern part, although in no place is it so marked as in the section south of Byron.

In the western and northwestern parts of the county where the rainfall is heaviest, summer fogs are frequent, and the humidity is greatest, the soils have a high content of organic matter and are dark colored. In the eastern part where the rainfall is light and the air is hot and dry during the summer, the soils have a lower content of organic matter and are predominantly lighter in color.

Important chemical as well as physical changes are brought about in the soils by environmental factors. The higher humidity and rainfall of the western part of the county produces a greater leaching of the soils. Under such conditions, the more readily soluble mineral compounds are largely leached from the soils which have the characteristics of pedalferic soils (*4*). In the drier eastern part of the county, leaching is not so pronounced and the soils are largely pedocalic (*4*). Figure 2 presents a sketch map of the county showing the distribution of the pedocalic and pedalferic soils with further differentiation of the pedocalic soils into darker colored and lighter colored pedocalic soils. As might be expected, the darker colored pedocalic soils are developed largely adjacent to the pedalferic soils, and the lighter colored pedocalic soils are developed in the section of least rainfall. For reasons which will be discussed later, the lighter colored and darker colored pedalferic soils occur together throughout the section of heaviest rainfall. The differences in physical and chemical character betwen the lighter colored and the darker colored pedocalic soils will be shown also in the subsequent discussion.

The area of pedalferic soils extending southeast from Antioch is composed, for the most part, of very sandy soils on which a light rainfall acting on an open permeable soil material has effectively leached the free lime carbonate. Included in this area, however, is a small body of generally shallow soil developed in place largely from

rocks containing no free lime carbonate, although lime is present in the lower part of the subsoil of a few spots within this body.

Within the areas of pedocalic and pedalferic soils as shown on the sketch map are intrazonal and other soils that are not typical of these groups. The organic and associated soils of the San Joaquin River delta section are of distinct hydromorphic development. Other variations from typical are inextensive and unimportant. Included with the pedalferic soils are small areas of calcareous soils in the valley bottoms, which have been developed under conditions of poor drainage, and the drainage waters have their source in soils high in lime. Other soils of the county are young and have not developed a profile characteristic of the general region.

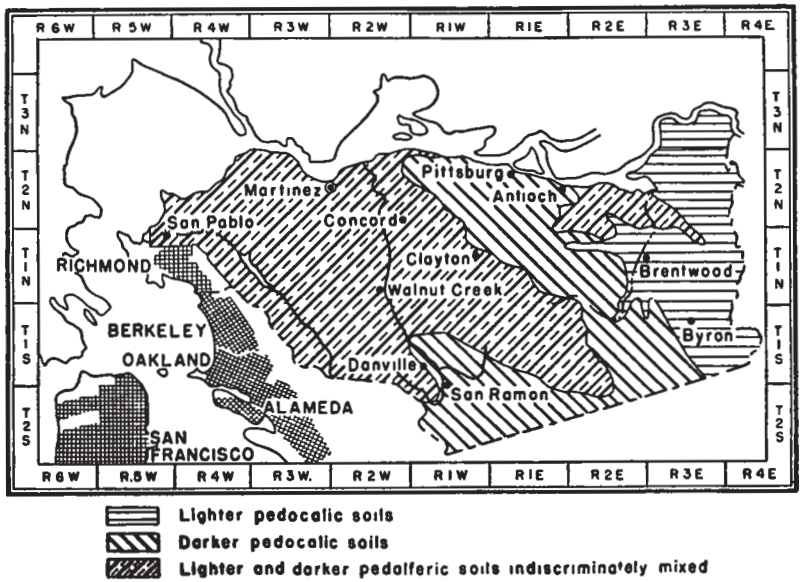


FIGURE 2.—Sketch map showing distribution of soil groups in climatic zones in Contra Costa County, Calif.

The lighter colored and darker colored pedalferic soils owe their difference in color largely to the differences in character of the parent materials and in the texture of the soil so far as it affects the ability of the soil to retain organic matter or humus. In general, the soils developed on parent materials containing lime are darker colored than those developed from parent materials without lime, even though free lime carbonate is completely leached from the soil profile. In some instances the sandy soils are unable to retain organic matter.

Differences in physical and chemical character between the lighter colored and the darker colored pedocalic soils are marked in this county. The pedocalic soils adjacent to the pedalferic soils in the sections of heavier rainfall have accumulated lime at greater depths in the subsoil, and the surface soils generally are less granular and are characterized by an abundance of worm casts. The surface soils of the soils developed on bedrock substrata are leached of lime,

whereas in the drier sections of the eastern part the soils developed on the same type of highly calcareous rocks contain lime in both the surface soil and subsoil. Many of the lighter colored pedocalic soils in the extreme eastern and southeastern parts contain appreciable quantities of saline salts.

A fuller discussion of the color, profile development, chemical characteristics (so far as they can be determined in the field), environmental factors, relationships, and detailed profile descriptions of representative normally developed pedalferic and pedocalic soils follows:

Nacimiento clay loam and Linne adobe clay are developed only in the rain shadow area of Mount Diablo in the southeastern part of the county. Both soils have calcareous surface soils and subsoils and represent immature stages in development, owing largely to erosion. The principal difference between them lies in the darker color of the Linne soil. The members of these two series are developed under a lighter rainfall than are those of the Diablo and Altamont series. Although the parent materials of the Diablo soils are calcareous and similar to those of the Linne or Nacimiento soils, the heavier rainfall which they receive has entirely leached the free lime carbonate from their surface soils. Variations in color occur in the soils of the Diablo series similar to those represented by the Linne and Nacimiento soils but are less pronounced and consistent. The surface soils of members of the Altamont series likewise are leached of lime, and their subsoil is less consistently and less highly calcareous than that of the Diablo soils. Their color is also much browner and lighter than that of the Diablo soils.

Antioch loam and the associated surrounding soils belong to the darker colored pedocalic group. They apparently represent a type of soil development with a solonetzlike profile (pl. 2, *B*). Olcott loam has a profile similar to that of the Antioch soil, but it contains no free lime carbonate.

Brentwood clay loam, Brentwood sandy clay loam, and Brentwood clay show normal development under conditions of light rainfall. They are similar in origin and profile characteristics to the soils of the Rincon series but are of lighter and richer brown color. They also correspond in origin as well as in stage of development, to the soils of the Zamora series in the group of pedalferic soils. The members of the Zamora and Botella series are leached of lime and are decidedly darker.

The soils of the Sorrento series represent the more arid equivalent of the Yolo soils. Their subsoil effervesces in dilute acid, whereas that of the Yolo soils typically does not. Both the Sorrento and Yolo are, however, young alluvial soils with undeveloped profiles, and it is believed the Yolo material will develop into a pedocalic soil.

Herdlyn loam and Solano silty clay, in the pedocalic group, are abnormally developed soils with solonetzlike profiles. They differ one from the other largely in the matter of color. The Herdlyn soil is generally light brown, whereas the Solano soil is more gray. The development of the solonetzlike type of profile is irregular in both soils.

Antone clay loam occurs generally, although not entirely, in the region of pedalferic soils. It is dark gray, and exposed profiles pre-

sent a peculiar deflocculated stuccolike appearance. It contains some salts and has developed under restricted drainage.

The Montezuma, Ambrose, and Salinas soils occur very largely in the region of dark-colored pedocalic soils. Montezuma adobe clay, especially, is very dark gray or black. Ambrose clay loam and Ambrose adobe clay are dark-brown soils that may represent a further stage in development of soils of the Rincon series. Salinas clay loam is dull brown and is youthful, although it represents an advanced stage in development of the Sorrento soils.

Clear Lake adobe clay and Clear Lake clay loam are dark gray or black and are poorly drained. They occur in the region of dark-colored pedocalic soils as well as in the region of pedalferic soils.

Sacramento adobe clay has developed under restricted drainage and periodical overflow, is dark colored, and borders the organic soils of the river delta and the light-colored soils of the pedocalic group.

Contra Costa sandy loam, Contra Costa clay, and Arnold sandy loam contain no free lime but are associated with soils of the pedocalic group. The Contra Costa soils are reddish brown, whereas the Arnold soil is gray. Table 7 shows the results of mechanical analyses of the surface soil and subsoil of Contra Costa clay.

TABLE 7.—*Mechanical analyses of Contra Costa clay in Contra Costa County, Calif.*

Sample No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
578438	Surface soil, 0 to 8 inches	0.1	0.4	1.2	19.0	14.0	29.6	35.7
578439	Subsoil, 8 to 30 inches	0	.2	.8	17.9	13.7	29.6	37.8

Los Osos clay loam and Los Osos adobe clay are similar in color and origin to the Altamont soils, but all free lime carbonate has been leached from their subsoils. Hugo clay loam and Hugo clay are differentiated from the Los Osos soils because of their gray-brown color.

Manzanita gravelly clay loam and Corning gravelly clay loam do not differ greatly, except that the surface soil of the former is thicker and more friable and it is developed on materials largely derived from basic rock, whereas the parent material of the Corning soil is derived, to greater extent, from acid rock. The Corning soil, although pedalferic, is associated with the pedocalic group in Contra Costa County.

Oakley sand is very sandy and, although it occurs only in the drier eastern pedocalic region, it is entirely leached of lime.

Columbia loam, Ryde clay loam, Egbert clay loam, and peat contain no lime. They occur on the delta lands. The Ryde and Egbert soils and peat are hydromorphous and highly organic. The Columbia soil consists of readily leached recent alluvial sediments, and the parent material contains little lime.

Cayucos loam and Cayucos adobe clay are dark colored and probably represent a more leached development of the soils of the Diablo series. In addition to large typical areas in the pedalferic region,

a small area of these soils is associated with the pedocalic soils. In the latter situation the soil mantle over bedrock is generally shallow.

Tierra loam represents another solonetzlike soil development and it is darker than the Antioch, Olcott, Herdlyn, or Solano soils.

Dublin adobe clay and Dublin adobe clay loam represent a pedalferic counterpart of the Clear Lake soils.

The following detailed description of a profile of Brentwood clay loam is representative of the pedocalic group:

A_1. 0 to three-fourths inch, fine-granular grayish-brown light clay loam with a reddish cast, containing partly oxidized organic residues.

A_2. Three-fourths inch to 11 inches, firm brown clay loam with a somewhat red cast. The material breaks into coarse clods that crumble under slight pressure to a fine-granular structure. It is interlaced with fine root cavities slightly coated with light gray on the inside, owing largely to molds. Insect burrows are more numerous than animal burrows, but evidence of activity by earthworms is not marked. The transition to the underlying layer is gradual.

B_1. 11 to 45 inches, dull-brown or dark-brown moderately compact clay loam which breaks into coarse irregularly shaped clods with sharp angles. Under moderate pressure these break into medium-sized irregularly shaped clods along structural parting planes. The structural particles are coated with dull-brown or dark-brown colloids that penetrate the structural units but slightly. When crushed, the material is decidedly lighter in color. Root cavities are numerous in this horizon but not so numerous as in the surface soil. The cavities are coated with dark-brown colloids, and many of them contain partly decayed plant remains. This material gives way abruptly to the lower subsoil horizon.

B_2. 45 to 72 inches, light-brown friable calcareous clay loam which breaks into soft lumps that are easily reduced to a fine-granular structure. No colloidal staining is apparent in the material, and root cavities are few. The lime is disseminated but has a slight tendency toward segregation in root cavities and partings in the soil. The gray segregated lime gives the impression of a mycelial growth.

Zamora clay loam occurs in the western subhumid part of the county where the soils are largely pedalferic, and the following description of a profile is representative of the soils of that group:

A_1. 0 to 1 inch, medium-granular dull grayish-brown heavy loam. Grass roots are very numerous, and the soil shakes from the roots in medium-sized granules. Organic matter is fairly well decomposed, and worm casts are numerous. This material changes gradually into the subsurface layer.

A_2. 1 to 14 inches, firm dull-brown or dark-brown clay loam which breaks into soft irregularly sized clods that crumble readily to a medium-granular structure under slight pressure. Root cavities are very numerous, and worm casts are particularly noticeable. Some dark-brown colloidal staining is present in the root cavities and on structural units in the lower part of this horizon. The surface soil grades imperceptibly into the upper subsoil layer.

B. 14 to 48 inches, dark grayish-brown moderately compact heavy clay loam. The material of this horizon breaks along imperfectly defined jointing planes into coarse irregularly shaped clods that generally have their longer axis in the perpendicular plane. The clods break under moderate pressure into small or medium-sized lumps along the faces, rather than across the structural aggregates. The outsides of structural units and the insides of root cavities are coated with a very dark brown colloidal deposition. The colloids penetrate the structural units slightly, but, when crushed in the fingers, these assume a lighter shade. Root cavities are numerous in this horizon, but worm casts, although plentiful, are fewer than in the overlying material. Few or no insect burrows are present. The subsoil changes abruptly to the lower subsoil layer.

C. 48 to 72 inches, light grayish-brown noncalcareous slightly compact clay loam. The material of this horizon is comparatively friable and reduces readily to a granular structure. Little or no colloidal staining is evident. The few root cavities that occur are generally coated or filled with light brownish-gray silty material.

LABORATORY STUDIES [7]

Mechanical analyses of all the samples of surface soils were made by a proximate method in which the air-dried soils were screened through a 2-millimeter sieve, the lumps being crushed and the particles coarser than 2 millimeters rubbed relatively clean. The screened soil was shaken in distilled water with sodium oxalate as a dispersant, then washed through a 300-mesh sieve to remove the sands, which are reported as total sands. The silt and clay suspension which passed through the sieve was made up to volume, allowed to stand, and sampled by the pipette at the proper time intervals to give effective maximum diameters of silt at 50 microns, clay at 2 microns, and colloid at 1 micron. The results of these analyses are not published as they were used only to check the field textural classification.

The samples from 13 soil profiles were analyzed by the more complete dispersal method whereby the soil was pretreated with hydrogen peroxide and hydrochloric acid to remove organic matter and carbonates, the subsequent manipulation being essentially the same as that just described. The results of these analyses are given in table 8.

TABLE 8.—*Mechanical analyses of samples of typical profiles of several soils from Contra Costa County, Calif.*

Soil type and sample No.	Depth	Fine gravel (2–1 mm)	Coarse sand (1–0.5 mm)	Medium sand (0.5–0.25 mm)	Fine sand (0.25–0.1 mm)	Very fine sand (0.1–0.05 mm)	Silt (0.05–0.005 mm)	Clay (0.005–0.001 mm)	Colloid (<0.001 mm)
Piper fine sandy loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
578401	0–4	0.27	1.75	11.07	61.59	7.33	6.97	4.44	6.00
578402	4–25	.04	3.57	10.84	65.73	10.14	3.03	1.26	4.27
578403	25–72	.11	1.39	8.90	70.03	11.89	2.12	.70	4.78
Oakley sand:									
578404	0–12	.80	13.32	11.69	45.52	17.70	4.60	.87	4.60
578405	12–47	.54	5.69	12.42	49.57	16.91	7.16	1.16	5.95
578406	47–72	.69	12.46	12.21	44.15	17.53	5.24	.11	5.49
Brentwood clay loam:									
578428	0–10	.10	1.25	1.74	15.79	18.85	29.00	11.89	21.40
578429	10–44	.11	.51	2.09	19.17	16.73	29.14	10.79	21.23
578430	44–72	.09	.95	1.50	18.78	22.67	27.45	10.10	18.78
Linne adobe clay:									
578431	0–11	.08	1.03	2.95	5.82	4.58	18.72	22.88	44.11
578432	11–42	.54	.60	.80	1.10	2.15	17.89	27.71	50.07
Ambrose clay loam:									
578462	0–9	.05	.47	1.88	8.21	14.58	43.44	7.47	23.26
578463	9–40	.06	.90	1.29	5.95	13.23	34.49	9.27	34.27
578464	40–72	.23	1.01	2.51	19.19	12.27	29.04	8.68	26.24
Antioch loam:									
578475	0–20	.35	1.73	5.85	20.40	17.55	34.86	5.96	14.26
578476	20–38	.37	1.96	3.73	17.58	12.70	21.62	6.68	36.85
578477	38–72	.02	.39	2.21	9.41	11.20	29.19	10.96	38.14
Altamont clay loam:									
578482	0–9	.13	2.62	4.15	20.23	18.87	25.59	7.46	22.08
578483	9–24	.08	.89	5.03	20.71	13.68	26.51	8.94	25.49
578484	24–34	.03	1.97	3.89	18.17	17.61	24.08	9.30	25.42
Cayucos loam:									
578490	0–8	.60	1.35	4.16	26.82	19.62	25.76	7.10	14.03
578491	8–27	.48	1.76	2.86	19.98	18.21	18.85	6.56	32.05

[7] This section was prepared by C. F. Shaw, head, division of soil technology, department of agronomy, University of California.

TABLE 8.—*Mechanical analyses of samples of typical profiles of several soils from Contra Costa County, Calif.*—Continued

Soil type and sample No.	Depth	Fine gravel (2–1 mm)	Coarse sand (1–0 5 mm)	Medium sand (0.5–0.25 mm)	Fine sand (0 25–0.1 mm)	Very fine sand (0.1–0 05 mm)	Silt (0.05–0.005 mm)	Clay (0.005–0 001 mm)	Colloid (<0 001 mm)
Olcott loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
578494	0–10	.43	3.31	3 37	20 13	28.69	26 66	5.27	11 80
578495	10–24	.74	3.12	4.00	22.17	23 42	27 86	5 40	12 47
578496	24–32	.59	3.29	3.46	16.51	16 90	18 10	5 35	36 36
578497	32–40	.11	1.40	3 86	18.84	14 78	25.43	4.80	30.68
578498	40–72	.43	4.97	4.31	22.97	19 70	21.90	6.56	18.57
Zamora clay loam:									
5784101	0–12	.16	.76	1.26	15.81	23.55	28.59	11.24	19.15
5784102	12–40	.40	.70	2.56	15.93	14 16	31 00	10.86	23 46
5784103	40–72	.47	1.27	1.80	11.52	14.32	33 05	11.52	24.53
Los Osos clay loam:									
5784112	0– 9					[1] 47.45	29 49	6.86	17 61
5784113	9–24	.54	3.10	3.60	16.55	18 93	28.46	6.88	21.56
Diablo adobe clay:									
5784122	0–10	.80	4 64	2 97	8 69	4.97	19.31	12 97	46.48
5784123	10–36	1.79	3.37	2.63	6.56	5.33	18.14	12.68	49.02
Hugo clay:									
5784142	0–10	.07	.75	2.15	10 78	8.71	42.07	16 39	18.27
5784143	10–35	.03	.32	.94	10.76	12.54	31 28	12.97	30.60

[1] Total sand.

A comparison of the results obtained by this complete dispersion method and the proximate method showed very minor differences, and in no instance would they change the textural classification of the soil. Usually the amount of clay was from 1 to 3 percent lower by the proximate method, whereas the amount of silt varied, sometimes being slightly lower and at other times slightly higher.

The proximate mechanical analyses of the surface soils, as a general rule, showed texture heavier than the original field classification. With the pedocalic soils nearly all of the analyses indicated the texture one grade finer than the field classification, whereas one-half of the analyses of pedalferic soils agreed with the field designation. The interpretation of mechanical analyses was based on dispersion with ammonia, which is not so complete as dispersion with sodium oxalate, and with the pedalferic soils it is probable that the older method of analysis would have agreed with the field textures. The presence of lime in pedocalic soils tends to mask the content of clay and, in field examinations, gives an impression of a coarser texture than mechanical analyses indicate. This is borne out also by the moisture equivalents, which in many instances indicate a texture heavier than that ascribed by the field men.

The analyses of the 13 profiles bring out certain features indicating the progressive stages in profile development of some of these soils. The Cayucos, Diablo, and Linne soils represent three stages in leaching, which essentially are responses to climatic environment. The Cayucos soil shows a very high concentration of clay in the subsoil, as compared with the surface soil. Although the content of clay in the subsoils of the Diablo and Linne soils is higher than that of their surface soils, it is less than that of the Cayucos soil. This same relationship exists between the noncalcareous Hugo soils and the Altamont soils which have calcareous subsoils. The clay content of the subsoils of the Hugo soils is nearly double that of their surface soils, whereas the clay content of the subsoils of the Altamont soils is not

markedly higher than that of their surface soils. The Ambrose and Antioch soils probably represent two stages in development. The accumulation of colloidal clay in the Ambrose subsoil is about 50 percent higher than that in the surface soil, whereas the Antioch subsoil contains two and one-half times as much colloidal clay as does the surface soil, indicating that the Antioch soil is a much older soil than the Ambrose soil. The Olcott soil, which has reached practically the same stage of development as the Antioch soil, has three times as much colloidal clay in the subsoil as in the surface soil, and the Zamora soils, which are younger, have only about 50 percent more. The Brentwood soils show their youthfulness by the even distribution of colloidal clay throughout the profile.

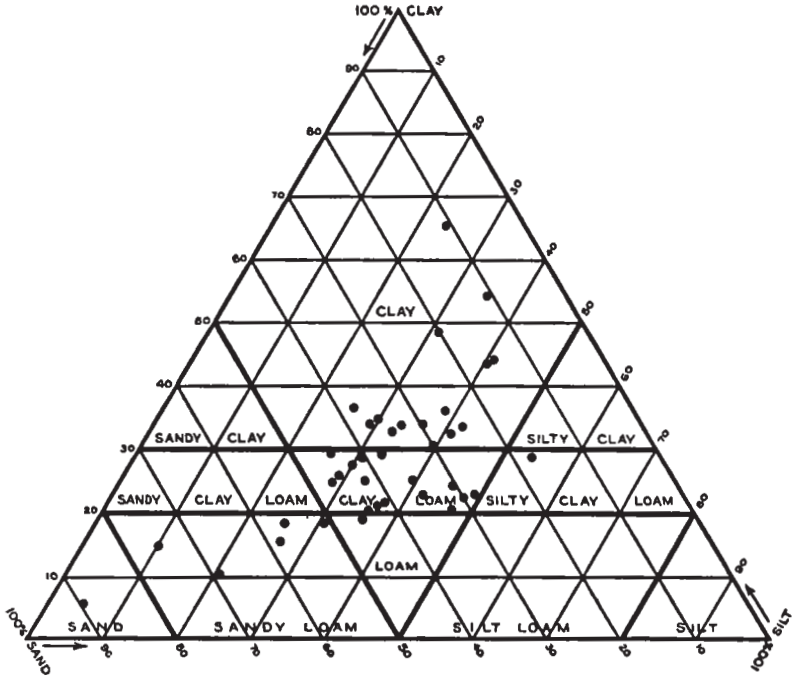


FIGURE 3.—Diagram showing the texture and physical composition of the surface soils of the soils of Contra Costa County, Calif. Clay loams and light clays predominate.

The average soils of this county have medium heavy textured surface soils. The larger proportion of the pedocalic soils are heavy textured, with a large number of clays, whereas the pedalferic soils have fewer clays and larger numbers of clay loams and sandy loams. This distribution is indicated by the triangular diagram (fig. 3).

The moisture equivalents were determined by the standard method in which 30 grams of saturated soil are subjected to a force of 1,000 times gravity in a centrifuge. The moisture equivalents are reported in percentage of moisture calculated on the basis of oven-dry soil. They represent approximately the normal field moisture capacity, or the amount of water held in a soil after a heavy rain or irrigation, where downward drainage is free and uninterrupted. The results,

together with pH determinations, are shown in table 9, and the textures do not deviate from the usual textures.

TABLE 9.—*Moisture-equivalent and pH determinations of samples of typical soil profiles from Contra Costa County, Calif.*

Soil type and sample No.	Depth	Moisture equivalent	pH
Piper fine sandy loam:	*Inches*	*Percent*	
578401	0–4	21.04	7.2
578402	4–25	13.03	8.6
578403	25–72	7.50	8.6
Oakley sand:			
578404	0–12	3.84	7.0
578405	12–47	4.85	6.8
578406	47–72	4.70	6.8
Ryde clay loam:			
578407	0–23	50.95	6.2
578408	23–72	-------	-----
Columbia loam:			
578409	0–12	25.03	7.0
578410	12–72	-------	6.6
Herdlyn loam:			
578411	0–7	16.64	6.4
578412	7–19	37.46	7.0
578413	19–42	38.76	8.6
578414	42–72	47.81	8.6
Solano silty clay:			
578415	0–6	25.86	6.6
578416	6–15	42.51	7.0
578417	15–38	48.74	8.6
578418	38–72	36.86	8.6
Marcuse clay:			
578419	0–20	37.53	8.6
578420	20–72	41.50	8.6
Sacramento adobe clay:			
578421	0–10	44.19	6.6
578422	10–45	44.78	6.8
578423	45–72	30.72	8.6
Egbert clay loam:			
578424	0–24	70.50	5.8
578425	24–72	-------	-----
Peat:			
578426	0–20	-------	4.8
578427	20–72	-------	4.4
Brentwood clay loam:			
578428	0–10	21.80	6.8
578429	10–44	21.22	7.0
578430	44–72	20.69	8.4
Linne adobe clay:			
578431	0–11	40.42	8.6
578432	11–42	46.92	8.6
Contra Costa sandy loam:			
578433	0–9	8.77	6.6
578434	9–29	9.25	6.8
Altamont adobe clay:			
578435	0–6	35.51	6.8
578436	6–25	35.92	6.8
578437	25–30	32.07	6.6
Contra Costa clay:			
578438	0–8	21.99	6.4
578439	8–30	21.81	6.6
Nacimiento clay loam:			
578440	0–7	23.34	8.0
578441	7–22	23.52	8.6
Corning gravelly clay loam:			
578442	0–12	16.19	6.6
578443	12+	21.15	6.8
Sorrento clay loam:			
578444	0–20	21.84	7.0
578445	20–72	-------	-----
Brentwood clay:			
578446	0–9	26.76	7.0
578447	9–36	28.90	7.8
578448	36–54	27.88	7.0
578449	54–72	26.39	7.2
Rincon clay:			
578450	0–10	31.45	6.8
578451	10–32	44.31	7.0
578452	32–72	40.63	8.6
Rincon clay loam:	*Inches*	*Percent*	
578453	0–10	22.99	6.6
578454	10–34	27.12	7.0
578455	34–72	25.12	8.6
Sorrento clay:			
578456	0–12	26.30	6.8
578457	12–40	26.14	7.8
578458	40–72	-------	-----
Zamora loam:			
578459	0–12	19.15	7.0
578460	12–40	20.25	6.6
578461	40–72	19.68	6.8
Ambrose clay loam:			
578462	0–9	22.12	6.4
578463	9–40	28.50	6.6
578464	40–72	28.56	8.6
Ambrose adobe clay:			
578465	0–10	24.95	6.4
578466	10–36	28.84	6.6
578467	36–72	24.88	8.2
Manzanita gravelly clay loam:			
578471	0–8	24.86	6.6
578472	8–24	22.61	6.8
578473	24–50	30.08	6.8
578474	50–70	29.39	6.8
Antioch loam:			
578475	0–20	15.88	5.6
578476	20–38	29.65	7.6
578477	38–72	26.92	8.2
Montezuma adobe clay:			
578478	0–10	27.33	6.4
578479	10–31	29.99	8.2
578480	31–45	27.43	8.6
578481	45–72	22.54	8.6
Altamont clay loam:			
578482	0–9	25.20	7.0
578483	9–24	24.15	7.0
578484	24–34	25.13	7.2
Cowell clay loam:			
578485	0–10	25.68	6.8
578486	10–46	27.90	6.6
578487	46–72	25.12	7.0
Marcuse loam:			
578488	0–10	17.26	8.0
578489	10–72	-------	-----
Cayucos loam:			
578490	0–8	16.62	5.4
578491	8–27	29.32	6.4
Hugo clay loam:			
578492	0–7	18.53	5.4
578493	7–20	18.53	5.4
Olcott loam:			
578494	0–10	14.39	5.8
578495	10–24	14.06	6.0
578496	24–32	30.00	6.0
578497	32–40	35.99	6.2
578498	40–72	21.89	6.4
Danville clay loam:			
578499	0–20	23.42	6.8
5784100	20–72	-------	-----
Zamora clay loam:			
5784101	0–12	21.39	7.0
5784102	12–40	22.87	7.4
5784103	40–72	24.78	7.4
Botella clay:			
5784104	0–12	26.53	6.2
5784105	12–45	28.23	6.4
5784106	45–72	28.68	6.6
Clear Lake adobe clay:			
5784107	0–12	27.55	6.2
5784108	12–36	47.77	8.0

TABLE 9.—*Moisture-equivalent and pH determinations of samples of typical soil profiles from Contra Costa County, Calif.*—Continued

Soil type and sample No.	Depth	Moisture equivalent	pH
Clear Lake abode clay—Continued	*Inches*	*Percent*	
5784109	36–72	39.34	8.2
Sobrante stony clay loam:			
5784110	0–12	23.55	6.8
5784111	12–30	21.28	6.4
Los Osos clay loam:			
5784112	0–9	21.26	6.4
5784113	9–24	23.61	6.4
Antone clay loam:			
5784117	0–7	39.28	7.8
5784118	7–15	79.50	8.6
5784119	15–34	87.92	8.6
5784120	34–48	99.10	8.6
5784121	48–72	61.12	8.6
Diablo adobe clay:			
5784122	0–10	33.87	8.0
5784123	10–36	39.26	8.6
Salinas clay loam:			
5784127	0–12	24.33	6.6
5784128	12–42	26.92	7.0
5784129	42–72	24.06	8.4
Botella clay loam:			
5784130	0–10	20.09	7.2
5784131	10–44	21.83	6.6
5784132	44–72	21.98	6.6
Los Osos adobe clay:			
5784135	0–9	27.18	6.0
5784136	9–34	29.30	6.2
Yolo loam:			
5784137	0–12	19.46	6.6
5784138	12–72	-----	-----
Arnold sandy loam:			
5784139	0–10	14.69	5.6
5784140	10–22	15.86	5.8
5784141	22–36	26.30	6.2
Hugo clay			
5784142	0–10	23.81	5.6
5784143	10–35	30.37	6.2
Tierra loam:			
5784144	0–18	19.63	6.2
5784145	18–45	37.47	6.6
5784146	45–72	28.78	6.8
Dublin adobe clay:			
5784147	0–20	31.26	6.2
5784148	20–72	33.20	6.2
Cayucos adobe clay.			
5784149	0–9	32.43	6.2
5784150	9–32	41.65	6.4
Alviso clay:			
5784151	0–12	59.52	7.0
5784152	12–72	-----	-----

The reaction of all the samples was determined by the colorimetric method which errs somewhat toward neutrality, tending to indicate that the acid soils are somewhat less acid and the basic soils somewhat less basic than is the case when the direct electrometric measurement is used. The distribution of acid and basic soils is discussed in the preceding section on Morphology and Genesis of Soils. In general, the soils of the western part of the county, which receive higher rainfall, are more acid, whereas the soils east and southeast of Mount Diablo, that is, in its rain shadow, are basic, not only in their subsoils but also in their surface soils.

SUMMARY

Contra Costa County is in the west-central part of California, just east of San Francisco Bay and south of San Pablo and Suisun Bays and associated tidal waterways, through which drainage waters of San Joaquin and Sacramento Rivers reach the Pacific Ocean. The county embraces 728 square miles, or 465,920 acres.

In the eastern part, alluvial-fan deposits and a part of the delta lands of San Joaquin River form a comparatively broad valley plain which in its northern part is occupied by a sand-hill area. A comparatively small valley in the central part of the county extends in a north-south direction and divides the county into two parts. Except for minor stream valleys and coastal-plain terraces, the rest of the land is hilly and mountainous.

Mount Diablo is the highest point in the county, and it is a prominent landmark and physiographic feature of this part of Cali-

fornia. This is the culminating point in the mountain block forming the central part of the county and has an elevation of 3,849 feet.

The first permanent settlement was made in 1823 with the issue of the first Spanish land grants. Since that time all the public lands have been placed in private ownership. The population of the county at the time of the 1930 census was 78,608, of whom slightly more than 55 percent lived in towns or cities of over 2,500 population.

The most thickly settled rural districts are in the Clayton, Ygnacio, and San Ramon Valleys. The valley plain in the eastern part also is rather thickly settled. Martinez is the county seat and one of the larger towns with a population of 6,569 at the time of the 1930 census. Numerous other towns afford trading and educational facilities and provide for the social and religious welfare of the surrounding districts.

The county has both water and rail transportation, as well as many paved and graveled roads.

The climate is mild, with no wide extremes of either heat or cold. Occasionally the temperature in the eastern part may exceed 100° F. in the summer, although the hot spells are of short duration. Grains and some hardy vegetables may be produced during the winter without danger of winter-killing. Most of the precipitation falls during the winter, and the summers are practically rainless. The precipitation varies greatly throughout the county, owing to variations in relief. Rainfall is heaviest on the higher hills in the western part where the normal precipitation is probably 30 inches or more, whereas most crops cannot be grown without irrigation in the eastern part. In the southeastern part the normal precipitation is probably less than 10 inches.

The wide variations in precipitation have had a marked influence on the native vegetation and on soil development. In the western part the more exposed southern and western slopes are covered mainly with grass and scattered oaks, and many of the northern and eastern slopes are thickly wooded or covered with shrubs and brush. In the eastern part there is some brush and a scantier growth of grasses and herbaceous plants. In the drier areas the vegetation is characteristic of more semiarid regions. The soils of the western part are leached of readily soluble mineral compounds, and in the eastern part lime is present in the soils to greater or less degree, together with some saline salts.

Agriculture is based on the production of fruits, vegetables, alfalfa, and smaller quantities of grain on the valley soils, and grain and grain hay on the smoother areas of the hilly lands. Sheep and cattle are grazed over the uncultivated hilly lands and on the grain lands after the crops have been harvested. Dairying is an important branch of agriculture, and good markets are available for whole milk and other dairy products in the cities of the San Francisco Bay district. Poultry raising, in general, is of minor importance, although a number of ranchers derive most of their income from the sale of poultry and poultry products. Good markets are available nearby for all poultry products

41674—39——6

The soils of the western and south-central parts of the county are developed mainly in place on the sandstones, shales, and miscellaneous rocks of the hilly and mountainous areas. The principal soils here are members of the Los Osos, Cayucos, Hugo, Sobrante, Diablo, and Altamont series. They are utilized mainly for pasture and for grain and grain hay grown without irrigation.

The soils of the local intermountain valleys are mainly those of the Salinas, Zamora, Cowell, Botella, Danville, Rincon, Sorrento, Yolo, Clear Lake, and Dublin series. They are utilized for pasture, grain hay, and general farming, and more intensively for the production of walnuts, deciduous fruits, vines, tomatoes, and truck crops. They include some of the most productive and highly valued soils of the county.

The eastern valley plains and the coastal-plain terraces are dominated by the Brentwood, Ambrose, Antioch, Tierra, Manzanita, and Montezuma soils. They are utilized for producing grapes, peaches, apricots, plums, prunes, walnuts, and almonds where irrigated and, in part, for general farming. Associated with these are the less well drained soils of the flatter valley plains, transitional to the organic soils of the river-delta area, including members of the Herdlyn, Marcuse, Olcott, Sacramento, and Solano series, and some of the Brentwood soils. They are utilized extensively for the production of sugar beets and for pasture.

The highly organic soils of the river-delta area include the Piper, Ryde, and Egbert soils, and peat. These soils have been reclaimed mainly from their original fresh- and brackish-water marsh condition by diking and draining. They are important for the growing of asparagus, onions, potatoes, corn, grain sorghums, and general farm crops.

The soils of the sand-hill area are represented by Oakley sand which is devoted extensively to the production of table and wine grapes, almonds, peaches, and apricots.

Irrigation is essential to the economic utilization of the soils of the eastern, less humid part of the county and is practiced as a means of supplementing the moisture supply in the culture of fruit and truck crops in other parts.

Problems of soil alkali are local and are confined to areas of saline soils marginal to areas of tidal marsh and the low poorly drained areas of the river-delta section.

LITERATURE CITED

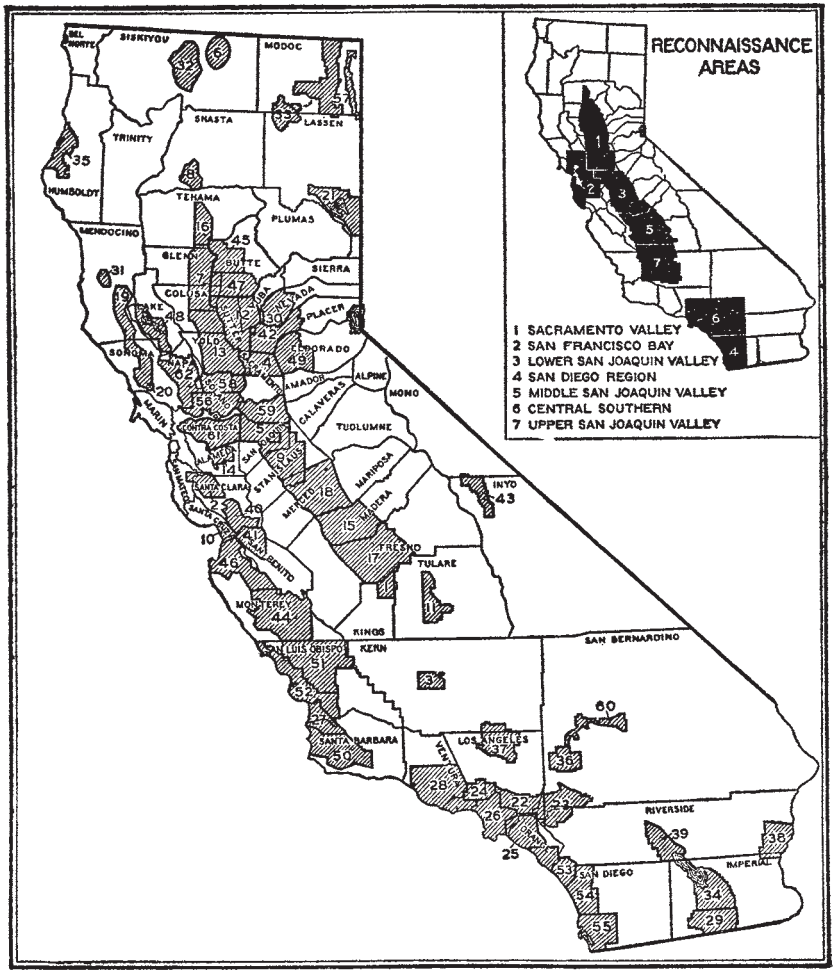
(1) HOLMES, L. C., and NELSON, J. W.
1919. RECONNAISSANCE SOIL SURVEY OF THE SAN FRANCISCO BAY REGION, CALIFORNIA. U. S. Dept. Agr., Bur. Soils Field Oper. 1914, Rept. 16: 2679–2784, illus.

(2) ——— NELSON, J. W., and party.
1916. RECONNAISSANCE SOIL SURVEY OF THE SACRAMENTO VALLEY, CALIFORNIA. U. S. Dept. Agr., Bur. Soils Field Oper. 1913, Rept. 15: 2297–2438, illus.

(3) HULANISKI, F. J.
1917. HISTORY OF CONTRA COSTA COUNTY (CALIF.). 635 pp., illus. Berkeley, Calif.

(4) MARBUT, C. F.
1935. SOILS OF THE UNITED STATES. U. S. Dept. Agr., Atlas of American Agriculture, pt. 3, Advance Sheets No. 8, 78 pp., illus.
(5) NELSON, J. W., GUERNSEY, J. E., HOLMES, L. C., and ECKMANN, E. C.
1919. RECONNAISSANCE SOIL SURVEY OF THE LOWER SAN JOAQUIN VALLEY, CALIFORNIA. U. S. Dept. Agr., Bur. Soils Field Oper. 1915, Rept. 17: 2583–2733, illus.
(6) STORIE, R. E.
1933. AN INDEX FOR RATING THE AGRICULTURAL VALUE OF SOILS. Calif. Agr. Expt. Sta. Bull. 556, 44 pp., illus.
(7) WESTOVER, H. L., and VAN DUYNE, C.
1912. SOIL SURVEY OF THE LIVERMORE AREA, CALIFORNIA. U. S. Dept. Agr., Bur. Soils Field Oper. 1910, Rept. 12: 1657–1716, illus.

U S GOVERNMENT PRINTING OFFICE 1939



Areas surveyed in California, shown by shading

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

Accessibility Statement

This document is not accessible by screen-reader software. The U.S. Department of Agriculture is committed to making its electronic and information technologies accessible to individuals with disabilities by meeting or exceeding the requirements of Section 508 of the Rehabilitation Act (29 U.S.C. 794d), as amended in 1998. Section 508 is a federal law that requires agencies to provide individuals with disabilities equal access to electronic information and data comparable to those who do not have disabilities, unless an undue burden would be imposed on the agency. The Section 508 standards are the technical requirements and criteria that are used to measure conformance within this law. More information on Section 508 and the technical standards can be found at www.section508.gov.

If you require assistance or wish to report an issue related to the accessibility of any content on this website, please email Section508@oc.usda.gov. If applicable, please include the web address or URL and the specific problems you have encountered. You may also contact a representative from the USDA Section 508 Coordination Team.

Nondiscrimination Statement

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the

Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at http://www.ascr.usda.gov/complaint_filing_cust.html and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by:

(1) mail: U.S. Department of Agriculture
Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW
Washington, D.C. 20250-9410;

(2) fax: (202) 690-7442; or

(3) email: program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.