

UNITED STATES DEPARTMENT OF AGRICULTURE

**Soil Survey**  
of  
**The Suisun Area, California**

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**Bureau of Chemistry and Soils**

In cooperation with the  
**University of California Agricultural Experiment Station**

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# SOIL SURVEY OF THE SUISUN AREA, CALIFORNIA<sup>1</sup>

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## AREA SURVEYED

The Suisun area lies in the central part of California, about 40 miles northeast of San Francisco, midway between that city and Sacramento, the capital of the State (fig. 1). The area comprises the southern half of Solano County and Grand and Sutter Islands, which are in Sacramento County. Sacramento River forms the eastern boundary. About 30 miles south of Sacramento, the river turns westward and, to a point where it empties into Suisun Bay, forms the southern boundary. This bay, Carquinez Strait, and a part of San Pablo Bay, form the rest of the southern boundary. The Napa-Solano County line forms the western boundary, and the northern boundary is the north line of T. 5 N.

The area comprises 550 square miles, or 352,000 acres. It includes parts of areas covered by the earlier reconnaissance soil surveys of the Sacramento Valley (6)<sup>2</sup> and the San Francisco Bay region (5) and joins in part with the later survey of the Dixon area.<sup>3</sup>

Physiographically the Suisun area includes part of the interior lowland of California known as the Sacramento Valley, and part of the Coast Ranges bounding the valleys on the west. That part of the Sacramento Valley lying within the limits of the area consists of two parts. One of these, consisting of the alluvial plain of Sacramento



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

<sup>1</sup>The available United States census data cover Solano County as a whole and are therefore not directly applicable to the area surveyed. These data are used, however, in connection with the agriculture of the area, serving as a basis of comparison. Data dealing directly with the area surveyed have been supplied by different individuals and organizations concerned with the agricultural development of the district. The authors are indebted to Verne De Tar, Solano County farm adviser, and Carl Spurlock, Solano County horticultural commissioner, for much data on crops, varieties, and agricultural practices; to Edward Hyatt, State engineer, of the State Department of Public Works, for data relative to acreage of crops in Suisun Valley and Green Valley and the acreage irrigated; and to R. M. Dewing, district agent for the California Packing Corporation, who supplied much data on asparagus culture and acreage. Data on agricultural industries, particularly those dealing with the feeding of beef animals and fertilizer byproducts, have been supplied by A. B. Miller, president of the B. E. Co.

<sup>2</sup>Italic numbers in parentheses refer to Literature Cited, p. 60.

<sup>3</sup>COSBY, S. W., and CARPENTER, E. J. SOIL SURVEY OF THE DIXON AREA, CALIFORNIA. U.S. Dept. Agr., Bur. Chem. and Soils, series 1931. illus. (Unpublished manuscript.)

River, lies in the eastern part of the area, and the other, consisting of a broad alluvial fan, stretches from the foot of the Coast Ranges eastward to the alluvial plain.

The alluvial plain of Sacramento River within this area constitutes the extreme southern part of the flood plain of that stream and that part of it constituting the delta of the river. The plain is traversed by a number of distributaries of the river, separating the eastern part into a number of islands. The western part is bounded on the east by these distributaries but on the west merges into the alluvial fan of the central part of the area. In this report the eastern part of the alluvial plain is described as the ridge and basin region. It is thus described because each of the islands is surrounded by the natural levee of the river or distributaries that bound it. These streams have overflowed the islands from time immemorial and have built their immediate banks, as usually happens in such cases, higher than the interior of the islands, or higher than that part of the alluvial plain lying west of the islands. The difference in elevation between these ridges (as they are described in this report), or natural levees, and the interiors of the islands, or the basins, is only a very few feet, but it is sufficient to be noticeable in flood periods.

The other part of that part of the Sacramento Valley lying within this area consists of a plain, the highest part of which lies along the boundary between the Sacramento Valley and the Coast Ranges, sloping eastward to the alluvial plain of Sacramento River. The maximum elevation of this part of the plain is about 40 feet above sea level. The plain slopes eastward to sea level or a little below sea level along the boundary of the flood plain of Sacramento River. It has been built up by the small streams which flow eastward out of the Coast Ranges, the coarse material being laid down close to the mountains and the finer material farther out into the valley.

That part of the Coast Ranges lying within the area consists of the southern end of two ranges of mountains, here barely high enough in a few places only to be called mountains, consisting mainly of ranges of hills. The most easterly of these two ranges, in the northern part of the area, is known locally as the Vaca Mountains. From these a narrow range of low hills extends southeastward, connecting them with the Montezuma Hills, a large area of low hills lying in the southeastern part of the area in the bend of Sacramento River. An isolated group of hills surrounded by a very low plain consists of the Potrero Hills. These may be considered as a part of the chain of low hills stretching from the Vaca Mountains to the Montezuma Hills, although they lie west of, and not continuous with, the chain of hills connecting the last two groups mentioned. Although this chain of hills, consisting of three or four parts as they are here described, constitute physiographically and topographically a more or less well-defined unit, it is well known that geologically it is not a unit. The geological structure of the Vaca Mountains is entirely different from that in the Montezuma Hills, and the age of the rocks in these different parts of the range is different. Notwithstanding this fact, there is a continuous range of highlands extending from the Vaca Mountains to and including the Montezuma Hills, and from that point of view the belt may be described as the extreme southern end of one of the Coast Ranges.

Another one of the Coast Ranges lies along the western part of the area. It terminates, so far as this area is concerned, on the south at Carquinez Strait and consists of a belt of very rough hilly country attaining a maximum elevation of somewhat more than 1,000 feet above sea level. This belt attains a width, at the south end, of about 8 miles. North of this, however, the western part of the belt lies west of the boundary of the area covered by the map. Between these two ranges, which are much wider apart in the southern part of the area than in the northern, lie Suisun Bay and a broad northern extension of the bay consisting of marshland or of very recent deposits along Suisun and Montezuma Creeks. This belt of low country extends northward, as the flood plains of Suisun and Ledge-wood Creeks, to the northern boundary of the area, but north of the latitude of Fairfield it is much narrower than south of that place. The narrow part of the valley along these creeks north of Fairfield is also higher than the broad area south of Fairfield. Suisun and Ledge-wood Creeks have built into this intermountain lowland belt an alluvial fan which terminates a few miles south of Fairfield.

Another lowland belt lies west of the second range, but only the extreme southern part of it lies within the area covered by this survey. This is brought about only because the extreme southern part of the area projects several miles farther west than the rest of the area, and in doing so extends into this westerly lowland belt, or intermountain valley. The southern end of this lowland belt, like that of the belt between the first and second ridges, is under water. That part of it consists of San Pablo Bay, just as the southern end of the first intermountain belt is under water in Suisun Bay. That part of the lowland north of San Pablo Bay is a few feet higher than the southern part of the lowland north of Suisun Bay. It consists of a very low alluvial plain.

Hilly and mountainous land constitutes 34.8 percent of the area (pl. 1, A); the alluvial fan and plains land, 29.3 percent; and the islands, basins, and swampy land, 35.9 percent.

Water for domestic use is plentiful and generally of good quality, though rarely is the quantity found sufficient for extensive irrigation. Well water obtained in the vicinity of the marshy land south of Suisun in places contains salt in sufficient quantities to make it unpalatable and unfit for use in irrigation. Most of the wells in Suisun and Green Valleys range from 80 to more than 120 feet in depth, and the water during the rainy season stands at a depth ranging from 15 to 25 feet, depending on location. During late summer the water in most places lowers in the wells an average of about 15 feet.

On the higher mountainous land scattered native digger pine trees and oaks form a forest cover of varying density. A few live oaks and valley oaks at one time dotted the stream valleys and alluvial fans, but they have largely been removed to allow planting of orchards and other cultivated crops. Under virgin conditions the plains were open and grass covered, but with settlement windbreaks of eucalyptus and boxwood were planted around the dwellings and farmsteads, and the plains are now dotted with numerous groves. The native and planted trees furnish firewood and fence posts, though none of them has commercial value as timber.

Wild game and fur-bearing animals at one time abounded in the Sacramento Valley, and the first white persons to visit the territory now embraced in Solano County were hunters and trappers. Men following this calling in their travels up and down the Sacramento Valley traversed the area now occupied by Solano County for many years prior to the first settlement.

In 1841 the Baca (or Vaca) and Pena families settled on a grant of 44,380 acres comprising the area now known as the "Vaca Valley." Somewhat later in the same year, Don Jose F. Armijo obtained a grant of 3 square leagues in Suisun Valley. The first American settler was John R. Wolfskill, who settled on the south bank of Putah Creek in 1842 (1). John Bidwell, who was destined later to become an important figure in the early history of Sacramento Valley, settled in the vicinity of Rio Vista in 1844 and later was granted the Los Ulpinos grant.

Solano County was created February 18, 1850, and was the twenty-first of the original 27 counties of the State of California. Benecia was named the county seat and retained the county offices until 1858, when they were moved to their present site in Fairfield. In 1859 the population of the county was 580 (?). The cessation of active mining operations in the Sierra Nevada turned many miners to agricultural pursuits and settlement throughout the Sacramento and San Joaquin Valleys. Local railroad projects and the completion of the transcontinental line cut-off between Sacramento and Benecia in 1879 further stimulated settlement, and in 1880 the county had a population of 18,475, according to the United States census.

The rush to the gold mines, commencing in 1849 and continuing for several years thereafter, attracted men from all parts of the globe, though the greater number came from the eastern part of the United States. The early settlers of the county were mainly people from the mines.

From 1880 to the present time settlement has progressed steadily, except during occasional land-development projects or industrial booms such as occurred during the period of the World War when many persons were employed at Mare Island in ship construction or other war work. The normal increase in population has averaged about 4,000 persons a decade since 1880. The 1930 census gives the total population of Solano County as 40,834, of which 17,389 are urban and 23,445 rural, the rural population having a density of 28.5 persons a square mile. The most thickly populated rural sections of the area are Suisun Valley, Green Valley, Grand Island, and Sutter Island. The plains and hill sections are sparsely settled, and in the mountains the density of population is less than one person a square mile.

About 5 percent of the farm population consists of Filipinos, Japanese, Chinese, and a few Hindus, but the population is largely American born. The foreign-born population is found largely in the island country, where the people are engaged in the production of vegetable crops, and to less extent in the fruit districts.

Vallejo, with a population of 14,476, is the location of the Mare Island Navy Yard as well as a large creamery company and a large

flour mill plant. Benecia has a creamery handling local dairy products, a cannery for fruits and vegetables, and a large tannery. In Fairfield, the county seat, is a large plant handling dried fruits and numerous packing plants for fresh fruits. Suisun is a freight division point on the Southern Pacific Railroad and the junction of a branch line of this railroad extending to Vallejo. A cannery located here handles all kinds of fresh fruits, but their principal pack consists of apricots and peaches. Rio Vista is located on Sacramento River adjacent to the large asparagus plantations of the river delta. A cannery located here handles asparagus exclusively, their pack in 1930 being 335,000 cases. St. Gertrude's Academy, a denominational school for girls, is located here; also St. Joseph's Military Academy for boys. All the towns mentioned have banks, schools, churches, electric power, water and sewage plants, and many business houses. Cordelia and Birds Landing are important shipping points for fruits and grain, respectively, and are also local trading points. Collinsville, located at the junction of Sacramento and San Joaquin Rivers, is maintained largely by a commercial fishing industry. Toland Landing, Maine Prairie, and Dutton Landing, as well as a number of other landings for river boats, have lost much of their former importance as shipping points for grain and other produce since the development of railroad and motor-truck transportation, though some grain is still shipped from these points. A number of local railway points or sidings load produce for shipment to market.

Solano County has 65 miles of water frontage on navigable deep waterways (?), the greater part of which is in the Suisun area. Steamers plying Sacramento River also enter most of the larger sloughs and pick up cargoes from the various landings. The main line of the Southern Pacific Railroad, operating between San Francisco and Portland, and eastward to Ogden, passes through the central part of the area, and a branch of the same line extends westward from Suisun to Vallejo, connecting there with lines running into the Napa and Sonoma Valleys. The Sacramento Northern Railroad (electric) traverses the east-central part of the area and operates a branch line into the Suisun Valley and to Vacaville lying just outside the area on the north. Another branch of this railroad serves the island country, terminating at Westfield in the northeastern part of the area.

The Pacific Coast Highway enters the area at Vallejo and runs northward through the central part, passing through all the larger towns. From Suisun, a paved road passes through the southern part of the area to Rio Vista, where it crosses Sacramento River, making connection with other paved roads traversing the island country. A number of county roads in Suisun and Green Valleys are paved, giving ready access to these districts throughout the year. Most of the other public roads are graded and surfaced with rock in the more thickly populated districts, and they are passable at all times. In the east-central part of the area, including much of the island and basin districts, many of the roads are in poor condition during the wetter months.

Telephones and electricity are available in all the more thickly populated rural sections. In addition gas for cooking or industrial

purposes is available in the larger communities. Rural mail delivery routes serve the Suisun, Green Valley, Benecia, and Vallejo districts, and schools and churches are conveniently located. The local farm bureau is well organized and is active in all matters pertaining to the agriculture of the area.

The principal crops are grown in excess of local market requirements and are shipped to Pacific coast or eastern markets. Most fruits produced in the area and the first asparagus reach the eastern markets at an early date, avoiding competition for a time with such products grown in the Southern and Eastern States.

### CLIMATE

As characteristic of the central and northern Pacific coast climate, the winters in the Suisun area are mild and wet, the summers warm and dry. The rainy season commences in November and continues into March. During this period approximately 83 percent of the annual rainfall occurs, the months of October, April, and May normally receive an inch or more of rainfall, and during the remainder of the year the rainfall is not sufficient to be of value to crops.

The winters are sufficiently mild that fall-sown grain does not winter-kill, and crops that are apt to be injured by frost can generally be planted early enough in the spring to mature before the soils lose their moisture during the dry summer season. Most perennial crops require some irrigation for maximum crop production, though many deep-rooted tree crops receive no moisture supply other than the annual rainfall. The farmers plan to handle their soils in such a way as to conserve the winter rainfall for the use of cultivated crops. They plant at a time that will insure the maturing of crops on the moisture stored in the soil. Late spring or summer rains generally do more harm than good to ripening forage, fruit, and cereal crops.

The rainfall throughout the area differs appreciably from east to west. Records from the United States Weather Bureau station at Vacaville, lying in the foothills of the Coast Range a short distance to the north, show an average annual precipitation of 26.53 inches. At Rio Vista the average annual precipitation for a period of 29 years is 17.39 inches. At Suisun records for a period of 38 years show an average precipitation of 19.79 inches. A private rain gage maintained on the Willota ranch 4 miles west of Suisun has a record of 32 years, showing an average annual precipitation of 22.48 inches. This gage lies about a mile east of the mountain foot slopes, and the record bears out the generally observed rainfall conditions of the region. From the data presented, it will be seen that the rainfall in the foot slopes of the Coast Range is from 5 to 10 inches greater than in the eastern part of the area bordering Sacramento River. The belt of highest rainfall does not extend a great distance east of the foot slopes, however, as is indicated by the records at Suisun and the Willota ranch. Eastward of the belt of highest rainfall the average annual rainfall differs only an inch or two from that in the western part of the area.

Frosts may be expected about the middle of November and from then on until about the middle of March. The Weather Bureau records at Vacaville show that the average date of the first killing frost is November 20, and the average date of the last is March 18. Frost has been recorded at this station as early as September 19 and as late as May 2. Some favored spots on the lower foot slopes of the mountains are comparatively frost free, and here citrus fruits can be grown successfully. Livestock can be grazed throughout the year without protection from the elements, although stockmen believe it advisable to provide shelter in cold rainy weather to the ewes and young lambs during the lambing period. Wet conditions of the fields rather than snow or cold weather limit grazing.

In the Suisun area the hot summer weather, so characteristic of the interior valleys of California, is tempered by cool moist winds blowing inland from the ocean and bay. Commencing late in May there is an almost continuous wind movement inland during the daytime in summer and early fall. Occasionally during the summer there may be a period of 2 or 3 days when the wind movement is from the north. These winds are hot and dry, and maximum temperatures of 110° to 115° F. are experienced. The north winds are unwelcome at any season of the year, as they do much damage to fruit and grain crops during the summer, and during the winter they are cold and raw; in fact, the coldest winter weather is experienced with the wind from the north. Winds from the southwest or south generally bring rain and moderate temperatures during the winter.

The climatic conditions prevailing in the area very largely determine the character of the agriculture. Summer fallowing is practiced in the production of dry-farmed small-grain crops, the land being left fallow in alternate years. Over the plains section, the soils, as a rule, have a low water-holding capacity, and under existing climatic conditions most of them are best adapted to grazing. Where water is not available for irrigation, the tree fruits are mainly of early-maturing varieties, the later-maturing varieties frequently returning unprofitable crops in seasons of low rainfall. The planting of cover crops uses much of the winter moisture supply, and such crops are therefore planted only in orchards where water is available for irrigation. The production of alfalfa is limited by moisture conditions to those soils capable of irrigation. The characteristically strong winds of the summer season not only hasten evaporation and transpiration but also necessitate the planting of grain varieties that do not shatter badly in ripening. The seasonal character of the rainfall governs practically all cultural and planting operations on the farms, and under careful cultural practices to conserve moisture crop failures are rarely experienced. Hail, snow, torrential rains, or destructive winds are practically unknown.

Table 1 gives the normal monthly, seasonal, and annual temperature and precipitation at Vacaville, also the mean annual precipitation for Rio Vista, Suisun, and the Willota ranch.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Vacaville, and mean precipitation at Rio Vista, Suisun, and Willota ranch, California

Month	Temperature at Vacaville			Mean precipitation			
	Mean	Absolute maximum	Absolute minimum	Vacaville	Rio Vista	Suisun	Willota ranch
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December.....	47.7	74	20	5.33	2.87	3.88	3.90
January.....	46.8	78	19	6.19	4.34	4.23	5.14
February.....	50.1	82	20	3.93	2.94	3.11	4.24
Winter.....	48.2	82	19	15.50	10.15	11.22	13.28
March.....	53.6	80	27	3.82	2.55	3.10	3.27
April.....	57.6	97	27	1.74	.80	1.27	1.03
May.....	62.8	109	30	1.16	.68	.69	.72
Spring.....	58.0	109	27	6.72	4.03	5.06	5.02
June.....	68.2	110	39	.12	.15	.21	.17
July.....	74.0	115	40	( <sup>1</sup> )	( <sup>1</sup> )	.02	.01
August.....	73.4	113	41	.03	.02	.02	.01
Summer.....	71.9	115	39	.15	.17	.25	.19
September.....	69.4	109	36	.37	.51	.35	.44
October.....	62.6	99	30	1.16	.87	1.95	1.00
November.....	54.4	94	19	2.63	1.66	1.96	2.55
Fall.....	62.1	109	19	4.16	3.04	3.26	3.99
Year.....	60.0	115	19	26.53	17.39	19.79	22.48

<sup>1</sup> Trace.

## AGRICULTURE

The early settlement, agricultural development, and history of California are closely linked with the founding of the missions and with the Spanish and Mexican land grants. Prior to 1800 no Spanish land grants existed, although 15 or 20 tracts were occupied under provisional licenses, and about a dozen more grants were made prior to 1822, the end of Spanish rule. In the first decade under Mexican rule the number was increased to about 50. From the advent of Governor Figueroa in 1833, under the Mexican colonization law about 50 land grants were issued each year up to 1846, when the total was nearly 500. Under Mexican law any citizen, native or naturalized, might select a tract of unoccupied land and apply to the Governor for a grant. The only qualifications were citizenship, character, and ability to utilize the land. Only 11 square leagues could be granted to one family or party (<sup>3</sup>).

The first grant of which there is record in Solano County was made in 1841 to the Baca (or Vaca) and Pena families, in the section now known as "Vaca Valley", north of the area surveyed. This grant was soon followed, in the same year, by a grant in the Suisun Valley to Don Jose F. Armijo. Although these were the first settlements in the area, the country had for a great number of years been the hunting and trapping grounds of men engaged in the fur trade. The area also lay in the path of emigrants passing from San Francisco northward up the west side of Sacramento River.

Several other land grants were made in this district prior to the discovery of gold on American River. During the period of the gold excitement little agricultural land was settled, but as the more easily worked gold diggings played out and the mining districts became overcrowded, many men turned their attention to agricultural pursuits, and consequently settlement proceeded rapidly in the late fifties and sixties.

The first important agricultural industry of the area consisted of the grazing of cattle for their hides and tallow and to supply the small demand for beef. Areas having the best forage and water supply were naturally selected by the early applicants for grants. Most of these areas comprised the better soils adjacent to the creeks and rivers. Aside from the grazing of cattle, the early agriculture consisted of the production of a few staple crops, such as wheat, beans, potatoes, and other cereal, fruit, and vegetable crops, to supply the home or neighborhood needs.

The rapid growth in population in the mining districts soon after the first settlement early led the settlers, who remained to till their lands, to expand the acreage of cultivated crops. The large mining population afforded a good market for agricultural products, and the numerous waterways afforded means of transporting the products to markets. Under the stimulus of a strong demand for agricultural products, the large land grants were soon divided into smaller holdings, and many settlements sprang up along the water routes of transportation. In 1852, at the beginning of settlement of the area by men returning from the mines, the acreage of the county in farms was 5,950 acres. By 1880 the area in farms amounted to 77.7 percent of the area of the county, or 408,837 acres, of which 369,634 acres were improved land. In 1930 the surveyed vacant land in the county was estimated at 1,896 acres. This vacant land lies mostly in those mountainous areas which are of little value for grazing or agricultural development.

As the district became more thickly settled the cattle that were formerly grazed over the bottom lands adjacent to the creeks were transferred to the mountains and poorer lands, and the better lands were utilized in the production of grains and fruits. Wheat, barley, and oats were the principal cereals grown at this time. Before the completion of the railroad in 1879, Maine Prairie ranked next to Stockton as a shipping point for grain. Grain yields were high, and much of the land now utilized only for grazing was sown to grain.

J. R. Wolfskill is credited with planting the first fig and olive trees in 1845. In 1852 the Pleasants planted the first apricot, apple, and pear trees. Grapes were planted at an early date and prior to 1870 were one of the most important fruit crops grown. They became infested during the seventies, and most of the vines were pulled out. The real fruit industry dates from about 1880, when extensive plantings of many varieties of fruit were made for commercial purposes. The advent of refrigerator cars in 1889 enabled growers to ship to distant markets and gave further stimulus to the industry (?).

According to the 1930 census, 431,401 acres in the county are in farms, of which 173,986 acres are crop land. The number of farms increased from 1,016 in 1880 to 1,479 in 1930. Each decade has

shown a material increase in the number of farms, indicating the breaking up of the larger holdings and more intensive cultivation of small units.

Deciduous fruits are grown extensively in the intermountain valleys and on the alluvial fans at the bases of the mountains. The plains section is devoted largely to the grazing of sheep and to less extent to grain production. The hill lands of good moisture-holding properties are used for grain production, and those not so well adapted to cultivated crops are valued for grazing cattle or sheep. The island or basin lands are devoted largely to asparagus culture, with smaller acreages given over to fruit, seed, or vegetable crops.

In 1930, in the Suisun and Green Valleys, 7,960 acres were devoted to deciduous fruits, 1,310 acres to grapes or other vine fruits, 180 acres to truck crops, 20 acres to alfalfa, and 3,920 acres to grain. The uncultivated land amounted to 5,710 acres, 100 acres of which were in town or village sites. At that time 5,000 acres in this district were irrigated. Most of the lands of the islands and basins are irrigated by control of the water table by means of pumps located along the drainage ditches or by flooding the land with water pumped from the sloughs.

The total value of all agricultural products in Solano County in 1929 was \$6,923,383, the fruit and nut crops being valued at \$2,364,218, the cereals at \$1,438,635, hay and forage at \$764,116, and vegetables at \$2,111,476. Domestic animals were valued at \$3,506,144. The value of land and buildings in 1930 was \$45,107,090, as compared with \$25,303,621 in 1910. The average value of land and buildings per farm in 1930 was \$30,498. The average acre value of the land, including buildings, was \$104.56, and the average value of farm buildings was \$4,472.36 a farm.

The average size of farms in the county in 1930 was 291.7 acres. Most of the fruit ranches range in size from 60 to slightly more than 100 acres; sheep ranches from 2,000 to more than 3,000 acres; and grain ranches from 1,000 to 2,000 acres.

The principal tree fruits grown are prunes, plums, apicots, pears, peaches, and cherries, named about in the order of their importance. In addition, some olives, figs, persimmons, and apples are grown, though they are not important commercially. The 1930 census reports 30,711 acres in orchards, vineyards, and nut trees in the county in 1929. Grapes were grown more extensively in the past than at the present, though there are several important vineyards in the area, notably in Green Valley and in the lower part of Suisun Valley.

Wheat is the principal cereal crop, occupying about 80 percent or more of the land devoted to grain production. The Hessian fly has given some trouble in certain districts in recent years, and to avoid loss from this pest many farmers are growing more barley than formerly. Oats are not extensively grown, as they shatter badly in the prevailing high winds of late spring and summer.

Asparagus is one of the more important vegetable crops grown, about 18,500 acres being devoted to its culture in the basin and island districts. The highly organic soils of these districts not in asparagus are devoted to annual crops, such as celery, onions, potatoes, beans, sugar beets, and milo. The production of carrot, beet, lettuce,

parsnip, and onion seed, as well as certain flower seeds, is becoming a more important agricultural industry of the island country each year.

On April 1, 1930, the number of sheep in Solano County was 264,941, and this county ranked first in the State in the number of sheep to the square mile, being credited with 322.3. It is estimated that about 50 percent of the sheep in the county are in the area surveyed. Sheep are produced largely for mutton, wool being a secondary consideration. The flocks are mostly crossbreeds of the Rambouillet and Hampshire or Shropshire breeds. During the lambing period the ewes are generally brought to a shed or enclosure, and after lambing they are fed alfalfa hay for a few days and then turned out to graze if the feed is good. When the lambs are between 4 and 5 months old they are generally ready for market, the desired weight ranging from 65 to 85 pounds.

In this area it is the common practice to shear sheep only once a year, in April or May. During the summer the sheep are pastured on fields that were not grazed during the spring, or more commonly in stubble fields after the grain is harvested. A few sheepmen move their flocks to the Yolo Bypass during the summer, though most of them depend on stubble pasture. Aside from the farms on which sheep raising is the principal industry, practically all the grain farmers keep a flock of sheep, the number depending on the natural feed available on the individual ranches (8, 13).

Commercial poultry raising and dairying are not extensively practiced, though a few ranches are dependent entirely on one or the other of these industries. Chickens of the Plymouth Rock, Rhode Island Red, and other general-purpose breeds are kept on most of the farms for domestic use. The White Leghorn is the most popular breed kept for commercial egg production.

The dairy herds are of mixed breeds. Most of the dairy products are sold as fresh milk to supply local demand, though in the vicinity of Vallejo and Benicia some dairymen sell their products to local creameries. Most of the dairymen depend on the natural feed supply for their cows. It is planned to have the cows freshen in the fall as green feed becomes available, feeding them some supplemental feeds, such as wild hay or alfalfa, during the summer when the pasture becomes short. The herds are mostly of mixed breeds, but Holstein-Friesian predominates.

In 1925 approximately 7,100 beef cattle were in Solano County, of which perhaps one half were in the Suisun area. The breeds are mixed, though cattle with Hereford blood predominate. The animals are grazed over the hill and mountain sections of the area surveyed throughout the year. They are marketed locally as 2-year-olds, generally in the spring or early summer when the grass begins to dry.

Most of the farmhouses are of modern construction and are supplied with running water, telephones, and electricity in the more thickly settled districts. In the fruit districts few farms have barns, but the drying yards, packing sheds, and tool houses are modern and serviceable. The barns throughout the grain-growing sections are generally in need of paint and repair, but they furnish the necessary protection for livestock and stored hay. On the better sheep ranches well-built barns for lambing and storage of feeds are in general use, and some shelter from the sun in summer is provided in some of the pastures.

The light- or medium-weight tractor is in universal use in the orchards, and motor-powered spray outfits are used on all the larger fruit ranches. The heavy tractor is used on many of the grain ranches, though horses or mules of medium weight are not uncommon. In 1930 there were 865 tractors in use in Solano County. Automobiles and light trucks are used on practically all the ranches. Most farm homes are equipped with radio sets.

Woven-wire fencing about 3 feet high, with two strands of barbed wire at the top, encloses most fields, especially those in which sheep are run.

Labor is in general plentiful and efficient. In the fruit orchards many Japanese and Chinese are employed throughout the year. During the harvest season, itinerant laborers that follow the fruit harvest from section to section of the State are employed. The labor in the island districts is mostly oriental, the greater number being Filipinos, with fewer Japanese and Hindus. Most of the men employed on dairy ranches are American born. Workers in the asparagus fields are paid 30 cents an hour for ordinary labor and 35 cents an hour as teamsters. The cutting of the asparagus crop is generally contracted to the Filipinos. The 1930 census reports 983 farms using hired labor in Solano County in 1929, at a cost of \$2,422,486, or \$2,464 a farm. In the same year, 961 farms reported the purchase of feed at a total cost of \$516,810, and 70 farms reported the purchase of fertilizer at a cost of \$13,184.

The greater number of farms in Solano County in 1930 were operated by the owners, 1,129 farms being reported operated by owners, 260 by tenants, and 90 by managers. Of the 260 tenants, 160 were cash tenants and the rest share tenants. On grain ranches rented on a share basis the common practice is for the tenant to furnish everything, giving the landowner one fourth of the crop delivered in the warehouse.

The principal agricultural industries of the Suisun area are the canning of asparagus, the canning and packing of fruits, and the feeding of sheep and cattle. Some fresh milk is shipped to the larger centers of population or consumed locally, but the manufacture of butter and other milk products is a minor industry.

Practically all the canning asparagus produced in the United States is grown in California, mainly in the delta, or island section, in part included in the area surveyed, in which a large part of the crop is utilized for canning purposes. Asparagus for canning is cut just as it emerges from the ground. It is collected in small bunches between the rows and hauled to the packing houses, where it is washed and the stalks cut to a uniform length. It is then packed in boxes ready for shipment to the canneries. Most of the packing houses are located along the sloughs and streams, and the boxes are picked up by river steamers and carried to the canneries. The canned asparagus is packed in cases and transported by river steamers to railroad points or to deep-water ports for shipment to outside markets. The pack of canned asparagus has increased greatly in recent years.

Most of the fruits produced in the area are marketed in eastern or foreign markets. Fresh fruits are picked in field boxes and hauled to packing sheds, where the fruit is carefully culled, graded, and

packed in standard-sized boxes for shipment. When market conditions are unfavorable for the sale of fresh fruit, the product is sold to canneries. As a rule, only the better-quality fruits are canned, and the culls are worked up into jams or other fruit byproducts. Dried fruits are generally dried on the ranch where produced. The product is sold in bulk to fruit buyers or commission dealers, who pack it in containers for sale to retail merchants.

A plant, located a short distance from Collinsville on navigable deep water, specializes in the fattening of baby beef, though a large number of lambs are also fed at this plant each year. It has a capacity for feeding from 2,000 to 4,000 head of beef cattle at a time and about 10,000 lambs. The entire number fed during a year amounts to about 10,000 head of cattle and 30,000 head of lambs. Baby beeves are available for feeding the year round, but the feeding period for lambs is limited to 6 or 8 months. Calves weighing from 400 to 500 pounds are purchased and are marketed when they have attained a weight ranging from about 850 to 950 pounds. Early lambs come principally from the Sacramento Valley, and later lambs are obtained in Oregon and Nevada. They are purchased when weighing about 55 or 60 pounds and marketed as finished lambs at 75 or 80 pounds. From 60 to 90 days are generally required to bring them to the desired weight.

While in the feed lots, animals are fed concentrates consisting largely of rolled barley, rice bran, and Hawaiian molasses, with either peanut or sesame meal for protein ration. Roughage generally consists of barley or oat hay mixed with alfalfa meal or bean straw. Corn, milo, and beet-top silage are also fed. Most of the livestock shipped to the feed lots comes by rail on the Sacramento Northern Railroad (electric), and the fattened animals are shipped to South San Francisco by barge, or to Oakland or Los Angeles by rail.

Grain crops in the Suisun area are grown almost exclusively under dry-farming practices. The grain is seeded in the fall after the first good rain, occasionally on dry ground shortly before the winter rains may be expected, or, if the rush of work prevents early seeding, during the winter whenever moisture conditions are favorable. The grain is broadcast and harrowed in, the acre rate of seeding ranging from 90 pounds of wheat, if fall sown, to as much as 110 pounds, if winter sown. If the crop makes a good growth early in the season and the fields are not too wet, it is common practice to pasture with sheep for as long a period as weather conditions allow. Wheat is generally harvested with a combine late in May or June, after which sheep are turned into the fields to browse on grain that was missed or was shattered in harvesting. The winter rains sprout weed and grain seed, and good pasturage is afforded during the winter. In the spring the fields are plowed and left fallow throughout the summer, sheep being pastured over them for a time to keep down any weed growth that may spring up after plowing. If the fields become foul with wild oats or other weeds, they are plowed before seeding. Plowing in the Montezuma Hills is accomplished with a tool peculiar to the region. Two heavy beams are bolted together and braced in the shape of an A. A wheel is placed at the apex and one at the end of either beam. Along the beams shovel plows are arranged to com-

pletely cover the ground as the tool is drawn forward. Elsewhere plowing is generally done with the common disk or moldboard plows.

Little Club wheat is the most common variety grown. Wheat yields average ten 130-pound sacks an acre, though maximum yields of 18 sacks are reported. Crop failures are rarely experienced. Barley yields range from ten to forty 114-pound sacks an acre, the average being about 18 sacks.

Asparagus is grown exclusively in the island and basin districts bordering Sacramento River and Suisun Bay (pl. 1, B). The soils were originally marshy and are high in content of organic matter. When first reclaimed most of them were planted to annual crops, such as sugar beets, celery, milo, onions, or potatoes. In late years, owing to the enormously increased demand for asparagus, both fresh and canned, large tracts of the basin soils of the area have been planted to this crop. In starting a plantation, it is first necessary to obtain pure seed of high viability (12, 17). The seed is soaked in water at a temperature of 85° or 90° F. for a period of 4 or 5 days, then sown in nursery rows in a moist seed bed. The rows are spaced from 24 to 30 inches apart and a space of 3 or 4 inches is left between the plants. After the plants are a year old they are ready to be dug and planted in the field. A 1-year-old crown is the best, although some 2-year-old crowns are planted. The crowns are placed in trenches about 8 or 10 inches deep and covered to a depth of 2 or 3 inches, and as they develop more soil is pulled over them until the desired depth is obtained. The rows are generally about 8 feet apart, and a space ranging from 24 to 30 inches is left between the plants.

The land is given clean cultivation to keep down weeds, and ridging of the rows may or may not be practiced, the general practice being to leave the fields flat until the plants are old enough to cut. In this section it is common practice to harvest the spears throughout a period of 3 or 4 weeks the year following planting. During the cutting season the rows are ridged an average of once every 10 days, and afterward the beds are given a good cultivation and the ridges leveled. The plant is then allowed to grow until killed by frost in the fall, when the stalks are either plowed under or burned, and the fields are left flat until cultivated in the spring.

The cutting season begins in February and extends through June. The early cuttings, up until about the middle of April, are of green asparagus for shipment to local or eastern markets. Cuttings the latter part of the season are of white asparagus for canning. About 75 percent of the crop is canned, and 25 percent is sold as fresh asparagus.

The asparagus beds will continue to produce for a period of 20 or more years, though it is generally considered advisable to replant them at the end of 11 or 12 years, depending on the individual beds. The average yield is about 4,500 pounds an acre, though maximum yields of 10,000 pounds an acre are reported. It is generally believed advisable to plant the old beds to cultivated annual crops for a year or two before resetting the field to asparagus. This rids the field of the old roots and any asparagus pests that may be present.

Asparagus plants are subject to rust, and two important rust-resistant strains have been developed by the United States Department of Agriculture, in cooperation with different State experiment stations. The Martha Washington is the most rust-resistant variety

in cultivation. The Mary Washington ranks next and is generally considered sufficiently rust resistant for most localities. It is the earlier maturing of the two and has the additional advantage of large size. The removal of all wild asparagus plants during the spring rust period will do much toward controlling rust.

The production of seed from certain root crops and from lettuce is year by year becoming more important in the island districts of the area. Onions, beets, carrots, and parsnips are planted from sets or roots in clean-cultivated fields in May or June. They are set in rows from 30 to 36 inches apart, and the plants are spaced at intervals ranging from 18 to 24 inches. Onions yield from 700 to 1,000 pounds of seed an acre, beets about 2,000 pounds, and carrots from 800 to 1,500 pounds. Lettuce is planted about the same time or somewhat earlier from seed, the plants being thinned to the required distance in the row. The fields are given sufficient cultivation to keep down the weeds until harvest time. Harvesting is done by hand, the stem being cut a few inches below the seed clusters and carried in the arms or on a wagon to large canvases spread on the ground, where they are left to dry for a period of several days. When dry, the seed is either trampled out or broken loose by means of heavy rollers. The coarser stems are then removed and the residue is left to dry for a time longer, being stirred occasionally. It is then trampled or flailed and winnowed to remove the chaff; this operation is repeated until the seed is reasonably clean.

The principal varieties of prunes grown, in the order of their importance, are the Agen (French), Sugar, Sergeant (Robe de Sergeant), and Imperial Epineuse. The ripening dates in the Suisun area range from August 10 to 20. As soon as the prunes are picked they are dipped in a hot solution of lye to remove the bloom and slightly check the skins to aid in drying. They are then rinsed in clean water and placed on trays to dry (pl. 2, A). Drying is accomplished either by a dehydrater or in the sun, the latter method being used almost exclusively. After drying about 10 days, the prunes are placed in bins to sweat and are then ready for delivery to the packing house. Yields range from 1 to slightly more than 2 tons of dried fruit an acre, the average yield being about  $1\frac{1}{4}$  tons (4, 11).

Prunes, as well as other orchard fruits, are given clean cultivation throughout the summer. After the fall rains begin, no cultivation is given, but weeds or planted cover crops are allowed to grow. The growing of leguminous or other planted cover crops is practiced in only a few orchards. The most commonly grown legume cover crop is vetch, though horsebeans have been tried in some orchards. Vetch seed is broadcast at the rate of about 30 pounds an acre and harrowed in about the time the fall rains may be expected. The volunteer or planted cover crops are plowed under before going to seed, generally in March or April. Where water is available for irrigation, the orchards are irrigated about a month before the crop is ready to harvest. If the cost is not prohibitive, they are irrigated a second time late in the summer, in order to increase the set of fruit for the next season. The basin type of irrigation is most commonly used.

Many varieties of plums are grown on a commercial scale. The Yellow Egg variety is grown largely for canning, as it is of better canning quality than the other varieties grown, which are produced for shipment, while fresh, to the eastern markets. The different varieties ripen from the latter part of May to early September. As a rule, the earlier varieties are the most profitable, as they do not have much competition from other fresh fruits (2).

The Royal variety of apricot occupies 97 percent of the acreage devoted to this fruit in the Suisun area, the Tilton occupies about 2 percent, and other varieties the remainder. The Royal is a good shipping apricot, as well as a good canner or drier. It ripens late in May in some orchards, though the greater part of the crop is not ready for picking until June. The Tilton variety ripens about a week later than the Royal. As apricots ripen early here, the first shipments command a good price. The fruit is marketed fresh as long as the market holds up, after which it is disposed of to canneries or is dried. The average yield of apricots is between 3½ and 4 tons an acre. Yields as high as 8 tons are reported from some orchards (16). Many apricot orchards in the Suisun Valley have failed to set fruit in recent years, and the trees are being top-worked to prunes or peaches.

Pears produced in the Suisun area are largely of the Bartlett variety, but the Wilder Early is also produced to some extent for early shipment to eastern markets, as it ripens about 3 weeks earlier than the Bartlett and in favored localities is ready for shipment by the middle of June. The fruit is shipped fresh as long as market conditions warrant, after which it is sold to canners or is dried.

About 50 percent of the peach acreage in the Suisun area is planted to the Elberta variety, 20 percent to Muir, 15 percent to Lovell, and a small acreage to the J. H. Hale and several other varieties. The Elberta is a good shipping peach and is in popular demand, though it has a somewhat bitter taste and is considered of only medium quality for eating. It has a red center and is not in demand for drying. The Lovell and Muir are good shipping, canning, or drying peaches, about 5 pounds of fresh fruit producing 1 pound of dried fruit. The J. H. Hale ripens earlier than the other varieties, being ready to ship from some parts of the area about the first week in July. It is a good shipper and of good quality. The Elberta ripens about the middle of July, the Muir is ready for shipment by the first week in August, and the Lovell about a week or 10 days later than the Muir. Most of the peaches are marketed while fresh, but if the market is not satisfactory they are sold to canneries or are dried. Peaches yield an average of about 14 tons an acre (9, 15).

The Suisun area is noted for its early cherries, express shipments having been sent to eastern markets on March 27 three times within the last 10 years. Car-lot shipments, however, are in general not sent out until the middle or last of April. The principal varieties grown are the Chapman, Bing, Black Tartarian, Napoleon (Royal Ann), Burbank, Lambert, Advance, Early Purple, and Republican. The Early Purple, Advance, Burbank, and Chapman are the earliest varieties, generally ripening the middle or last of April. The Early Purple ripens a few days earlier than the other varieties. The later-maturing varieties are generally of better quality than the earlier



A, Characteristic relief in the hilly part of the Suisun area, occupied by soils of the Los Osos, Hugo, and Konokti series. B, Harvesting asparagus on muck and peat land, Grizzly Island.



ones. Most of the cherries produced are shipped fresh, though some Napoleons are sold to local canneries each season. Yields average between  $1\frac{1}{2}$  and 2 tons an acre (10, 18).

Most of the grapes grown are of the juice or wine varieties, principally the Alicante Bouschet, Henri Bouschet, Carignane, Petit Syrah, Zinfandel, and Grenache. They are mostly marketed locally at present, as prices preclude shipment. Yields range from 3 to 4 tons an acre.

### SOILS AND CROPS

The urban population of the Suisun area is largely dependent on agriculture or on catering to the farming population of Solano County. At present about 40 or 45 percent of the land is under cultivation. An additional 15 or 20 percent is capable of cultivation and would no doubt be utilized in the production of grain if grain growing were more profitable than raising and fattening sheep.

The leading natural factors affecting the utilization of land and the distribution of crops, aside from climate, which is fairly uniform throughout the area, are surface features, water supply, and soils.

The climatic features in any agricultural section are important, however, especially when their effects on soil development, extending over a long period, are considered. The younger soils of the area partake very largely of the character of the parent material, though under the influence of the climate they develop in time regional characteristics independent of the character of the parent materials. Under the prevailing rainfall the surface soils become moderately leached, the degree of leaching depending on the length of time the soils have lain undisturbed and subject to this influence. Materials leached from the surface soil gradually accumulate in the subsoil, those soils saturated with a deflocculating mineral showing the greatest accumulation within a definite period. The organic matter that accumulates in the soils during the wet season of the year is largely oxidized or destroyed during the warm dry season. The well-drained soils bordering bodies of water, where the humidity of the air is greater during the summer, show a higher organic-matter content than the soils elsewhere. As the climate of the area is fairly uniform, its greatest effect on the distribution of crops is through its effects on the soil.

Surface features play a rather important role in influencing the distribution of crops. In certain areas lying slightly higher than the surrounding soils, the air drainage is such that frosts rarely occur, and in such localities semitropical fruits can be produced. Other soils that might be utilized for grain production occupy steep or mountainous areas that preclude the possibility of such use. Surface features, such as poor drainage, have resulted in alkali accumulation in some soils and in others have given rise to marshy conditions resulting in organic soils which on reclamation are especially adapted to the truck crops commonly grown.

The water supply, although rather important, has not had so much influence in the distribution of crops as has climate or soil. The grain crops are produced on soils of good water-holding capacity in which the normal seasonal rainfall is sufficient to mature a crop

under dry-farming practices. The orchards are also planted on soils of good water-holding capacity, and until recent years were not irrigated to a great extent. The water table in those areas in which fruit trees are grown was at one time slightly higher than at present, and no doubt had something to do with the distribution of the crop.

The character of the soil determines in large measure the localities where grazing of sheep is more profitable than production of grain; soil characteristics determine very largely the distribution of the different varieties of fruit grown; the continued profitable production of grain crops is determined very largely by soil character; and the vegetable crops might be grown in a number of localities, so far as climate and surface features are concerned, but their distribution is governed very largely by soil conditions.

Not all the cultivated crops of the area can be grown successfully on all the soil types. The fruit crops in general occupy the greater proportion of the soils adapted to their culture, and the same applies to the vegetable, grain, hay, and other crops. The grazing of sheep, however, might be extended over all the different soils, though it would probably not give so great a return per unit area as the cultivated crops grown on the soils adapted to their culture.

Though climatic conditions for the area as a whole are fairly uniform, considerable fluctuation occurs in the rainfall and some variation in the temperature from year to year. The yearly fluctuations in climate and markets and the adaptation of the crop to the soil determine in large measure the degree of profit or loss to the farm operator. The climate and usually the markets are beyond the control of the individual farmer, though the matter of crop adaptation to soil is not. It is the problem of each farmer to determine the crops best adapted to his soil, as crops grown on soils not well adapted to their culture can hardly compete with the same crops grown on soils to which they are well adapted.

The soils of the Suisun area fall naturally into the following three major groups based on physiographic occurrences: (1) Mountain and hill soils; (2) alluvial-fan and plains soils; and (3) island and basin soils. The mountain and hill soils occupy 34.8 percent of the area, the alluvial-fan and plains soils 29.3 percent, and the island and basin soils 35.9 percent.

Differences in climatic influence, degree of weathering, character of parent materials, drainage, and content of lime have all contributed to the development of a number of distinct soil series within each of the physiographic divisions. A soil series includes several soil types, which are the units of mapping. All soil types in a series have weathered under similar climatic influences and from the same character of parent material; consequently they are of similar color, degree of weathering, and lime content. The types within a series differ from each other only in texture which is determined by the relative amounts of sand, silt, and clay in the surface soils. Subordinate differences in the character of a soil type are designated as phases.

In the following pages of this report, the soils of the Suisun area are described in detail and their agricultural relationships are discussed; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 2.

TABLE 2.—Acreage and proportionate extent of soils mapped in the Suisun area, California

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Konokti stony clay loam	10,240	2.9	Capay loam	1,856	0.5
Konokti stony clay loam, shallow phase	4,032	1.1	Capay silty clay loam	9,600	2.7
Los Osos clay loam	18,944	5.4	Capay silty clay loam, heavy-textured phase	4,224	1.2
Los Osos clay loam, steep phase	10,944	3.1	Lindsey clay loam	3,264	.9
Los Osos clay adobe	3,968	1.1	Antioch fine sandy loam	26,176	7.4
Hugo sandy loam	4,416	1.3	Antioch fine sandy loam, dark-colored phase	1,664	.5
Hugo clay loam	5,504	1.6	Olcott fine sandy loam	8,512	2.4
Hugo clay loam, steep phase	4,288	1.2	Olcott fine sandy loam, gray phase	1,984	.6
Montezuma clay adobe	43,136	12.3	Olcott fine sandy loam, shallow phase	320	.1
Denverton clay adobe	11,584	3.3	Denverton clay adobe, light-textured phase	2,304	.7
Denverton clay adobe, light-textured phase	1,472	.4	Konokti, Los Osos, and Hugo soils, undifferentiated, steep phase	3,840	1.1
Konokti, Los Osos, and Hugo soils, undifferentiated, steep phase	3,840	1.1	Yolo silty clay loam	6,336	1.8
Yolo silty clay loam	6,336	1.8	Yolo silty clay loam, poorly drained phase	2,560	.7
Yolo silty clay loam, poorly drained phase	2,560	.7	Yolo silty clay loam, calcareous phase	1,024	.3
Yolo silty clay loam, calcareous phase	1,024	.3	Yolo silty clay loam, gray phase	320	.1
Yolo silty clay loam, gray phase	320	.1	Yolo silty clay loam, dark-colored phase	2,432	.7
Yolo silty clay loam, dark-colored phase	2,432	.7	Columbia silty clay loam	13,696	3.9
Columbia silty clay loam	13,696	3.9	Conejo clay loam	1,600	.5
Conejo clay loam	1,600	.5	Esparto silty clay loam	3,008	.8
Esparto silty clay loam	3,008	.8	Esparto silty clay loam, light-textured phase	256	.1
Esparto silty clay loam, light-textured phase	256	.1	Zamora fine sandy loam	1,984	.6
Zamora fine sandy loam	1,984	.6	Zamora clay loam	4,608	1.3
Zamora clay loam	4,608	1.3			
			Total	352,000	-----

## MOUNTAIN AND HILL SOILS

The soils of the mountainous and hilly areas include the Konokti, Los Osos, Hugo, Montezuma, and Denverton soils, which have weathered in place from underlying consolidated or partly consolidated bedrock. They range in color from rich brown, brown, and light brown to dull dark grayish brown. The subsoils show but little accumulation of clay or other evidences of weathering. At a depth ranging from 20 to 50 inches they are underlain by bedrock. Underlying the soils of the Konokti, Los Osos, and Hugo series the bedrock is firmly consolidated, but the Montezuma and Denverton soils are derived from weathered partly consolidated calcareous sediments. The soils of the last two series are weathered somewhat more deeply than the other mountain and hill soils. The water-holding capacity of all these soils is good, though it is limited by the depth to bedrock.

The Montezuma and Denverton soils are utilized largely in the production of grain, wheat being the principal cereal grown, with smaller acreages of barley, and a very small acreage of oats. The lime contained in these soils flocculates them and improves their structure, ease of handling, fertility, and water-holding capacity. The other mountain and hill soils, included in the Konokti, Los Osos, and Hugo soils, do not possess these qualities to the same degree, are of less favorable surface relief, and are utilized largely for grazing (pl. 1, A). Small areas of the Konokti soils are used in the production of grapes, cherries, and apricots. The fruit is of good quality, but the yields are lower than on the deeper valley soils. The soils of this group not adapted to grain are, under present eco-

conomic conditions, probably best utilized for grazing. When placed under cultivation they are best adapted to shallow-rooted early-maturing crops.

**Konokti stony clay loam.**—The surface soil of Konokti stony clay loam consists of an 8- or 10-inch layer of pale-brown or pale reddish-brown material. The subsoil is pale reddish-brown material very similar to the surface soil in texture but as a rule is slightly redder and more compact. At a depth ranging from 24 to 40 inches, or an average depth of about 30 inches, the subsoil grades into partly weathered bedrock. The parent material, or bedrock, consists of basalt, diabase, andesite, or in places of a tuffaceous rhyolite. Many rock outcrops occur on the steeper slopes.

The surface soil is low in organic matter and in most places contains more or less angular gravel and stones ranging from medium to large. A few bodies occur which are gravel and stone free. The stones and gravel interfere somewhat with cultivation and make the soil somewhat looser and more droughty than it would otherwise be. The soil is granular and friable, and plant roots, air, and moisture penetrate it readily. The deeper areas under cultivation return fair yields of fruit.

This soil occurs only in the northwestern part of the area surveyed, where it is most extensively developed in the hill and mountain lands bordering both sides of Green Valley. About 1 percent of the land is under cultivation to cherries, apricots, and grapes, and the rest is brush or tree covered and will be of little or no agricultural value until cleared. The cost of clearing and planting to fruit would in most places not be warranted under present economic conditions.

**Konokti stony clay loam, shallow phase.**—The shallow phase of Konokti stony clay loam differs from the typical soil only in the slighter thickness of the surface soil and subsoil. Bedrock is present in most places at a depth ranging from 15 to 24 inches. Bodies of this character are east and west of Cordelia and in a range of low hills extending about 6 miles south of that place. This soil supports a scant growth of grass and is valued only for the small amount of grazing it affords.

**Los Osos clay loam.**—Los Osos clay loam is characterized by a brown or dull-brown surface soil from 8 to 12 inches thick. The subsoil, to a depth ranging from 24 to 40 inches, is dull-brown or dark-brown somewhat more compact material of about the same or slightly heavier texture. The lower 2- to 4-inch layer of the subsoil contains partly weathered fragments of shale or sandstone bedrock. In a few places the unweathered bedrock contains some lime carbonate, though this material is typically absent from the weathered soil material.

The surface soil is fairly well supplied with organic matter, and the entire soil mass is permeable and has a high water-holding capacity. Under cultivation it is fairly easily handled, though it has a high clay content, and it returns very good yields in favorable seasons. Some bodies of this soil are slightly heavier textured than typical.

This soil is extensive. It is most typically developed in the hills north of Benicia and extending westward to Vallejo. Several large areas border American and Jameson Canyons west of Cordelia, a

number of small areas are in the Potrero Hills and in the hills along the east side of Denverton Slough, and several scattered bodies occupy low hills north and south of Cannon.

About 10 percent of the land is under cultivation to wheat and barley. Wheat yields from 7 to 10 sacks an acre and barley slightly more. The areas not under cultivation support a good growth of grass and provide good grazing for sheep and cattle. The soil is well adapted to grazing or to grain production.

**Los Osos clay loam, steep phase.**—A steep phase of Los Osos clay loam is mapped, differing in no essential respect from the typical soil except in surface relief. The soil is for the most part open and grass covered and occupies steep hilly land where little or none of it is susceptible of cultivation. It is differentiated from the undifferentiated steep phases of the Konokti, Los Osos, and Hugo soils because of its more open grass-covered condition and the more even contour of the slopes. Soil of this phase is most extensively developed in the higher hills of the western part of the area, extending from Elkhorn Peak southward nearly to Benicia. A smaller body lies a few miles north of Fairfield. Cattle or sheep are grazed over this soil throughout the year.

**Los Osos clay adobe.**—The surface soil and subsoil materials of Los Osos clay adobe are of heavy texture, cloddy adobe structure, and of rather dark dull-brown or dull grayish-brown color. The soil is sticky and plastic when wet, and on drying it shrinks and checks into large irregular blocks separated by wide cracks. A secondary checking develops a surface structure of small, hard, irregular lumps and coarse granular particles. The material is comparatively high in organic-matter content and under favorable moisture and physical conditions is very friable.

Less than 10 percent of the land is under cultivation, but good yields of barley, wheat, and oats are produced in favorable seasons, the yields being about equal to those obtained on Los Osos clay loam. Uncultivated areas support a very good growth of grass, and the land is valued highly for grazing dairy and beef cattle throughout the year.

Aside from a few acres in the Potrero Hills, this soil occurs largely in the hill lands north of Benicia. Wild artichokes are a serious pest over areas of this soil as well as of other soils in the districts bordering Carquinez Strait. Keeping the plants from seeding or digging them out will control them.

**Hugo sandy loam.**—Hugo sandy loam has an 8- to 12-inch light grayish-brown surface soil. The subsoil is light grayish-brown, light brownish-gray, or yellowish-brown slightly more compact material of about the same or slightly heavier texture than the surface soil. At a depth ranging from about 26 to 36 inches, the subsoil contains many partly weathered shale or sandstone fragments of bedrock, and it grades abruptly into the parent rock.

This soil is rather poor in organic matter but is readily permeable to plant roots, air, and moisture, though it has a rather low water-holding capacity. It occupies rolling or hilly areas having good or excessive drainage.

A large part of the soil is gravelly, and such areas are shown on the soil map by gravel symbols. The gravel consists of small or

medium-sized water-worn rocks which constitute 20 percent or more of the soil mass. The rocks interfere materially with cultivation, and render the soil very droughty. Only a few acres of these gravelly areas are under cultivation to grain, and the yields are rather poor. The remainder of the gravelly areas are valued at a low figure for grazing. A nearly continuous body of this character extends from a few miles north of Denverton to a point about a mile south of Rio Vista Junction.

Typical areas of sandy loam texture are in the Potrero Hills, occupy a number of low hills south of Cannon, and several widely scattered bodies occur along the northern foot slopes of the Montezuma Hills. About 2 or 3 percent of the land is under cultivation in association with other soils. Wheat and barley return somewhat lower yields than on the associated soils. Areas not under cultivation are used for grazing sheep or cattle and have a rather low value.

**Hugo clay loam.**—The surface soil and subsoil materials of Hugo clay loam are of similar or of somewhat darker-brown and duller-brown color than the corresponding layers of Hugo sandy loam, and they are of decidedly heavier texture. The surface soil is comparatively poor in organic matter, and this soil is in general not considered so fertile as Los Osos clay loam. The surface soil is plastic when wet and has a fairly high water-holding capacity, but it is comparatively friable under favorable moisture conditions and is comparatively easy to handle under cultivation.

Several bodies occur in the vicinity of Sulphur Springs Mountain, though the largest development is in the low hills north of Fairfield. A few small bodies are in the low hills in the vicinity of Cannon. About 5 or 10 percent of the land is under cultivation, and the remainder is largely open and grass covered and is valued for grazing. A small acreage is planted to grapes, apricots, and other fruits, though most of the cultivated acreage is devoted to grain production. Yields are slightly lower than on Los Osos clay loam.

**Hugo clay loam, steep phase.**—The steep phase of Hugo clay loam has a somewhat shallower soil covering overlying bedrock than the typical soil. It occupies open grass-covered steeply sloping hills. Little or none of this steep land is susceptible of cultivation, but because of its value for grazing and more even character of slope, it has been separated from the undifferentiated steep phases of the Konokti, Los Osos, and Hugo soils. Bodies of this soil occur near Sulphur Springs Mountain and in the hills north of Fairfield in association with typical Hugo clay loam. The land has a comparatively high value for grazing.

**Montezuma clay adobe.**—The surface soil of Montezuma clay adobe, to a depth ranging from 9 to 12 inches, consists of very dark grayish-brown or black material which grades into a slightly more compact cloddy dark grayish-brown or dark brownish-gray material that is slightly or moderately calcareous. At a depth ranging from 36 to 50 inches, the subsoil grades into highly calcareous partly consolidated parent sediments of yellowish-brown color. Lime carbonate nodules and seams occur in the subsoil and are numerous in the upper part of the partly consolidated material. The surface soil is well supplied with organic matter, and the soil is absorptive and retentive of moisture. The subsoil is flocculent, permeable, and well

adapted to plant-root development. Though the surface soil is heavy textured and sticky when wet, through a process of shrinking, checking, and cracking on exposure it develops a granular or small cloddy structure and is easily handled.

This soil occupies gently rolling hill country, though a few areas are flat. Such areas have a less pronounced lime accumulation, and the deeper subsoil material is less compacted or consolidated. The soil is typically developed in the southern part and in a number of scattered bodies in the northern part of the Montezuma Hills and in the Potrero Hills. The land is productive and is utilized extensively in the production of grain. About 90 percent of it is under cultivation, with the greater proportion planted to wheat from season to season. Barley occupies a small acreage, and oats are planted only to supply local requirements. Uncultivated areas support a good grass growth and are used for grazing. Wheat yields from 6 to 18 sacks an acre, the average yield being about 11 sacks, and barley yields from 10 to 40 sacks, averaging about 20 sacks. The soil is perhaps as well adapted to grain crops as any soil of the area.

**Denverton clay adobe.**—Denverton clay adobe is characterized by an 8- to 10-inch dark-brown or dark chocolate-brown surface soil. The upper part of the subsoil, to a depth ranging from 18 to 24 inches, is brown or rich-brown slightly more compact material of about the same texture as the surface soil. The lower part of the subsoil is light-brown or light yellowish-brown slightly compact calcareous material of similar or lighter texture than the surface soil. At a depth ranging from 30 to 48 inches, the subsoil grades into the parent material consisting of brownish-gray highly calcareous partly consolidated sediments. The lime in the parent material is accumulated through weathering agencies in the upper part of this layer, but more or less lime occurs throughout this material. The surface soil is moderately well supplied with organic matter. It is of pronounced adobe structure, sticky when wet and hard and cloddy when dry, but it is comparatively easy to handle if worked at the proper moisture content. Plowing is generally done at a time when the soil is only slightly damp, and on drying the material crumbles readily to a small cloddy and granular structure and produces a good seed bed. The subsoil is permeable and is absorptive and retentive of moisture.

This soil is typically and extensively developed in the northern part of the Montezuma Hills. It has a rolling or hilly surface relief, and drainage is good. Practically all the land is under cultivation, with wheat occupying about 80 percent of the cultivated acreage and barley the rest. The yields are similar to or slightly lower than those on Montezuma clay adobe. Denverton clay adobe is inherently fertile and well adapted to grain production under dry-farming practices. Sheep production, when practiced as a side line, returns a good revenue and assists in balancing the farm program.

**Denverton clay adobe, light-textured phase.**—The light-textured phase of Denverton clay adobe embraces soil areas of loam texture, that have the same sequence of soil layers as the typical soil and like depth to the calcareous partly consolidated bedrock that underlies typical Denverton clay adobe. Soil of the light-textured phase has a poorer organic-matter supply than typical Denverton clay adobe,

and it does not have so good a water-holding capacity. It is easily worked and maintained in good tilth and is of comparatively high value for crop production.

A number of bodies of this soil are about 2 miles southeast of Rio Vista Junction and along the western foot slopes of the Montezuma Hills south of this point, and several areas occur about 5 miles northeast of Fairfield and 2 miles north of that point. The soil occupies low rolling hills with well-developed drainage.

About 80 percent of the land is under cultivation, with wheat and other grain crops occupying about 90 percent of the cultivated acreage. A few small plantings of grapes, apricots, and other fruits occupy the other cultivated areas. Fruit yields are somewhat lower than on the alluvial-fan soils, and the yields of grain are not so high as on typical Denver clay adobe. The highly calcareous subsoil limits the value of the land for fruit growing, and the poorer moisture-holding capacity renders it less well adapted to grain growing.

**Konokti, Los Osos, and Hugo soils, undifferentiated, steep phase.**—The group of soils comprising the undifferentiated steep phases of the Konokti, Los Osos, and Hugo soils includes areas of rough and mountainous surface relief in which the difficulty and expense of examination incident to detailed mapping was not thought warranted at this time. Owing to the rough and mountainous relief, the soils are generally unsuited to cultivation, though some of the more open treeless areas afford good grazing (pl. 1, A), and with future development small areas of this land may be cultivated.

These undifferentiated soils occur only in one body in the northwestern part of the area surveyed. Probably the greater part of this body consists of Konokti stony clay loam, and other parts, particularly in the southern part of the body, are similar to the Los Osos and Hugo soils. This land is largely brush and tree covered and is valued only for the slight amount of grazing it affords or for the firewood and fence posts produced.

#### ALLUVIAL-FAN AND PLAINS SOILS

The brown alluvial-fan and plains soils include the Yolo, Columbia, Conejo, Esparto, Zamora, Capay, Lindsey, Antioch, Olcott, and Solano soils. The Yolo, Columbia, and Conejo soils are characterized by permeable friable surface soils and subsoils, which are readily penetrated by roots, air, and moisture. The soils of this group have been subject to overflow in the past, though at present they are seldom, if ever, inundated and are for the most part well drained. Under irrigation they require more frequent applications of water than the soils having somewhat more compact or heavier-textured subsoils. Columbia silty clay loam and the calcareous phase of Yolo silty clay loam occupy the more pronounced channel ridges bordering the larger streams and are slightly looser and more pervious than the other soils of this group.

The slight elevation of the soils of this group gives slightly better protection from frost, and the soils are well adapted to early fruits grown in this section, especially cherries and plums. Near the island district they are utilized largely for pears, though the moister spring

weather of this section is apparently favorable to the spread of fire blight and many of the orchards are being pulled out. In this section some vegetable crops, such as parsnips, carrots, beets, and lettuce, produce good seed crops on these soils, and most of the former orchard lands are now being used to grow vegetable seed. Though these soils are well adapted to peaches, plums, prunes, and a number of other fruits, such fruits are not being planted extensively at present, owing to the expense involved and the uncertainty of a market.

With the exception of Conejo clay loam and the calcareous phase of Yolo silty clay loam, the upper subsoil layers of these soils are slightly darker than the surface soils, owing to staining by organic colloids, and they are slightly more compact or heavier textured. The lower subsoil layers consist of light-colored material showing no effects of weathering. These soils have weathered sufficiently to develop a slight profile a little more favorable to the absorption and retention of moisture. They are readily permeable to plant roots, air, and moisture to a depth ranging from 6 to 10 feet or deeper. They occur mostly on the lower stream ridges or on alluvial fans. The two soils mentioned are of better moisture-holding capacity and are better supplied with organic matter, or humus, than the other soils of this group, and they are more permeable than the older soils of the alluvial fans and plains.

The Esparto, Zamora, Capay, and Lindsey soils of the alluvial-fan and plains soils group are also brown or dull grayish brown, and they are underlain by appreciably darker upper subsoil layers and lighter-colored lower subsoil layers. They have been weathered more than the Yolo and Conejo soils, and their upper subsoil layers show an appreciable accumulation of clay and colloidal material, though they are penetrated by plant roots and moisture. These soils have a high water-holding capacity and, where well drained, are generally fertile and well adapted to agriculture. The Esparto and Zamora soils have good surface drainage and subdrainage, the Capay soils have slightly restricted subdrainage, and the Lindsey soils are poorly drained and frequently covered with water during a part of the rainy season. These soils are apparently better adapted to shallow-rooted general farm crops than are the other soils of this physiographic division that have less well-developed profiles. The Lindsey soils are adapted only to grazing and are not valued highly even for that purpose.

The Antioch, Olcott, and Solano soils are distinctive, in that the surface soils are of loose friable light-brown or light grayish-brown material. At a depth ranging from 15 to 20 inches the surface soils change abruptly to dull dark-brown sandy clay or clay. The upper subsoil layers are tight and compact when moist, but on drying break to a columnar structure (pl. 2, B). The lower subsoil layers are light-colored more friable material. The dense compact subsoils are comparatively impervious to air, and they materially retard the penetration of plant roots or water. During the rainy season the surface soils are frequently saturated and become soft and boggy. In wet seasons fall-sown grain frequently drowns out on these soils, and in dry years crops soon suffer from lack of moisture early in the summer. Though the soils have a higher water-holding capacity, the tight heavy-textured subsoils give up moisture slowly and the soils

are therefore comparatively droughty. They occupy level or gently sloping plains or terraces. Surface drainage is generally good, except in the Solano soils, though subdrainage is restricted by the tight subsoils. The soils of this subgroup are utilized principally for grazing, though small acreages are devoted to grain crops each year and satisfactory yields are obtained in favorable seasons. In the better-drained areas grapes are fairly well adapted to these soils, though yields are generally low. The soils are probably best adapted to grazing or to shallow-rooted annual crops when market conditions warrant their production.

**Yolo silty clay loam.**—The surface soil of Yolo silty clay loam is brown or dark dull grayish-brown friable material with minor lighter-brown inclusions, to a depth ranging from 9 to 12 inches. As occurring in this area, the upper subsoil layer, to a depth ranging from 36 to 48 inches, consists of slightly compact and of similar or slightly heavier textured dark-brown or dark grayish-brown material. The lower subsoil layer, to a depth of more than 6 feet, is light-brown or pale yellowish-brown friable material of about the same texture as the surface soil. The soil is derived largely from material outwashed from deposits of sandstone or shale, though it is recognized as containing some material of basic igneous origin. It occupies alluvial fans and low stream terraces, and most of the land is well drained.

As typically developed the surface soil is moderately well supplied with organic matter. It is friable and easily maintained in good tilth if cultivated at the proper moisture content, though it is of rather high clay content. The subsoil is sufficiently heavy textured and compact to have a good water-holding capacity, though it is sufficiently porous and friable to allow deep penetration of plant roots, air, and moisture.

As mapped in this area Yolo silty clay loam includes small bodies of somewhat lighter color, looser consistence, and lower moisture-holding capacity.

This soil is adapted to a wide range of crops and is generally regarded as of high agricultural value. Typical areas are confined largely to the Suisun Valley, though small bodies occur elsewhere along small drainage ways, notably in the Montezuma Hills 3 miles west of Rio Vista and in a small valley north of Southampton Bay. Practically all the land is under cultivation, the greater part being utilized in fruit production and the rest mainly for wheat and barley. Cherries, prunes, plums, apricots, pears, grapes, and small acreages of other fruits and walnuts are grown. Cherries yield from 3,000 to 3,500 pounds an acre, prunes from 1 to 2 tons of dried fruit, plums from 3 to 4 tons, apricots from 2½ to 4 tons, and other fruits equally as well. The yields of wheat and barley are about the same or somewhat higher than on the Montezuma and Denverton soils.

The lighter-colored areas having looser subsoils occur along Suisun Creek from a point near Manka southward to the rocky butte northeast of Cordelia. They are all under cultivation, with a variety of fruit trees occupying about 95 percent of the land. Areas not in fruit are used for truck crops, including asparagus, lettuce, peas, and tomatoes. Tree fruits grown include peaches, in addition to the other fruits grown on this soil.

**Yolo silty clay loam, poorly drained phase.**—The poorly drained phase of Yolo silty clay loam differs from the typical soil in having poorly developed subdrainage. The surface soil is similar to that of the typical soil, but the subsoil is highly mottled with rust brown and drab, and during the rainy season the water table stands at a depth ranging from 2 to 4 feet below the surface. Low concentrations of alkali salts occur in some of the lower-lying areas in the vicinity of the marshlands about 3 miles southwest of Suisun.

Areas of this poorly drained soil are in the lower part of Green Valley, bordering the marshlands east of Cordelia, and a comparatively large body occurs at Suisun, extending westward about 1½ miles.

About 50 percent of the land is under cultivation, and the uncultivated areas are used for grazing. The cultivated areas are used in the production of grain crops, pears, asparagus, and alfalfa. Alfalfa stands are rather short-lived, and grain yields are sometimes reduced by injury from alkali salts. In the alkali-free areas, truck crops seem especially well adapted to the soil, and pears are perhaps better adapted to it than any other fruit crop.

**Yolo silty clay loam, calcareous phase.**—The calcareous phase of Yolo silty clay loam has a light-brown or rich-brown calcareous surface soil and subsoil. Some of the land does not contain lime in the surface soil, though the subsoil is everywhere calcareous. The largest area lies northeast of Armijo. Near the marshlands the subsoil is in most places darker than typical and consists of poorly drained marshy sediments. Three small areas of this character border the marshland south of Cordelia, a fourth is one half mile south of Goodyear, and a fifth is on the alluvial fan about 2 miles east of Cordelia. About 50 percent of this calcareous land is under cultivation, and the remainder is used for grazing. With the exception of about 5 percent of their acreage, the cultivated areas are used for grain production, and they return very good yields of wheat and barley. Truck crops occupy the remainder of the cultivated acreage. The soil seems well adapted to truck crops and might be used more extensively in their culture.

**Yolo silty clay loam, gray phase.**—The surface soil of the gray phase of Yolo silty clay loam is dull gray or light brownish-gray silt loam or silty clay loam. The upper subsoil layer is slightly compact dull-gray loam or clay loam mottled with rust brown. The lower subsoil layer is of about the same texture and color as the surface soil but is highly mottled with rust brown. The soil is subject to seepage from higher-lying land and is poorly drained.

A number of small scattered areas, ranging from 5 to 20 acres each, occur in different places in the area surveyed. Several bodies lie a short distance north and northwest of Cordelia in Green Valley, and two are along the northern boundary of the area a mile northwest of Cannon. About 15 percent of the land is under cultivation in connection with better-drained soils. Grapes occupy most of the cultivated acreage, and the uncultivated areas afford fairly good grazing.

**Yolo silty clay loam, dark-colored phase.**—Yolo silty clay loam, dark-colored phase, is characterized by a dull-gray, dull brownish-gray, dark brownish-gray, or dark dull grayish-brown surface soil

which extends to a depth ranging from 8 to 12 inches. The upper subsoil layer is slightly compact dull brownish-gray or dark brownish-gray material of slightly heavier texture than the surface soil. At a depth ranging from 38 to 48 inches, the upper subsoil layer is underlain by light-brown or light grayish-brown mildly calcareous material of about the same texture as the surface soil, that continues uniform in character to an undetermined depth below 6 feet. The surface soil is moderately well supplied with organic matter, though it has a tendency to run together and bake badly unless cultivated. It has a fair water-holding capacity and is very permeable.

This soil occupies narrow drainage ways, in which wash from the adjacent hills contributes to a variability in texture and drainage conditions. Some small areas have ponded drainage, and here the soil is darker and generally heavier in texture. In some other areas the texture ranges from loam to sandy loam. However, such areas are of small extent and could not be shown separately on the map.

This dark-colored soil occurs only along drainage ways originating in the Montezuma Hills. It is most extensively developed about 4 miles north of Birds Landing and northwest of Rio Vista.

About 50 percent of the land is under cultivation, and the remainder is used as pasture land. The cultivated areas are used largely for wheat, though some oats and barley are grown. Areas of this soil are somewhat sheltered from the wind, and oats can be grown more successfully here than elsewhere. The yields are lower than on the associated hill soils.

**Columbia silty clay loam.**—Columbia silty clay loam is characterized by light-brown or pale yellowish-brown friable material to a depth of 15 or 18 inches. The subsoil is stratified light-brown or pale yellowish-brown material of about the same texture as the surface soil, and it is highly mottled with rust brown. In local areas some mottling is apparent in the surface soil, especially the deeper part, and the soil material is of more pronounced yellow color than is typical of the Columbia soils, approaching in character the Ramada soils as mapped in the Chico area (14).

Columbia silty clay loam consists of unweathered recent alluvial stream deposits which occupy the channel ridges of the streams and sloughs in the island district of the area surveyed. In the wider areas which fan out onto the central part of the islands, the stream-deposited material becomes thinner and is underlain by dark-colored highly organic soils. In such areas the typical light-brown soil material may range in thickness from a few inches on the outer margins to several feet near the channels of the streams. Most of the areas having a darker-colored subsoil are small and irregular and were not differentiated from the typical soil.

This soil is absorptive and retentive of moisture, is friable and easily maintained in good tilth, and in physical character resembles a soil of lighter texture. It is comparatively poor in organic matter. As mapped, local areas are included in which the surface soil is of fine sandy loam or silt loam texture. Most of these included areas lie near the stream channels or levees.

A large body of this soil is on Sutter Island, and Ryer Island is nearly encircled by an area ranging from a few rods to about one half mile in width. Areas of different sizes occur on all the other

islands northeast of Rio Vista. In the Suisun Bay district a large body in the central part of Grizzly Island is devoted almost exclusively to the production of barley and wheat, the yields of barley averaging about 20 sacks and of wheat about 11 sacks an acre.

Other areas of this soil are wholly under cultivation and are planted to pears, prunes, plums, peaches, and other fruits, and to truck and seed crops. Pears yield an average of about 8 tons an acre, prunes about  $1\frac{1}{4}$  tons, plums 4 tons, and other fruits equally as high. Fire blight, or pear blight, is causing considerable damage to pear trees, and many orchards are being pulled out. Seed crops, such as parsnips, onions, carrots, lettuce, and beets are now being grown on areas formerly devoted to pears. Beets yield about 2,000 pounds of seed an acre, carrots from 800 to 1,500 pounds, and onions from 700 to 1,000 pounds. Some asparagus is grown, and yields are better than the average for the area.

**Conejo clay loam.**—The 8- or 10-inch surface soil of Conejo clay loam consists of dark chocolate-brown or dark dull-brown material. The upper subsoil layer, to a depth ranging from 42 to 48 inches, is slightly compact very dark brown or dark chocolate-brown material of similar or of only slightly heavier texture. The lower subsoil layer is dull-brown or very dark grayish-brown stratified material of about the same texture as the surface soil. Most areas of this soil are well drained, though locally some iron staining or mottling is present in the subsoil, an evidence of poor subdrainage. The soil is slightly weathered and is derived largely from material of basic igneous origin.

Conejo clay loam is a friable soil of comparatively high organic-matter content. Although of high clay content, it is easily cultivated and under good management can be maintained in good tilth. Water, air, and roots penetrate the soil readily, and under cultivation it retains moisture well. Gravelly areas, shown on the map by gravel symbols, occur in the upper part of Green Valley and  $1\frac{1}{2}$  miles north of Rockville. In such areas the gravel constitutes from 10 to more than 20 percent of the soil mass. The gravelly soils have poorer water-holding capacity, and crop yields are, as a rule, less than on the gravel-free areas.

Typical areas of Conejo clay loam are confined largely to the lower part of Green Valley, though a few small bodies lie on fans south of Cordelia and in the vicinity of Rockville. About 90 percent of the land is under cultivation to cherries, grapes, apricots, prunes, and other fruits, and the remainder is grass covered and used for grazing. Cherries yield an average of about 3,500 pounds an acre, apricots from 2 to 5 tons, and other fruits return yields similar to those obtained on Yolo silty clay loam. For continued successful fruit production, leguminous cover crops or other organic manures high in nitrogen should be turned under at intervals. This soil is well adapted to deep-rooted tree crops, as well as to most other fruit and general farm crops of the region.

**Esparto silty clay loam.**—The surface soil of Esparto silty clay loam consists of light-brown or pale yellowish-brown somewhat cloddy but comparatively friable material from 8 to 12 inches thick. The upper subsoil layer, to a depth ranging from 40 to 50 inches, is dull grayish-brown or dark dull-brown compact material of

heavier texture than the surface soil. The lower subsoil layer, to an undetermined depth below 6 feet, is of similar color and of about the same or somewhat heavier texture than the surface soil. This soil is well drained. It has developed by the weathering of material outwashed from rocks of sedimentary origin. The surface soil is rather low in organic matter and high in clay content, though under good cultural practices it can be readily worked down to a mellow granular structure. It has a very good water-holding capacity, and plant roots, air, and moisture penetrate it readily. It occupies alluvial fans or stream terraces with well-entrenched drainage ways.

This soil is most extensively and typically developed in the upper part of Suisun Valley, particularly in the vicinity of Rockville and along the margin of the valley north of that point. A small area occurs at Armijo, and one lies along the northern boundary of the area surveyed north of that place.

Practically all the land is under cultivation, with approximately 90 percent devoted to fruit growing and the remainder to grain. Prunes, plums, peaches, cherries, grapes, and other fruits adapted to the local climatic conditions are grown successfully, with yields similar to those on Yolo silty clay loam. The turning under of organic matter would improve the water-holding capacity, ease of cultivation, and fertility of the soil.

**Esparto silty clay loam, light-textured phase.**—The surface soil of the light-textured phase of Esparto silty clay loam is of fine sandy loam texture. The soil conforms in color to typical Esparto silty clay loam, though the subsoil is comparatively heavy and is underlain by compact sediments. The soil is low in organic-matter content and is of rather low water-holding capacity.

Soil of this phase occupies low mounds or ridges, where drainage ranges from good to excessive. A body including about 300 acres is in the north-central part of the area about 4 miles east of Cannon. None of the land is under cultivation, but it is used as grazing land in connection with lower, more poorly drained adjoining soils. Native grasses make a vigorous growth on this soil.

**Zamora fine sandy loam.**—Zamora fine sandy loam is characterized by dull-brown, dark dull-brown, or rich-brown friable material to a depth ranging from 8 to 12 inches. The upper subsoil layer is dark dull brown, dark chocolate brown, or dull grayish brown in color, very compact, and appreciably heavier textured than the surface soil. At a depth ranging from 30 to 45 inches, the subsoil becomes dull-brown or pale yellowish-brown moderately compact material usually of about the same texture as the surface soil. This soil is derived largely from the weathering of material outwashed from sedimentary rocks, and it occupies alluvial fans and stream terraces well above overflow. Drainage is well developed.

Zamora fine sandy loam is moderately well supplied with organic matter, is friable and easily cultivated, and can be easily prepared for seeding. It has a good water-holding capacity and is well adapted to the more intensified forms of agriculture practiced in this section. As mapped, the texture of the surface soil varies slightly, some small areas being of loam or sandy loam texture, but such slight variations have little bearing on the agricultural value or

utilization of the land. A few small areas west of Cordelia have rather poor subdrainage and are not so well adapted to agriculture as the better-drained areas.

A comparatively large body of this soil lies at the eastern end of the Potrero Hills, several areas are north of Vallejo, and several are on the alluvial fans near the mouth of American Canyon. About 35 percent of the land is under cultivation, and the remainder is utilized as pasture land in connection with the dairy industry. Fruits and grain occupy about equal areas of the cultivated acreage. The yields are slightly lower than on Rincon clay loam.

**Zamora clay loam.**—Zamora clay loam is somewhat more difficult to handle than the lighter-textured Zamora fine sandy loam, which it resembles except in its heavier texture, though it is better supplied with organic matter and has a better water-holding capacity than that soil. The clay loam is permeable and is well adapted to intensive agricultural practices. Under virgin conditions the soil is heavily carpeted with native grasses in the spring, which afford excellent grazing.

Zamora clay loam is extensively and typically developed in a rather large area a short distance south of Cordelia. A number of smaller areas are near Vallejo and on alluvial fans and the bottoms of streams originating in the mountainous area between Vallejo and Cordelia. Comparatively large areas occur along Laurel Creek and on an alluvial fan a mile north of Vanden.

About 70 percent of this soil is under cultivation, of which the greater part is devoted to tree fruits, principally prunes, and a few rather large plantings of grapes. About 25 percent of the land is utilized in the production of wheat and other grains. Yields of wheat range from 5 to 18 sacks an acre, depending on the season and the previous cropping practices. Prunes yield from three fourths to 1½ tons of dried fruit. Most of the grapes grown are of the wine, or juice, varieties, and yields range from 2 to 4 tons. This soil is well adapted to irrigation where water is available.

**Capay loam.**—Capay loam is characterized by a dull-brown or dull grayish-brown surface soil from 9 to 12 inches thick. The upper part of the subsoil is dark dull-brown, dull grayish-brown, or lighter-brown compact material, typically of appreciably heavier texture than the surface soil. The material in this layer is porous, and the insides of the channels or cavities are coated with dark-colored colloidal material. The lower part of the subsoil, which extends from a depth ranging from 40 to 50 inches to an undetermined depth below 6 feet, is light-brown or pale yellowish-brown friable material of variable texture. This lower layer contains varying quantities of lime carbonate which in most places is more or less disseminated but may occur in small nodular accumulations. Material outwashed from sedimentary rocks has contributed largely to the formation of this soil, though it is recognized that material of basic or acid igneous origin has also entered into its formation. The surface soil is fairly well drained, but subdrainage is restricted.

This soil is friable and easily cultivated, though it is of heavy loam texture. It has a comparatively high content of organic matter and is absorptive and retentive of moisture under cultivation, though it loses moisture rather quickly when not cultivated. The soil con-

tains considerable medium-textured sand, and in local areas the texture may closely approach a sandy loam. In other places, areas of heavier clay loam texture may be included.

The largest areas of this soil are in the vicinity of Cannon and north of Scandia School. Two small unimportant areas lie east of Vallejo, and two of comparatively slight importance are about a mile west of Fairfield.

About 65 percent of the land is under cultivation. Of the cultivated acreage, only about 60 acres are devoted to fruits and the remainder is used in the production of wheat and barley. Wheat yields from 5 to 15 sacks and barley from 10 to 30 sacks an acre. The uncultivated areas support a good growth of grass and are of comparatively high value for grazing.

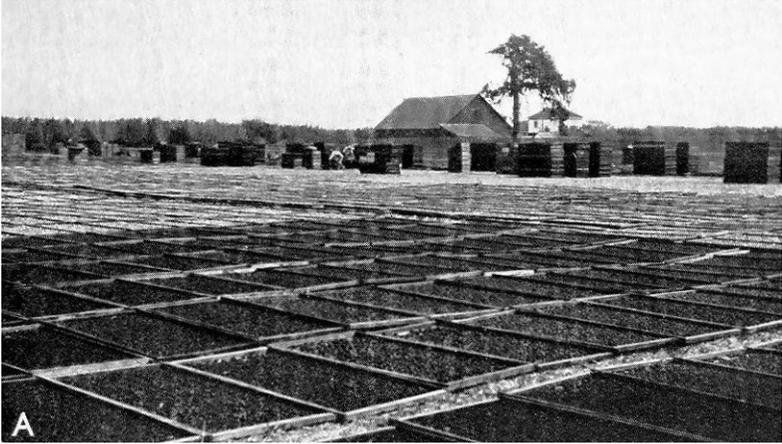
**Capay silty clay loam.**—Capay silty clay loam is similar in general characteristics to Capay loam, but it is of slightly darker and duller color, heavier texture, and less friable consistence. Though of heavy texture and of somewhat cloddy character, this soil can be readily worked down to a fine granular seed bed under good cultural practices. The soil has a comparatively high organic-matter content and is absorptive and retentive of moisture under cultivation. When not cultivated it tends to check into cracks an inch or two in diameter, which extend to a depth ranging from 3 to 4 feet. This hastens the drying out of the soil during the dry summer months.

Capay silty clay loam is one of the more extensive plains soils of the area. It occupies a large part of the plains west of Maine Prairie. The smaller areas are toward the west where the plains merge into the alluvial fans at the base of the mountains. A rather large area is in lower Suisun Valley west of Fairfield, and many small bodies occupy local depressions or areas of poor subdrainage throughout the area surveyed.

About 60 percent of the land is under cultivation, and the rest is used largely as grazing land for sheep. Of the cultivated acreage about 20 percent is used for pear, prune, apricot, and plum orchards, and the remainder is utilized largely in the production of grain under dry-farming practices. Pears yield from 2 to 5 tons an acre, dried prunes an average of about  $1\frac{1}{4}$  tons, apricots about  $2\frac{1}{2}$  tons, and plums about 3 tons. The yields of wheat and barley vary, depending on the season and the care exercised in the preparation of the seed bed but, in general, they average somewhat lower than on Capay loam. During unusually wet seasons fall-sown grain frequently drowns out.

**Capay silty clay loam, heavy-textured phase.**—The surface soil of the heavy-textured phase of Capay silty clay loam is of clay texture. The soil is rather hard to handle, but if plowed when dry it crumbles to a medium-granular structure with the first fall rains. If it is not puddled by working when too wet, it can be handled with only slightly more effort than typical Capay silty clay loam. It is well supplied with organic matter and has a high water-holding capacity. Owing to the high content of clay the soil gives up moisture slowly, and crops generally return unsatisfactory yields in dry seasons.

The largest area of this soil and a number of smaller areas are at Fairfield. A number of small bodies are along the northern margin of the Montezuma Hills, in the plains section at Maine Prairie, and



A, Fruit-drying yard in Suisun Valley. B, Profile of Olcott fine sandy loam, gray phase, showing solonetz structure. Note rounded tops of columns in B horizon, coated with a thin gray siliceous layer.



west of that place. About 20 percent of the land is under cultivation and is used exclusively for grain production. The yields are fairly high except in wet seasons when much of the fall sown grain is drowned out. Spring sowing of grain cannot be practiced in most places, because of the wet condition of the soil, and the grain must be sown early in order that it may mature before the soil dries out. Uncultivated areas afford very good grazing.

**Lindsey clay loam.**—The surface soil of Lindsey clay loam consists typically of dull-gray, dark-gray, or dull brownish-gray material extending to a depth of 8 or 10 inches, in many places having a shade of yellow and in spots containing some lime. The upper part of the subsoil, to a depth ranging from 30 to 48 inches, is dull brownish-gray or dull yellowish-brown moderately heavy textured compact material that is in most places slightly calcareous. The deeper part of the subsoil, to a depth of more than 6 feet, is brownish-gray or pale yellowish-gray highly calcareous material of similar or lighter texture. In most places the lime occurs in hard nodules or concretions, though the entire mass of the deeper subsoil is calcareous.

The soil occupies low areas with poorly developed drainage. The surface soil is deflocculated and when dry is hard and baked. It contains a large proportion of fine sand and very fine sand, but its physical characteristics are indicative of a much heavier textured soil than is shown by mechanical analysis.

Lindsey clay loam has a comparatively high water-holding capacity, though it takes water slowly and loses it rapidly unless cultivated. It is low in organic-matter content, and most areas contain more or less alkali. During the rainy season many areas of this soil are covered with water for weeks or months at a time, and during the dry season the water table in local areas lies from 3 to 5 feet below the surface.

The largest areas of this soil occur northeast of the Montezuma Hills bordering the Yolo Basin, and a large number of small bodies, ranging in size from 5 to 20 acres, are associated with the plains soils in the north-central part of the area. About 5 percent of the land is under cultivation in connection with better agricultural soils. Yields of barley are in general low. Much of the land is barren of vegetation and under the best of conditions affords but scant grazing. It has little potential value for agriculture.

**Antioch fine sandy loam.**—The surface soil of Antioch fine sandy loam, as developed typically in this area, is light-brown or light grayish-brown friable granular material which extends to a depth ranging from 16 to 20 inches. It passes abruptly into dark dull-brown dense compact clay which breaks into small or medium-sized columns when dry, changes to a lighter-brown color at a depth ranging from 30 to 36 inches, and is underlain to a depth ranging from 40 to 46 inches by slightly lighter textured material of small cubical structure. Lime-carbonate nodules or accumulations form gray specks or blotches throughout this layer. The deeper part of the subsoil, to a depth of more than 6 feet, is pale yellowish-brown material of dense consistence and of about the same texture as, or perhaps slightly lighter or heavier than, the surface soil. This soil is developed on sedimentary materials of mixed origin and occupies alluvial plains and terraces.

The surface soil is friable and easily tilled, though it is poor in organic matter. The soil has a high water-holding capacity, though the subsoil takes water and gives it up to plants very slowly. Following heavy rains the land is boggy in most places.

As mapped, some areas of this soil are of heavy fine sandy loam texture, closely approaching a loam. The soil also includes a small area at the head of Hill Slough north of the Potrero Hills, which has poorly developed drainage and in which some alkali is present.

Antioch fine sandy loam is the most extensively developed plains soil of the area. It occupies a large proportion of the plains north of the Potrero Hills and extends eastward along the foot slopes of the Montezuma Hills. A large area lies along the western slopes of the Montezuma Hills south of Birds Landing, and a few small areas occur along the foot slopes of the mountains west of Suisun Marsh and in the vicinity of Vallejo. About 20 percent of the land is under cultivation, and the remainder is valued as grazing land for sheep. Much of the land under cultivation from year to year is used for grazing land and is broken up only when it becomes foul with weeds. Wheat and barley are the principal cultivated crops, and yields are good if climatic conditions are favorable. In seasons of low rainfall yields are reduced, owing to lack of moisture, and in seasons of unusually high rainfall the fall-sown grain sometimes drowns out. Wheat yields average about eight sacks an acre. The heavy clay subsoil limits the agricultural use of the land to the shallow-rooted annual crops or to early-maturing shallow-rooted tree or vine crops. Under present economic conditions the soil is probably best adapted to grazing and to grain production.

**Antioch fine sandy loam, dark-colored phase.**—The dark-colored phase of Antioch fine sandy loam is characterized by a dark dull-brown or dull grayish-brown surface soil overlying a subsoil similar in all respects to the subsoil of typical Antioch fine sandy loam of this survey, except that the upper part of the subsoil is a shade darker than in the typical soil. The dark-colored soil has a slightly better content of organic matter, but otherwise it has about the same cultural properties as the typical soil. It occurs along the southern slopes of the Potrero Hills and along the Montezuma Hills northwest of Birds Landing, occupying a total area of 1,664 acres. About 10 percent of the land is cropped to wheat in alternate years under dry-farming practices. Yields are slightly higher than on typical Antioch fine sandy loam.

**Olcott fine sandy loam.**—Olcott fine sandy loam has a brown, light-brown, or pale reddish-brown surface soil extending to a depth of 15 or 18 inches. This layer changes abruptly to a dull reddish-brown or rich-brown heavy plastic clay or sandy clay subsoil that continues to a depth ranging from 34 to 42 inches. The material in the subsoil is dense and amorphous when wet, but on drying it assumes a columnar or prismatic structure. The lower part of the subsoil, to a depth of more than 6 feet, is dense compact light yellowish-brown or pale-yellow partly consolidated material. When brought up on an auger, it is mottled with gray and rust brown. The soil is developed on old sedimentary materials of mixed origin. Surface drainage is fairly well developed, but subdrainage is restricted.

The surface soil is loose and friable and can be easily worked down to a fine-granular seed bed though it contains, according to mechanical analysis, a comparatively high proportion of clay. The material is low in organic-matter content, tends to run together and bake on drying, and loses moisture very rapidly. The heavy subsoil retards root penetration and materially impedes the downward movement of air and moisture. Following heavy rains, the surface soil becomes saturated and the land is boggy. Though the soil has a high water-holding capacity, the heavy clay layer limits root development to the upper soil layers, and crops soon suffer from lack of moisture during the hot, dry summers.

This soil occurs only on the better-drained plains. It is extensively developed in the vicinity of Olcott, a great number of areas border the low hills in the central part of the plains section, and several bodies border the Potrero Hills. One small body lies a short distance north of Vallejo in the western part of the area.

About 25 percent of the land is under cultivation, and the remainder, which supports a good stand of native grasses, is valued as grazing land in connection with the sheep industry. Some small plantings of fruit are on the land, though most of the cultivated acreage is devoted to grain production. Yields of fruit are generally low, though the fruit is of good quality and is sufficient for home needs. Grain crops yield about the same as on Antioch fine sandy loam. The agricultural utilization of the land is limited mainly, because of the dense impervious character of the subsoil, to the production of grain and to grazing.

**Olcott fine sandy loam, gray phase.**—The gray phase of Olcott fine sandy loam has a dull-brown, dark grayish-brown, or dark brownish-gray surface soil and a tight compact heavy-textured subsoil similar to that of typical Olcott fine sandy loam, except that the upper part of the subsoil is somewhat darker colored (pl. 2, B). In places the lower part of the subsoil and the substratum contain nodules or accumulations of lime carbonate. The soil of this phase is somewhat better supplied with humus than typical Olcott fine sandy loam, though it has the same limitations as to culture and utilization. This gray soil occurs only on the alluvial terraces along the western foot slopes of the Montezuma Hills. It is most extensively developed south and east of Denverton. About 15 percent of the land is used, in connection with better soils, in the production of wheat. Yields are generally low, averaging slightly higher, however, than on Antioch fine sandy loam.

**Olcott fine sandy loam, shallow phase.**—The shallow phase of Olcott fine sandy loam is similar in all respects to the typical soil, except that the underlying substratum of partly consolidated materials is reached at a depth ranging from 24 to 30 inches. In some areas the abrupt transition from surface soil to subsoil is not so pronounced as in typical Olcott fine sandy loam. This shallow soil has a low water-holding capacity, though it is easily cultivated and prepared for crops. It occurs only in two areas, one including about 300 acres and the other about 20 acres, bordering or occupying the low hills southeast of Cannon. None of the land is under cultivation, but it is utilized for grazing. It has little or no value for the production of cultivated crops under present economic conditions.

**Solano fine sandy loam.**—The surface soil of Solano fine sandy loam is light-gray or light yellowish-gray deflocculated material extending to a depth ranging from 5 to 18 inches, shallower material occurring in somewhat eroded areas. The surface soil changes abruptly to yellowish-brown or grayish-brown tight compact clay or sandy clay that is moderately calcareous. The lower part of the subsoil is pale yellowish-brown or pale yellowish-gray highly calcareous material of similar or somewhat lighter texture. Hard lime-carbonate concretions are numerous in the lower part of the subsoil.

This soil is poorly drained and contains more or less alkali. The surface soil is poor in organic matter, and when not cultivated the material runs together and bakes badly on drying. When cultivated it is easy to handle and works down readily to a fine-granular seed bed. Owing to the heavy tight subsoil, moisture penetrates the soil slowly, and following heavy rains the land is boggy. The heavy clay subsoil limits the rooting zone of plants largely to the surface soil.

As mapped, this soil includes three small undifferentiated areas of clay loam texture. One is  $1\frac{1}{4}$  miles southwest of Scandia School, the second is 1 mile south of this school, and the third is one half mile northwest of Denverton. Areas of the typical soil are just south of Scandia School and at Denverton.

About 100 acres of this soil are used in the production of grain crops, principally wheat, and the rest of the land is utilized only for grazing. Yields of wheat range from 4 to 20 sacks an acre. This soil has little agricultural value other than for grazing.

**Solano fine sandy loam, hummocky phase.**—The hummocky phase of Solano fine sandy loam differs from the typical soil in the thickness of the surface soil and in the presence of alternate hummocks and depressions over the surface. The surface soil on the tops of the hummocks is similar in thickness to the typical soil, but at the edges it is only a few inches thick. Large areas of this hummocky soil occur west and southwest of Olcott, and a number of smaller areas are in this same general section. The land is not used for cultivated crops but affords a fair amount of grazing for sheep. Under present economic conditions the value of the soil is limited to grazing.

#### ISLAND AND BASIN SOILS

The island and basin soils include the Egbert, Sacramento, Clear Lake, and Stockton soils which, in general, are dark gray, dull gray, or black. Those without profile development, represented by the Egbert soils, have a high organic-matter content and are loose and permeable to a depth of more than 6 feet. The subsoils are characterized by alternating strata of muck, peat, or river sediments. Except where protected by levees, these soils are subject to annual overflow and are more or less swampy. The water table stands at a depth of about 3 feet, and the soils are best adapted to truck crops. In the Suisun area they are utilized almost exclusively in the production of asparagus. Sugar beets, beans, celery, and milo are grown on small acreages. The Egbert soils are easily cultivated, have a high water-holding capacity, are fertile, and produce heavy yields. In the vicinity of Suisun and San Pablo Bays many bodies of these soils contain appreciable quantities of salt and are valued only for grazing.

The surface soils of the Sacramento, Clear Lake, and Stockton soils are composed for the most part of heavy-textured dark-colored sediments. The subsoils are lighter colored, lighter textured, and contain more or less lime. The Stockton soils have a compact and partly cemented lower subsoil layer, but the other soils of the group have slightly compact though permeable subsoils to a depth of more than 6 feet. These soils have poorly developed drainage, and water frequently stands over the surface during the rainy season unless the soils are protected from overflow by levees. The Sacramento soils are largely under cultivation and are used largely in the production of asparagus, grain, alfalfa, pears, celery, beans, sugar beets, and milo. Small acreages of the Clear Lake and Stockton soils are used for grain production, though for the most part they are valued for grazing.

**Egbert loam.**—Egbert loam is characterized by a dark dull-gray or dark brownish-gray granular surface soil to a depth of 12 or 15 inches. This layer is underlain, to a depth of more than 6 feet, by dark-gray or dark brownish-gray stratified muck, peat, and stream-laid sediments. The surface soil contains large quantities of peaty material, and the subsoil at a depth ranging from 30 to 36 inches in many places has a thin layer of partly weathered peat. Organic material probably constitutes from 10 to 20 percent of the surface soil and not less than 20 percent of the subsoil mass.<sup>4</sup> This soil is developed in flat shallow basins with poor drainage, where partly decomposed organic materials from tules, reeds, and sedges have accumulated for centuries and, together with the sediments brought in by flood waters, have built up the soils.

Egbert loam is granular, friable, and readily penetrated by plant roots, air, and moisture. It has a high water-holding capacity and under cultivation retains moisture well. The water table stands at a depth ranging from 30 to 40 inches. The proportions of organic matter and mineral matter are such that the soil is very fertile and returns high yields. This soil is most extensively developed in Yolo Basin, west of Cache Slough, on Ryer Island, in the Yolo By-pass between Cache Slough and Miner Slough, and in the central and southern parts of Grand Island.

Practically all the land is under cultivation, with approximately 80 percent devoted to asparagus. Small areas are used for celery production during the fall and winter and for growing beans or other annual crops during the summer. Some wheat and barley are grown and give high yields, but trouble is often experienced with the grain lodging. In the Yolo By-pass, where the land is overflowed at irregular intervals, the soil is devoted entirely to annual crops, such as milo, sugar beets, beans, and onions. Milo yields from 1 to slightly more than 2 tons an acre. Onions yield an average of about 400 sacks and sugar beets from 10 to 18 tons. Asparagus gives an average yield of about 4,500 pounds an acre, though yields as high as 10,000 pounds are reported on this soil.

**Egbert loam, mucky phase.**—The mucky phase of Egbert loam consists of areas of Egbert loam having a comparatively high con-

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<sup>4</sup> A typical sample of the subsoil of Egbert loam, taken 1 mile west of the Ryer Island-Grand Island Ferry, showed 30 percent loss on ignition when tested in the laboratory of the Division of Soil Technology, University of California.

tent of decomposed organic matter in the surface soil and an appreciable quantity of muck and peat in the subsoil. This mucky soil contains appreciable mineral material, but the content of organic matter is noticeably higher than in the typical soil.

Areas of this soil occupy the central lower part of Grand Island south of Ryde. The land is used largely in the production of asparagus, with smaller acreages devoted to celery and onions. Yields of asparagus are about the same as on the typical soil, and onions and celery produce slightly higher yields. The soil is especially adapted to annual truck crops.

**Egbert clay loam, light-colored phase.**—Typical Egbert clay loam is not developed in the Suisun area but is represented by a light-colored phase, in which the surface soil material is of heavier texture and of somewhat lighter color than Egbert loam. The heavy texture, however, is largely masked by the high content of organic matter, and the soil is easily cultivated and maintained in a fine-granular state. It is absorptive and retentive of moisture and readily penetrated by plant roots. A rather high water table, standing at a depth ranging from 36 to 45 inches during the summer months, limits the depth of root penetration of all crops grown on this soil.

The soil is extensively developed on Grand Island, Sutter Island, and Ryer Island, and smaller areas are in the Yolo By-pass. The cultivated areas are confined largely to the island and basin country northeast of Rio Vista. The uncultivated areas, which are in general salty, are used largely for pasture, though a few such areas are used to grow asparagus. Areas containing more or less salts border Suisun Bay, particularly on Grizzly, Hammond, Wheeler, Van Sickle, and Chipps Islands. As mapped, these undeveloped salty areas may include some undifferentiated areas of muck and peat.

Practically all the land of this phase lying northeast of Rio Vista is under cultivation, but only a few acres of that bordering Suisun Bay are cultivated. Asparagus occupies about 85 percent of the cultivated acreage, and the rest is used for annual truck crops including onions, celery, tomatoes, cucumbers, and beans. Some grain grown on this soil returns good yields, though grain has a tendency to form a heavy stalk growth and lodge badly. The yields obtained are high where good cultural practices are followed and, in general, they are comparable to those on Egbert loam. This soil is fertile and well adapted to the production of truck crops. The crop grown is determined largely by the market demand and the acre return.

**Sacramento mucky loam.**—Sacramento mucky loam has a surface soil of dark-gray or dark brownish-gray smooth fine-textured mucky material of high organic-matter content, containing fragments of partly decayed as well as more thoroughly decomposed vegetable material. The subsoil is more compact, of dull-gray, brownish-gray, or bluish-gray color, of heavy texture, and of lower organic-matter content. Disseminated or, in places, nodular lime carbonate is present in the lower part of the subsoil, together with some crystals of gypsum. The subsoil contains appreciable quantities of lacustrine-like sediments and but little organic material. Rust-brown and grayish-drab mottlings occur in the lower part of the subsoil.

The surface soil is friable and easily tilled. The subsoil is grayer than that in other Sacramento soils, and it contains a large quantity

of lime. This soil is readily permeable and has a high water-holding capacity. The water table stands at a depth of about 4 feet during the summer and is somewhat higher during the rainy season.

A large body of Sacramento mucky loam lies 2 miles southeast of Maine Prairie, and several areas occur along the margin of Yolo Basin a few miles north of Rio Vista. All the land is under cultivation, about 70 percent being devoted to asparagus growing. Alfalfa is grown for hay on about 20 percent of the land, and the remainder is used for various other truck or general farm crops. Asparagus yields an average of about 4,000 pounds an acre, and alfalfa yields from 4 to 8 tons, depending on the condition of the stand. Owing to imperfect subdrainage, alfalfa is rather short-lived, though good yields of an excellent quality of hay are obtained during the first few seasons.

**Sacramento clay loam.**—The surface soil of Sacramento clay loam consists of dark dull brownish-gray, dark dull-gray, or nearly black clay loam containing an appreciable quantity of partly decayed organic matter. The material is plastic when wet, but under favorable moisture and cultural conditions it is granular and comparatively friable. The subsoil, to a depth of more than 6 feet, is of about the same texture as the surface soil, is somewhat more compact, is of lower organic-matter content, and is of dull-gray, dark brownish-gray, or bluish-gray color mottled with rust brown and grayish drab in the deeper part, which also contains disseminated or nodular lime carbonate. This soil absorbs water readily, retains moisture well, and is easily maintained in good tilth.

As mapped, the soil includes some bodies having a calcareous surface soil and a more permeable better-drained subsoil than other areas. Over most of the soil the water table stands at a depth ranging from about 4 to 5 feet during the summer. Several bodies of the more calcareous soil border Sacramento River in the northern part of Grand Island, and a small area of this character is  $2\frac{1}{2}$  miles south of Denverton. Areas of typical soil occur at Westfield, in the Yolo By-pass a short distance west of Westfield, and several smaller areas are in this same general locality and elsewhere in the northern part of the island district north of Rio Vista.

About 80 percent of the land is under cultivation, and the remainder is marshy and unsuited to cultivation until reclaimed. Asparagus occupies about 35 percent of the cultivated acreage, and the rest is used in the production of milo, beans, sugar beets, onions, and other truck crops. Asparagus yields an average of about 4,000 pounds an acre, sugar beets from 10 to 18 tons, and beans about 1,200 pounds. This soil is well adapted to truck crops and is utilized in their production wherever possible.

**Clear Lake clay adobe.**—The surface soil of Clear Lake clay adobe is dark gray, dark brownish gray, or black in color, of heavy clay texture, and of adobe structure. The upper part of the subsoil, to a depth ranging from 30 to 45 inches, is somewhat more compact dark-gray or black material of about the same texture as the surface soil. The lower part of the subsoil, to a depth of more than 6 feet, is more or less variable, consisting of light-brown or dull yellowish-brown material in the better-drained areas and dull-gray or dull brownish-gray material, with some mottling of rust brown, in the more poorly

drained areas. The lower part of the subsoil ranges from mildly to highly calcareous. This soil occupies depressions or basins and has developed under poor drainage.

The surface soil is intractable and can be worked only under a favorably low moisture content. If the soil is worked when only slightly moist or when dry, it cracks into clods that by continued progressive checking produce a fine cloddy or coarsely granular structure. If worked when too wet the soil loses the desirable structure that alone makes its utilization successful. It absorbs water slowly and retains it well under cultivation, but, as is characteristic of clay soils, it gives up moisture slowly to crops, and, where not irrigated, crops are likely to suffer from lack of moisture during the hot summer months. This soil is well supplied with humus, though it contains little undecomposed organic matter.

Included with the soil in mapping are three small areas that do not have the calcareous subsoil typical of the Clear Lake soils. One body of this character occurs in Jameson Canyon, the second is 2 miles southwest of Manka, and the third is 3 miles north of Fairfield. Large bodies of the typical soil are east of Maine Prairie, extending southward along the border of Yolo Basin to a point north of Rio Vista. A comparatively large area is in Lucol Hollow, in the Montezuma Hills, and a number of smaller ones occupy parts of the drainage ways in this same district. A large number of areas occur in Green Valley, in Suisun Valley, and in the district north and east of Fairfield. A number of small valleys in the vicinity of Vallejo and in the mountainous district northeast of that place are occupied by bodies of this soil. Areas in the plains section are small and numerous.

About 25 percent of the land is under cultivation. On the uncultivated areas bur clover, alfilaria, wild oats, foxtail, and other native grasses make a vigorous growth during the rainy season and furnish pasture to sheep and cattle throughout the year. Wheat and barley are the only crops extensively grown on the cultivated areas, and yields are rather low. A few acres devoted to pears return fair yields.

**Stockton clay adobe.**—The surface soil of Stockton clay adobe consists of dark-gray or black heavy-textured plastic material. The subsoil, to a depth ranging from 30 to 40 inches, is dark-gray or dark brownish-gray material of about the same texture as the surface soil, but somewhat more compact. The lower part of the subsoil to a depth of more than 6 feet consists of light-brown or light brownish-gray partly consolidated material containing an appreciable quantity of accumulated lime. The upper part of the substratum is more firmly consolidated than the lower part and contains more lime. This soil has developed under poor drainage. When cultivated the soil works up to a cloddy structure, and by progressive checking the clods break down to a fine-cloddy or fine-granular condition, which property makes cultivation of the land possible. If plowed when too wet the soil is plastic and difficult to handle and its value for agriculture is largely destroyed. The soil has a good water-holding capacity, though the rooting zone of plants is limited by the cemented substratum, and the heavy texture of the soil material tends to make it rather droughty.

Stockton clay adobe occurs only in a small district bordering Yolo Basin northeast of Rio Vista. About 50 percent of the land is under cultivation, and the remainder, which supports a vigorous growth of native grasses, is valued for grazing. A small acreage of the cultivated land is used for growing asparagus, though the greater part is devoted to alfalfa or grain, being about equally divided between the two. Alfalfa is irrigated and yields from 4 to 8 tons an acre, though, owing to the shallowness of the soil, the stand is not so long-lived as on the deeper soils. Yields of barley or wheat are good in favorable years, though crops are apt to drown out in wet years and suffer from drought in years of low rainfall.

**Muck and peat.**—Muck and peat consist of organic deposits in various stages of decomposition, together with an admixture of small quantities of mineral sediments. The surface material, as a rule, consists of partly decayed organic material and some mineral soil. The subsoil is more or less stratified with fibrous organic material and dark-brown or black completely decayed mucky organic remains. The surface soil is difficult to handle in places where the content of undecomposed fibrous material is high, and the soil, as a rule, is rather poorly adapted to cultivation unless it contains an appreciable quantity of mineral matter. Bodies of this soil bordering Suisun Bay contain various quantities of salt that would have to be leached out before the soil could be profitably cultivated.

A rather large body near the junction of Cache and Miner Sloughs is under cultivation to annual crops, chiefly sugar beets, milo, and baby Lima beans. Many bodies of this soil are on Van Sickle, Chipps, and Grizzly Islands and between Montezuma Slough and Montezuma Hills. Only a few acres in this locality are used for cultivated crops, most of the land being used as grazing land for dairy cattle. Yields of cultivated crops are usually fair if the salt concentration is not too high.

**Marshland.**—Large areas of marshland, particularly in the vicinity of Suisun Bay, are wet and marshy throughout the year, and in some localities tule grows to a height of more than 6 feet. Many sloughs and artificial canals traverse the areas of marshland, making travel on foot practically impossible. As the field party was not equipped with boats or other equipment necessary to cover these areas in detail, the soils have been classed in a group as marshland. This land is in general more or less salty, and it is unsuited to cultivation unless diked and reclaimed. A narrow strip of soil, conforming in general to the Columbia soils, borders the sloughs. The amount of mineral matter in the soil becomes progressively less with distance from the sloughs, and the soil in such positions is generally similar to soils classified in the Egbert series or as muck and peat.

Areas of marshland are south of Suisun and bordering Denverton Slough south of Denverton. The soil on a number of islands occurring in Suisun Bay and on parts of Simmons and Wheeler Islands is classed as marshland. None of this land is under cultivation, and the only use made of it is for grazing cattle or as sites of duck-hunting clubs. If reclaimed, this land should be adapted to the same crops as are grown on the Columbia and Egbert soils.

**Marshland, tidal phase.**—Bordering Suisun Bay north of Simmons Island is a small area consisting of bluish-drab clay and muck which is alternately exposed and submerged by the recurrent tides. This has been classed as marshland, tidal phase. Along the inner margin of this body tules have established a foothold, but the outer margin bordering the bay is barren of vegetation. The soil contains more or less salt and has no value for agriculture unless diked and reclaimed.

**Made land.**—Made land occurs along Sacramento River from Colinsville eastward as far as Steamboat Slough, where the river has been dredged to widen the channel, improving navigation and allowing more rapid drainage of flood waters into Suisun Bay. The materials dredged from the river have been dumped on flat benches adjacent to the river. Made land consists of unsorted river sand, silt, and clay and in most places is several feet thick. In surface texture the material ranges from fine sand to silt loam or clay loam, but there is no uniformity in the occurrence of areas of different texture, their occurrence depending on mechanical disposition of the material from the dredges.

One of the largest areas of made land is northeast of Rio Vista. A few acres of this land are under cultivation in connection with other soils, and fair yields of wheat or barley are obtained. With future development this land should be best adapted to grazing and grain production. The more sandy areas will probably be limited to the grazing of sheep or cattle.

#### SOILS AND THEIR INTERPRETATION

The Suisun area lies along the western margin of that part of the great interior valley of California drained by Sacramento River. The soils have weathered under a distinctive climatic cycle characteristic of the Pacific coast soil region. The summers are warm and dry, and the winters are cool and moist. During the summer, temperatures ranging from 100° to 110° F. are frequently experienced, the mean temperature is about 70°, and little or no rain falls during this period. The winter season is characterized by moderate temperatures, with frosts at occasional intervals, and frequent gentle rains.

Under the prevailing climate, the natural vegetation consists largely of grasses on the well-drained plains, alluvial fans, and lower foothills; oaks and brush occupy the higher hills and mountains; and tules, sedges, and water-loving or alkali-resistant grasses cover the more poorly drained land. On the grass-covered soils a luxuriant growth of wild oats, bur clover, and alfilaria carpet the soils during the rainy season, but with the coming of the warm dry months of summer the plants soon wither, and they remain in a parched brown condition until the coming of the fall rains which beat them to the ground and favor decomposition. The organic matter that accumulates from their decay is largely oxidized and destroyed, however, during late spring, summer, and fall.

The oxides of iron and aluminum, rather than humus, determine the color of the surface soils, with the result that most of the well-drained surface soils are light brown or light reddish brown, and the subsoils are dull brown or dark brown. On the tree- or brush-covered soils, live oaks, white oaks, chamiso, and other low-growing

trees or brush form a fairly heavy vegetal cover, though they contribute little organic matter to the soils. Most of the soils in such localities have surface soils of various shades of brown or reddish brown, and the subsoils are, as a rule, of somewhat redder or richer brown color than the surface soils. Grasses and sedges cover the poorly drained lowlands, and conditions are such that bacterial activity is at a minimum, with the result that humus accumulates rapidly and the soils have dull-brown, dark-gray, or black surface soils, depending on local drainage conditions and the state of decomposition of the organic material.

The soils are never frozen, though results somewhat comparable to freezing are had, in the heavy clay soils or those with high colloidal clay accumulation in the subsoils, by the checking and cracking that takes place as the soils dry out during the summer. Such soils have well-defined jointing planes, and in the soils with well-developed heavy-textured B horizons the numerous vertical joints give well-defined structural forms which are described in detail in connection with soils of the Antioch series.

The soils of the Suisun area fall naturally into the following three physiographic divisions: (1) Soils of the mountainous and hilly areas, (2) soils of the alluvial fans and plains, and (3) soils of the islands and basins. The soils of each physiographic division are further classified into one or more of four groups based on color and stage of maturity of development as expressed in the profile. This group classification is shown in table 3.

TABLE 3.—Soil groups in the Suisun area, California.

Groups on basis of physiographic divisions	Groups on basis of soil profile			
	Soils with unmodified or very slightly developed profiles	Soils with youthful or moderately developed profiles	Soils with well-developed profiles	Soils with pronounced profile development
Brown soils of mountainous and hilly areas.		{Konokti Los Osos Hugo Montezuma Denverton		
Brown soils of alluvial fans and plains.	{Yolo..... Columbia..... Conejo.....}		{Esparto..... Zamora..... Capay..... Lindsey.....}	{Antioch Olcott Solano
Dark soils of islands and basins.	Egbert.....	{Sacramento..... Clear Lake.....}	Stockton	

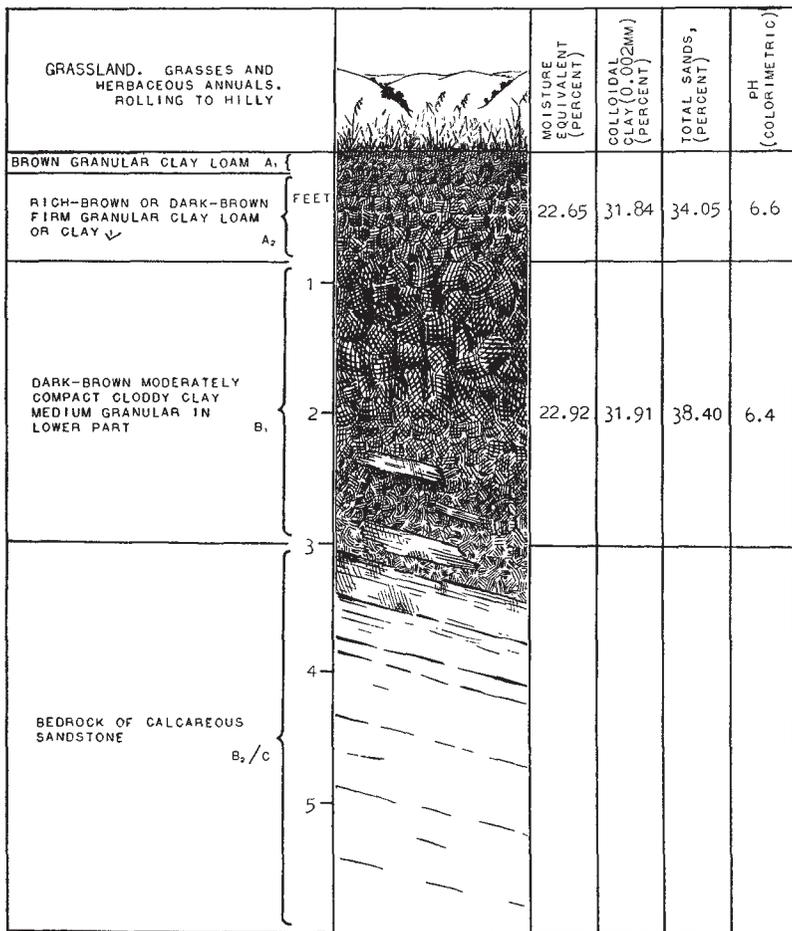
Some of the soil series and types recognized in the Suisun area present apparent conflicts in mapping and classification with those of the earlier reconnaissance surveys of the Sacramento Valley (6) and the San Francisco Bay Region (5). These conflicts and discrepancies are the result in part of differences in the scope, character, and purpose of the two kinds of surveys. The purpose of the earlier reconnaissance surveys was to obtain information of a general character covering a large area of country within a short space of time. The maps were drawn on a small linear scale, and for practical purposes the soils were classified into inclusive related or closely associated series and groups, but in the present survey a smaller area is

mapped in much greater detail, and the classification is the result of much more intensive field observation and technical study. A second dominant factor in creating apparent conflicts in classification is the result of the period of field study, amassing of information, and natural development in the science of soils and their classification since the date of the earlier surveys, resulting in the recognition of many new soil series and the dividing of former inclusive soil series into two or more individual soil series defined on a more detailed and more accurate scientific basis.

The soils of the mountainous and hilly areas have developed in place on the country rocks of consolidated or of soft partly consolidated character. Erosion and soil creep are more or less active and keep pace with weathering agencies, resulting in immature soil development. The surface soils in all except the heavier-textured soils are of soft cloddy and granular structure and are friable. The subsoils are slightly more compact and in part slightly heavier textured than the surface soils, though no B horizon of pronounced accumulation of clay or colloidal material occurs, and these soils partake more nearly of the mineral or chemical character of the parent materials from which they are derived than do other soils in the area. They are predominantly brown, ranging from light brown to very dark dull brown or nearly black. They are represented by soils of the Konokti, Los Osos, and Hugo series developed on the harder rocks, and by soils of the Montezuma and Denverton series developed on softer materials of calcareous character.

A typical profile of the soils of this group is represented by Los Osos clay loam and is shown in figure 2. Under virgin conditions the A<sub>1</sub> horizon, to a depth of about 2 inches, consists of dull grayish-brown or rather rich-brown heavy clay loam or clay of granular structure, which has the physical field properties of a lighter-textured soil than is indicated by the high clay content. Grass roots are very numerous in this horizon and on decaying leave the soil permeated with small threadlike channels which, together with the action of earthworms, give the soil its granular structure when broken up. The A<sub>2</sub> horizon, to a depth of 8 or 10 inches, consists of rich-brown, dull-brown, or dark-brown clay loam or clay of firm consistence until broken up under slight pressure, when it crumbles readily to a medium-granular condition. Like the A<sub>1</sub> horizon the material in this layer is permeated with grass roots and worm channels. A barely perceptible change in color and structure marks the transition from the surface soil to the subsoil, which consists of heavy clay loam or clay of slightly darker color and more compact structure than the surface soil. This horizon contains numerous root channels, though fewer earthworm burrows than the surface soil, and when disturbed it breaks down to a medium or coarse cloddy structure that may be broken down under moderate pressure to a granular condition. At a depth ranging from 26 to 34 inches, the subsoil becomes lighter in color and of slightly lighter texture, and it contains numerous partly weathered chips of the sandstone or shale bedrock from which the soils are derived. This material also contains appreciable pore space, though much less than the horizons above. It is of granular or single-grain structure. The unweathered parent materials contain a slight amount of lime carbonate in local areas, though none occurs within the weathered soil materials.

The Los Osos soils have only recently been recognized as representing a distinct series of soils. They were, in the earlier reconnaissance surveys, included with the Altamont soils which they strongly resemble and from which they are distinguished by the absence of lime carbonate in the weathered soil material which occurs intermittently



∇ SENSIBLE, OR APPARENT, TEXTURE OF HAND SAMPLE IN FIELD

FIGURE 2.—Profile of Los Osos clay loam.

or irregularly in the Altamont soils. Absence of lime in the Los Osos soils may be owing to original absence of lime in the parent rocks or to removal of the lime carbonate from the weathered material by leaching. These soils are thus developed on parent materials having a little lower lime content or under an environment of slightly higher rainfall than the Altamont soils.

The soils of the Hugo series are developed on parent materials which in few places contain an appreciable amount of lime carbonate, though in other respects they are similar to the materials giving rise

to the Los Osos soils. As compared with the Los Osos soils, the Hugo soils are, as a rule, somewhat shallower, apparently conditions have not been so favorable to accumulation of organic matter, and they are more grayish brown or somewhat more yellowish brown. Like the Los Osos soils they were formerly included in the Altamont series.

The Konokti soils are developed on hard rocks of basic igneous character, which are resistant to weathering. These soils are more shallow than the Los Osos soils, are stony in many places, and the parent rock crops out in a few places. The soils are of paler-brown or pale reddish-brown color, possibly due, in part at least, to the higher iron content of the parent materials. In the reconnaissance surveys they were not differentiated but were included with a group of undifferentiated stony soils, and to some extent with the Altamont and the Aiken soils, the latter soils now being recognized as conforming more closely to soils of the Konokti series.

The soils of the Montezuma and Denverton series are developed on partly consolidated calcareous stratified parent materials. They have weathered more deeply and have better-developed profiles than the other soils of this group, which are developed on the more resistant hard rock formations. These soils, with appreciable lime in the parent materials, are more favorable to the accumulation of humus and are darker colored than the soils containing little or no lime. The lower subsoil materials range from mildly to strongly calcareous, the lime occurring mainly as seams and irregular nodules. The subsoils contain no pronounced accumulation of clay or colloidal material and when disturbed break into coarse clods that have no suggestion of the prismatic structure that characterizes many of the older soils of this section.

The Montezuma soils are very dark dull grayish brown or nearly black, but the Denverton soils, which have weathered under conditions less favorable to the accumulation of humus, are of dark-brown or dull-brown color, in which a shade of richer brown is developed under field conditions. The Montezuma soils were first identified and mapped in the reconnaissance survey of the Sacramento Valley. They were, however, not mapped consistently or in detail, and parts of the soil areas now recognized as conforming better to the Montezuma soils were included with the darker-colored and heavier-textured soils of the Altamont and Dublin series. The Denverton soils were at that time mainly included with the Montezuma soils, though they were recognized as representing a development of brown material, conforming otherwise to the Montezuma soils, to which the name Denverton has since been given.

The alluvial fans and plains soils, with but slight profile development, consist of assorted stream sediments that are stratified in character. The sediments are of more or less mixed geological origin, depending on the character of the rocks occurring in the drainage basins of the streams, through the agency of which they have been transported and deposited. They are unweathered or but very slightly modified soils that on weathering will develop definite profile characteristics similar to those in the more mature soils of this physiographic group. They are represented by the Yolo, Columbia, and Conejo soils.

The Yolo soils as occurring in this area have, with local exceptions, developed an incipient B horizon of illuviation, indicated by slight compaction and by dark colloidal staining of the soil aggregates. These features depart slightly from the typical Yolo soils as recognized, without any appreciable modification in profile, in previous surveys.

A typical profile is illustrated by Yolo silty clay loam. The surface soil, to a depth ranging from 9 to 12 inches, consists of brown or dull grayish-brown friable soil having the physical character of a silty clay loam but of high clay content, according to mechanical analysis. The material in this horizon is very porous as the result of the penetration and decay of innumerable plant roots, leaving minute or fairly large channels, and to the action of earthworms. When disturbed, the surface soil breaks up into fairly firm clods that are reduced to a medium-granular structure under slight pressure. In virgin areas the topmost inch or two of surface soil contains a large number of grass roots, and the soil is naturally of granular structure, but under cultivation this characteristic is lost. The surface soil grades into dark dull-brown slightly compact material of similar texture, containing numerous root channels and other pore spaces. The insides of the root channels and other pore spaces, as well as the outsides of structural units, are coated very slightly with dark-brown colloidal material that gives to this horizon its darker color. The colloidal accumulation is very slight and does not stain the insides of structural particles, as, when rubbed between the fingers, the soil from this horizon assumes a lighter-brown color similar to the surface soil. At a depth ranging from 36 to 48 inches the B horizon grades into the C horizon of light-brown or pale yellowish-brown friable material showing no colloidal staining. Root cavities or animal burrows are not so numerous as in the A or B horizons, and they disappear almost entirely at a depth of 6 feet or slightly deeper. The soils of the Yolo series are derived largely from material outwashed from sedimentary rocks.

The soils of the Columbia series consist of unweathered stratified stream-laid materials transported and deposited by the larger streams and derived from a wide range of rocks. Owing to the fact that they occur along low channel ridges and flat marginal island areas, where they are subject to a high water table or have in the past been inundated by flood waters, they are not so well drained as the Yolo soils, and the subsoils are mottled with rust brown and in many places consist of darker-colored materials of higher organic-matter content.

In the earlier reconnaissance mapping in the Sacramento Valley survey, some of the Columbia soils were included with the Sacramento soils, into which they merge, and some narrow areas were not differentiated from the extensive and associated areas of muck and peat, owing to the difficulty of showing them on the small-scale map of that survey.

The Conejo soil, in structural arrangement and sequence of horizons and an incipient stage of weathering, is similar to the Yolo soils, but it is developed on material outwashed from areas of basic igneous rocks and is of darker-brown, dark grayish-brown, or dark chocolate-brown color, the color appearing to be associated with differences in the parent materials.

This soil is somewhat older than the related Vina soils as mapped elsewhere in the Sacramento Valley and has weathered under a slightly higher rainfall, with the result that the Conejo soil is somewhat darker.

The alluvial fans and plains soils that have well-developed profiles have pronounced accumulation of clay and colloidal material in the B horizon. This horizon is noticeably compacted and is underlain by a comparatively friable and permeable C horizon to a

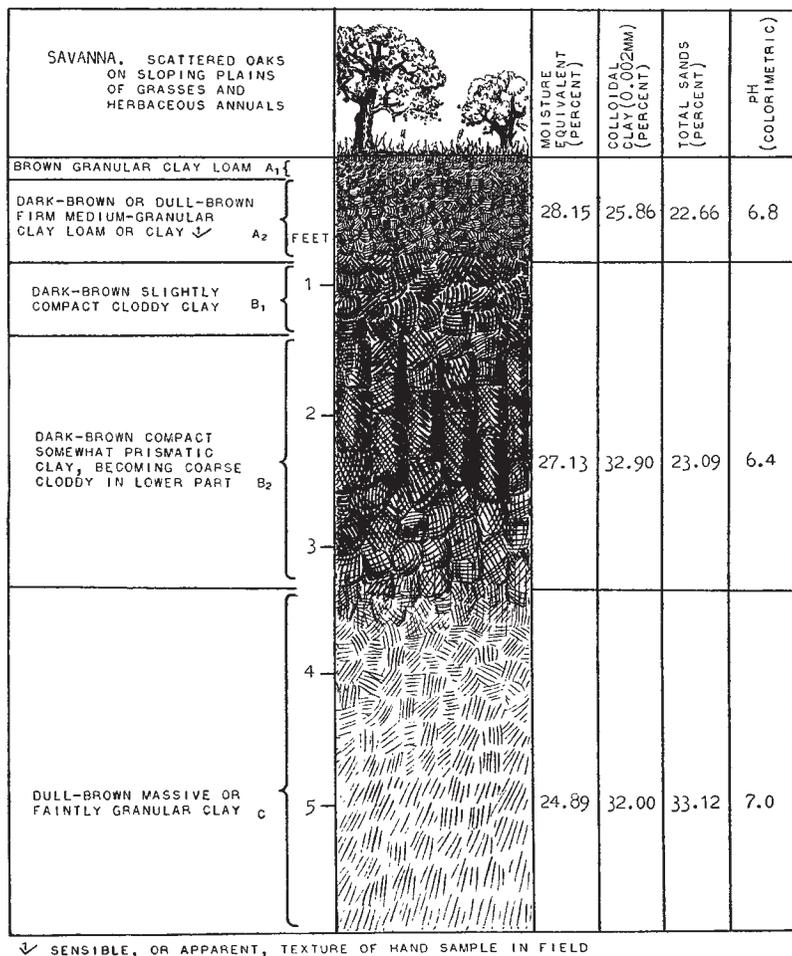


FIGURE 3.—Profile of Zamora clay loam.

depth of more than 6 feet. It may or may not contain lime carbonate, depending largely on local drainage conditions. These soils have developed on old sedimentary materials of mixed geological origin and have been differentiated, on the basis of differences in color, lime content, and drainage, into soils of the Esparto, Zamora, Capay, and Lindsey series.

Zamora clay loam represents a normally developed profile of these soils, as illustrated in figure 3. Under virgin conditions the A<sub>1</sub> hori-

zon, to a depth of 2 inches, consists of dull-brown friable granular clay loam containing an appreciable quantity of grass roots in various stages of decay. The granular structure is the result of inter-lacing root channels and the action of earthworms and other burrowing animals or insects. The  $A_2$  horizon consists of dull-brown or dark-brown heavy clay loam that is very porous and firm until disturbed under slight pressure, when it assumes a medium-granular structure. At a depth ranging from 8 to 12 inches, the  $A_2$  horizon grades into the  $B_1$  horizon, that is of similar or slightly heavier texture and of slightly darker color than the surface soil. The degree of compaction and the clay accumulation increase with depth, until, at a depth of 15 or 18 inches, the  $B_2$  horizon consists of dark-brown or dark chocolate-brown compact clay loam or clay of poorly developed columnar or prismatic structure. The columns extend to the lower part of this horizon and consist of irregular 5- to 8-faced columns that are from 3 to more than 6 inches in diameter. In the lower part the faces are rather poorly developed, and the material breaks to a coarse cloddy structure. Numerous root channels and worm or insect cavities permeate the horizon, though they are not so numerous as in the horizons above. The insides of the cavities, as well as the faces of the jointing planes, are coated with dark-brown colloidal material that stains the soil around the openings and on the faces of the joints. The degree of staining is less intense an eighth of an inch from the opening or joint and in few places extends through a structural particle. The upper part of the  $B_2$  horizon contains a greater accumulation of colloidal material than the lower part, and the staining is consequently greater. The  $B_2$  horizon extends to a depth ranging from 36 to 45 inches and is underlain by dull grayish-brown or dull-brown clay loam or clay, without structural development. A few root cavities are present in this horizon, though they become progressively smaller and less numerous with depth. The material is moderately compact but may be broken to a granular structure under moderate pressure. The soil is weathered from material largely of sedimentary origin, though it is recognized as containing some admixture of igneous materials.

In the earlier surveys the Zamora soils were included mainly with the Yolo, from which they differ in their more advanced stage of weathering. Some of the flatter and more poorly drained areas were included with the Solano soils which in the reconnaissance work were much more inclusive than in the present detailed survey. Small areas occupying local valleys in association with the hill and mountain soils were included with the Altamont soils of those surveys, owing to limited extent and small scale in mapping.

The soils of the Esparto series are moderately well weathered soils of alluvial deposition that have the same structural arrangement and sequence of horizons as occur in Zamora clay loam. The Esparto soils, however, have light-brown or pale yellowish-brown surface soils overlying darker dull-brown material in the B horizon and light-brown or pale yellowish-brown material in the C horizon. The soil material has its origin largely in sedimentary rocks. Like the Zamora soils, the Esparto soils were included in the reconnaissance

mapping mainly with the Yolo soils, but they are now recognized as representing much older soils with a more maturely weathered profile.

The soils of the Capay series are characterized by an accumulation of lime carbonate in the  $C_1$  horizon, which is associated with poorly developed subdrainage. The lime may occur as disseminated lime carbonate in the lighter-textured soils of the series, though as a rule nodular concretions are present in association with disseminated lime in the heavier-textured soils. The soils are weathered to the same degree as those in the Zamora series and have similar structural development. In color the Capay soils are slightly grayer than the Zamora soils, being dull brown or dull grayish brown in the A horizons and dark dull brown in the B horizons. The color of the  $C_1$  horizon, however, is similar in both series.

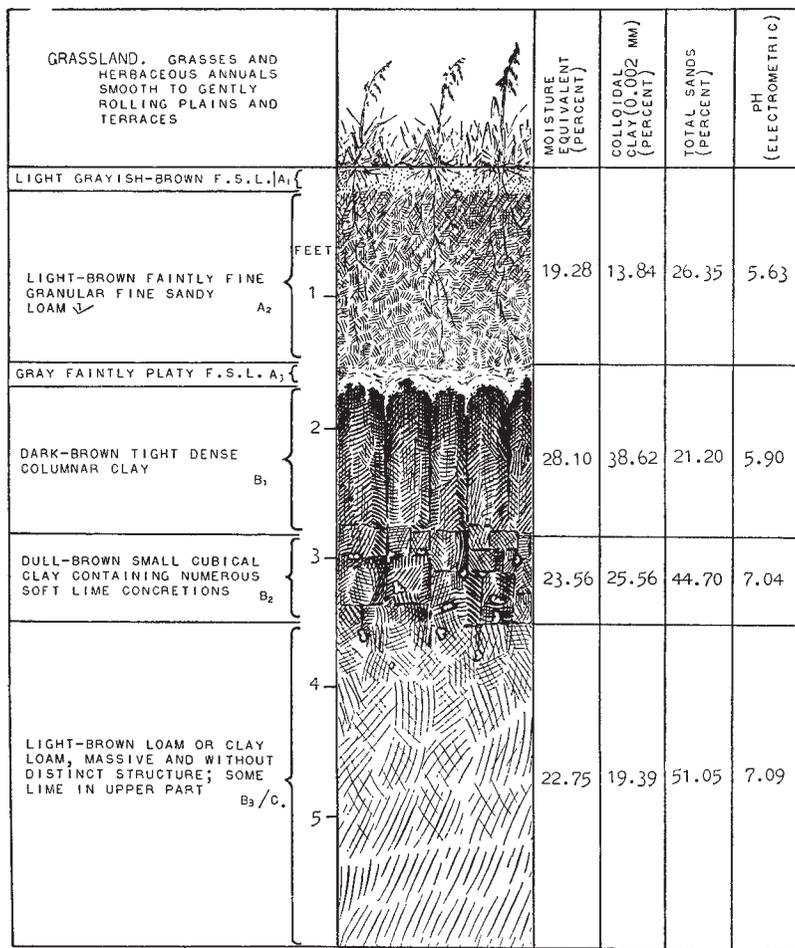
In the earlier reconnaissance mapping, many areas of the Capay soils were included with the Solano soils, a group of imperfectly drained soils occupying flat areas.

The soils of the Lindsey series do not have very well developed A horizons, and it is believed this material has been removed largely by erosion. The material composing the surface soil is dull gray or dull brownish gray, and it is in most places compact and deflocculated. It breaks into coarse clods and generally shows some colloidal staining on the faces of partings and cavities. In places some lime carbonate nodules occur in the surface soil. The B horizons, to a depth ranging from 30 to 48 inches, are dull brownish-gray or dull yellowish-gray compact material of heavier texture than the surface soil. This material contains some accumulated lime and has an imperfectly developed columnar structure. In structure and other characteristics it approaches the solonetz soils of the Solano series. Gray silty material coats the faces of partings and cavities, though the soil material is stained slightly with dull-brown colloids. The lower subsoil layer contains an abundance of accumulated and disseminated lime carbonate, and it is light brown or pale yellowish brown in color. These soils are developed on many different parent sedimentary materials and have weathered under conditions of poor drainage.

In the reconnaissance survey of the Sacramento Valley this soil was included in part with the extensive and inclusive areas of Solano soils, since differentiated into a number of series and types, and in part with the darker-colored Sacramento soils of that survey, which, in the detailed mapping, have been differentiated into soils of the Sacramento, Clear Lake, Lindsey, and Egbert series.

The alluvial fans and plains soils with pronounced profile development are distinctive and may be readily distinguished from other soils of the area. The soils of this group have developed, in the process of weathering, a friable surface soil to a depth ranging from 15 to slightly more than 18 inches. The friable surface soil is abruptly underlain by stiff plastic clay of columnar structure. The columns have rounded tops, and most of them are capped with a gray siliceous deposit ranging from one half inch to 2 inches in thickness. The transition from surface soil to subsoil occurs within an inch or less, and when the soil profile is exposed, the transitional line is distinctly marked as a slightly undulating line with reference

to a smooth flat surface. The A horizons of the soils of this group, weathering under a rainfall of about 20 inches, are much deeper than in soils of similar profile development weathering under a rainfall of 10 or 12 inches in more arid sections of the State. The series in this group are separated one from the other largely on the basis of differences in color, lime content, and character of parent materials. In structural development and sequence of the different horizons they are very similar.



✓ SENSIBLE, OR APPARENT, TEXTURE OF HAND SAMPLE IN FIELD

FIGURE 4.—Profile of Antioch fine sandy loam.

Antioch fine sandy loam represents a normally developed profile (fig. 4) in the soils of this group, which is described as follows:

Horizon A<sub>1</sub>. 0 to 2 inches. Under virgin conditions the soil material consists of light brownish-gray or light grayish-brown loamy fine sand or fine sandy loam of single-grain structure. Numerous grass roots, in various stages of oxidation, permeate this horizon. These, together with a high content of quartz sand, give the material its gray cast. The insides of root cavities have a slight deposit of light-gray material, probably of siliceous character. This horizon is not apparent in fields that have been cultivated.

- Horizon A<sub>2</sub>. 2 to 18 inches. A slight difference in color and better granulation marks the transition from the A<sub>1</sub> to the A<sub>2</sub> horizon. The material in this layer is light-brown or light grayish-brown fine sandy loam or loam of firm consistence, which breaks up under slight pressure to a fine-granular condition. Innumerable threadlike root cavities, together with fewer earthworm or insect burrows, interlace this horizon. The organic material is in various stages of oxidation and in places forms dark-brown specks or mottlings. Worm or insect casts fill the larger cavities. In places some organic staining is present on the insides of root cavities, though for the most part the cavities are lined with a barely perceptible gray coating. This coating is more noticeable in the lower part of the horizon, and the material assumes a more granular structure. The structural particles in the extreme lower part are slightly coated with the same gray siliceouslike material.
- Horizon A<sub>3</sub>. 18 to 20 inches. This horizon is universally present in the soils of this group in the Suisun area, though it is better developed in some places than in others. It consists of gray siliceouslike material of fine sandy loam texture, which in the upper part is distinctly laminated or platy until disturbed, when it breaks up granular. The material in the lower part is firm, but it breaks up readily to a coarse granular gritty structure. Numerous rust-brown stains and a few iron pellets occur in the lower part of the horizon, resting on the tops of the columnar material.
- Horizon B<sub>1</sub>. 20 to 34 inches. An abrupt transition from surface soil to subsoil marks the beginning of this horizon which consists of dark dull-brown clay of columnar structure. When wet the material is compact and massive, but on drying and shrinking it assumes definite columns, or prisms, with well-defined jointing planes. The columns are from 2 to 4 inches in diameter and have from 5 to 8 faces. Root cavities are fairly numerous, and they are coated to greater or less extent with dull-brown or dark-brown colloidal material, as are also the faces of the partings, or joints. The colloidal staining forms concentric circles around the root cavities, the intensity of the staining decreasing with distance from the cavity, until, at a distance of only a small fraction of an inch, the staining is no longer apparent. The staining in few places extends through the smaller granules or structural particles. It is more pronounced at the tops of the columns and becomes of lighter color and less pronounced in their lower part. The columns have rounded tops, the angle of slope increasing sharply at their outer margins. Sharp angles in the columns separate the vertical jointing planes. The columns are from 4 to 6 inches long in the upper part and become shorter with depth, until, in the lower part of the horizon, a fairly regular pattern of cubes is developed. The columns are resistant to breakage.
- Horizon B<sub>2</sub>. 34 to 45 inches. This horizon is characterized by a cubical structure and the development of lime carbonate nodules or soft concretions. It consists of dull-brown or light yellowish-brown clay loam. The accumulations of lime carbonate occur in the vertical jointing planes, as a rule, and in small cavities in the soil structure. The lime does not generally permeate the adjoining soil except for an infinitesimal distance or in root cavities. A slight yellowish-brown or dull-brown colloidal coating occurs on the faces of joints or root cavities in this horizon. Root cavities are much less numerous than in the horizons above. A few dark-brown stains occur in the soil as the result of partial decay of plant roots. Most of the cubes formed as the result of structural cleavage range from 2 to 3 inches in diameter.
- Horizon C<sub>1</sub>. 45 to 72 inches. This horizon consists of pale yellowish-brown amorphous loam or clay loam. The material is very compact and breaks to a coarse cloddy structure that may be reduced to a granular structure under moderate pressure. No colloidal accumulation is apparent, and root cavities are scarce. A few accumulations of lime carbonate occur in the upper part of the horizon, though lime is not apparent in the lower part.

In the earlier reconnaissance mapping, the Antioch soils of the Suisun area were included in part with the Solano soils, and small areas now recognized in the detailed mapping as conforming to

the Antioch soils were included with heavy-textured areas of Yolo soils, in the hilly areas with Altamont and Montezuma soils, owing to the necessity of ignoring areas of small extent in the small scale adopted in the reconnaissance mapping.

The surface soils and subsoils of the Olcott series are of somewhat more pronounced brown color than the corresponding layers of the Antioch soils, they have no lime carbonate accumulation, and the C horizon generally is very compact, in places partly consolidated, and it is characterized by many dark-brown or rust-brown mottlings. In structural arrangement and sequence of horizons the soils are identical (pl. 2, B). The Olcott soils have only in the present survey been recognized as representing a distinct series of soils, and in the older less detailed reconnaissance mapping were included with the Antioch, Solano, and other associated soils.

The soils of the Solano series have developed under conditions of poorer drainage, and apparently in the presence of sodium salts. The surface soils are light gray or light yellowish gray, and the B horizons are slightly darker. The lower part of the B horizons, as well as the C horizons, are strongly calcareous. The soils of this series are of pronounced solonetz structure and have the same structural development and arrangement of horizons as Antioch fine sandy loam.

The soils of the islands and basins are, with the possible exception of the Montezuma soil, of darker color than the other soils of the area. Unlike the Montezuma soil, they have accumulated and developed in flat or slightly depressed shallow basinlike areas which in the past have been frequently or periodically subject to overflow and a shallow fluctuating water table, and they have supported a vegetation of sedges, tules, grasses, and other plants growing in overflowed or wet localities. These conditions have been favorable to the accumulation of organic matter and the development of a dark color. The mineral matter consists mainly of fine-textured material, much of it of colloidal character, which is derived from a wide range of rocks and which has been transported mainly by Sacramento River and its distributaries and deposited from turbid flood waters in backwater areas during flood periods.

The soils of the islands and basins without profile development are represented by the Egbert soils. The surface soils of these soils are typically dark dull gray, and they usually contain from 10 to 25 percent of organic matter. The subsoils are of still higher organic-matter content and consist of stratified deposits of muck, peat, and alluvial sediments of dark-gray or dark brownish-gray color. In the reconnaissance mapping, the Egbert soils were included with the Sacramento soils and with muck and peat areas, which they strongly resemble and with which they merge.

The islands and basins soils having young profiles have weathered under poor drainage. The soils of this subgroup have uniformly dark colored surface soils and lighter-colored calcareous subsoils. They are but slightly weathered and do not show any pronounced accumulation of clay or colloidal material in any part of the profile. They include the Sacramento and Clear Lake soils.

The Sacramento soils are of lower organic-matter content and are less permeable than the Egbert soils, but the dull-gray or dull brownish-gray surface soils are highly mottled with dark-brown

partly decayed organic materials. The upper part of the subsoil or B horizon, is slightly compact dark dull-gray or dark brownish-gray material containing less organic material than the surface soil. The subsoil is slightly heavier textured than the surface soil, and when exposed to drying the material checks into a faintly developed columnar structure. The lower part of the subsoil is dull-gray or bluish-gray heavy-textured mucky material. More or less lime carbonate and a few crystals of gypsum occur in the subsoil. Some mottling of rust brown, gray, and yellow generally occurs in the upper and lower parts of the subsoil.

The soils of the Clear Lake series have been developed under conditions of less frequent or less pronounced overflow and less vegetal growth. They are darker colored than the soils of the Sacramento series, and the organic matter is less evident and more thoroughly decomposed. The Clear Lake soils had not been recognized as representing a distinct series of soils at the time of the earlier reconnaissance surveys, and they were mainly included with the Sacramento soils which they resemble and with which they merge. Small areas were included with the Yolo and Solano soils, owing to the small scale used in reconnaissance mapping.

The Stockton soils represent a slightly more mature profile. They are differentiated from the Clear Lake soils in part on the basis of differences in the character of the deeper material which, in the Stockton soils, consists of light-brown or light brownish-gray partly consolidated sediments highly impregnated with lime in the upper part and very firmly consolidated at that point. It is thought that this deeper material represents an older geological foreign material. The surface soil and upper subsoil layer are of the same color and structure as the Clear Lake soils.

#### LABORATORY STUDIES<sup>5</sup>

The official samples collected during the progress of the soil survey of the Suisun area, Calif., have been studied in the laboratories of the division of soil technology, University of California, Berkeley, Calif., where mechanical analyses and moisture-equivalent determinations have been made, together with a number of other determinations on individual samples.

The moisture equivalents were determined by the standard method that has been in use in California for years. The soils were air-dried, screened through a 2-millimeter sieve, and the moisture equivalents were determined by using a weighed amount (30 grams) in the cups of a centrifuge developing a force of 1,000 times gravity. The results are expressed in terms of percentage of moisture calculated on the basis of oven-dry weight. The moisture equivalent has been found by experiments to coincide approximately with the normal field moisture capacity or the amount of water that is held in the soil after heavy rains or irrigation, where downward drainage is free and uninterrupted. The moisture equivalent reflects the influence of large quantities of organic matter and of colloidal clay. The unusually high moisture equivalent of Columbia silty clay loam (sample no. 577803) is due to the organic matter present in this soil.

<sup>5</sup>This section of the report was prepared by C. F. Shaw, head, Division of Soil Technology, University of California.

The subsoil horizons of Lindsey clay loam (sample nos. 577868 and 577869) and of Clear Lake clay adobe (sample nos. 577873 and 577874) are due to the combined influence of organic matter and colloidal clay. Although the ultra clay content of the subsoil horizons of Lindsey clay loam is not exceptionally high, the particles appear to be exceedingly fine textured and to retain water to an unusually high degree. Although these subsoils contain lime, they are generally deflocculated because of the presence of alkali.

The mechanical analyses of these samples were made by the modified pipette method. The soils were air dried and screened through a 2-millimeter sieve. Subsamples were then taken, treated with hydrogen peroxide to destroy the readily oxidizable organic matter, and with weak hydrochloric acid to remove the carbonates. The excess of acid was removed by thorough washing and the soils were oven dried to determine loss due to pretreatment. They were then dispersed by shaking with sodium oxalate as a deflocculating agent. The thoroughly dispersed soil was then washed through a 300-mesh sieve which retained the sand particles. These sands were dried and screened to the standard grades. The silt and clay suspension was made up to the proper quantity to fill tall cylinders, stirred thoroughly to make sure that the particles were well dispersed, and then allowed to stand in a constant-temperature chamber during the period of settling. Samples were withdrawn by a single-orifice pipette at the end of definite periods as calculated by Stokes' Law to recover all particles 5 microns and less and 2 microns and less in effective diameter. In table 4 clay particles range from 5 to 2 microns in diameter and ultra clay particles are less than 2 microns.

The severe pretreatment with hydrogen peroxide and hydrochloric acid disintegrates many fairly stable aggregates and gives a clay content that is usually considerably higher than that obtained by the centrifugal method of analysis, using ammonia as the deflocculent. Several of the samples were analyzed by the centrifugal method, and in every case the quantity of total clay was much less and the quantity of silt greater than the results as shown by the pipette method. All the samples except one showed that the increase in clay was due to a decrease in silt, essentially a breaking up of aggregates of silt size. One sample showed a slight decrease in the sands, as well as a marked decrease of silt. The textural grades—loam, clay loam, etc.—were established on the basis of their mechanical analyses by the centrifugal method, and if the standards so established are compared with the results shown in table 4, it will be noted that most of the soils show much too great a content of clay for the textural name given them. This is owing to the increased dispersion brought about by the severe pretreatment. The textural names, as given in table 4, have been determined after careful study of the soil samples and comparisons with the centrifugal analyses, wherever the latter were available, and are correct on the basis of their field characteristics. Further research is necessary in order to determine the relation between the textural name and the content of silt and clay as shown by the method of analysis which uses severe pretreatment. Yolo silty clay loam, which by the centrifugal method yields 54.7 percent silt and 23.22 percent clay, gives 46.01 percent silt and 33 percent clay by the pipette method. Columbia silty clay loam shows an increase of

clay from 25.85 percent by the centrifugal method to 37.78 percent by the pipette method, and Conejo clay loam shows an increase from 23.29 percent to 31.92 percent. All these soils are distinctly silty clay loams or clay loams as judged in the field and are so shown by the centrifugal method of analysis, but they would rate as clays on the basis of the analyses by the pipette method.

Determinations of the reaction and the pH values were made on a number of samples but are not reported here. Most of the surface soils, except those definitely affected by alkali, showed a slightly acid reaction. The recent-alluvial soils of the Yolo series were very nearly neutral, and those containing alkali differed markedly in reaction, all being well above pH 8. All the primary soils of the hilly regions and most of the soils having a solonetz structure are distinctly acid in reaction in the surface horizon. The subsoils are generally neutral or moderately alkaline in reaction.

Table 4 shows the results of mechanical analyses and the moisture-equivalent determinations of samples of many of the soils occurring in the Suisun area.

TABLE 4.—*Mechanical analyses and moisture-equivalent determinations of soils of the Suisun area, California*

Soil type and sample no.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay <sup>1</sup>	Colloid <sup>2</sup>	Moisture equivalent
	Inches	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent
Konokti stony clay loam: 577821.....	0-10	0.52	0.54	1.61	5.61	6.58	47.00	17.58	20.56	26.08
Hugo sandy loam: 577838.....	0-9	1.31	4.44	13.74	24.48	17.56	20.44	4.53	13.50	16.48
577839.....	9-24	.47	4.62	23.37	30.00	13.59	16.22	1.79	9.94	11.60
Hugo clay loam: 577829.....	0-10	.12	1.26	4.12	9.91	9.36	28.78	9.91	36.54	25.52
577830.....	10-28	.24	1.85	1.51	6.36	5.34	27.90	12.80	44.00	28.59
Los Osos clay loam: 577826.....	0-10	.05	.15	.46	12.74	20.70	25.07	8.99	31.84	22.65
577827.....	10-36	.06	.21	.24	16.54	21.41	22.63	7.00	31.91	22.92
Los Osos clay adobe: 577878.....	0-9	.05	.48	.30	1.01	2.33	26.93	14.48	54.42	31.00
577879.....	9-32	.03	.61	.31	1.20	2.04	26.81	15.60	53.40	29.97
Montezuma clay adobe: 577852.....	0-10	.05	.19	.46	5.82	8.22	28.78	13.58	42.90	34.12
577853.....	10-42	.06	.25	.81	5.13	9.81	22.86	9.87	51.21	35.50
Denverton clay adobe: 577844.....	0-9	.57	.16	.68	22.08	13.71	24.65	5.15	33.00	24.30
577845.....	9-20	.34	.15	1.12	20.62	15.40	25.85	4.90	31.62	24.59
577846.....	20-30	.37	.40	.58	14.69	18.05	26.66	7.13	32.12	24.20
Antioch fine sandy loam: 577840.....	0-18	.04	.16	1.00	10.75	14.44	45.78	14.00	13.84	19.28
577841.....	18-34	.14	.20	.49	6.79	13.72	31.76	8.28	38.62	28.10
577842.....	34-42	.03	.11	.42	20.38	23.79	24.89	5.88	25.50	23.56
577843.....	42-72	.03	.05	1.11	33.20	16.69	24.42	5.11	19.39	22.75
Stockton clay adobe: 577862.....	0-10	.77	1.78	2.32	7.28	8.31	25.59	13.55	40.40	28.45
577863.....	10-35	1.24	1.89	2.15	6.45	9.91	26.71	6.65	45.00	28.34
577864.....	35-40	.20	.13	.39	32.18	29.31	18.11	3.76	15.92	23.97
Solano fine sandy loam: 577875.....	3-5	.12	.28	3.37	21.76	23.03	38.58	5.73	7.13	15.12
577876.....	5-24	.03	.87	1.74	11.55	11.76	33.72	9.33	31.50	16.04
577877.....	24-72	1.39	1.33	1.61	5.50	8.47	40.32	9.58	31.80	51.30
Lindsey clay loam: 577867.....	0-8	.04	.25	.92	23.08	30.75	25.33	6.23	13.40	28.26
577868.....	8-34	.05	.31	2.26	11.14	13.65	25.29	8.54	38.76	86.80
577869.....	34-72	.00	.06	.27	6.04	8.08	35.90	16.98	32.67	89.20
Zamora fine sandy loam: 577857.....	0-8	.71	2.54	7.90	23.75	23.22	27.74	3.80	10.34	29.48
577858.....	8-30	.41	3.08	4.77	22.98	24.48	28.40	3.92	11.96	29.53
577859.....	30-70	.39	2.07	7.20	23.50	17.12	26.47	3.04	19.61	29.02

<sup>1</sup> Clay includes particles from 0.005 to 0.002 millimeter in diameter.

<sup>2</sup> Colloid includes particles less than 0.002 millimeter in diameter.

TABLE 4.—*Mechanical analyses and moisture-equivalent determinations of soils of the Suisun area, California—Continued*

Soil type and sample no.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay <sup>1</sup>	Colloid <sup>2</sup>	Moisture equivalent
	Inches	Per-cent	Per-cent	Per-cent <sup>3</sup>	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent
<b>Zamora clay loam:</b>										
577823-----	0-10	.17	.38	7.78	1.09	13.41	38.26	12.85	25.86	28.15
577824-----	10-40	.36	.34	1.13	7.32	14.30	29.15	14.50	32.90	27.13
577825-----	40-72	1.58	2.07	1.61	10.70	18.74	24.56	8.74	32.00	24.89
<b>Capay loam:</b>										
577834-----	0-10	.33	.32	.96	12.52	18.20	38.04	7.61	22.02	24.36
577835-----	10-30	.00	.04	1.05	17.32	16.32	41.29	9.54	14.44	22.78
577836-----	30-52	.19	1.42	4.39	15.26	11.85	24.11	8.06	34.72	41.73
577837-----	52-74	.04	1.19	10.62	21.08	8.23	16.14	5.30	37.40	29.36
<b>Capay silty clay loam:</b>										
577807-----	0-12	.25	.43	.74	5.86	13.52	40.86	8.69	29.65	26.04
577808-----	12-40	.17	.16	.78	7.05	15.31	38.09	7.22	31.22	25.83
577809-----	40-72	.00	.04	.07	7.89	16.49	45.29	11.04	17.18	24.96
<b>Esparto silty clay loam:</b>										
577815-----	0-10	.08	.18	.70	2.45	4.18	53.63	17.36	21.42	25.56
577816-----	10-40	.07	.25	.55	1.74	3.08	40.69	12.62	41.00	26.62
577817-----	42-72	.06	.39	.47	1.72	2.67	38.69	14.20	41.80	29.85
<b>Oleott fine sandy loam:</b>										
577831-----	0-15	.20	.47	4.36	26.08	17.29	30.60	5.79	15.21	25.91
577832-----	15-36	.07	.21	2.91	14.34	11.86	19.46	4.07	47.08	34.23
577833-----	36-70	.14	.70	1.97	16.37	19.97	23.45	7.32	30.08	27.63
<b>Conejo clay loam:</b>										
577818-----	0-8	5.36	4.16	4.61	13.79	11.25	28.91	6.83	25.09	26.43
577819-----	8-45	6.56	6.87	4.69	15.45	8.24	32.36	10.53	15.30	29.41
577820-----	45-72	5.88	6.54	4.30	12.67	9.66	29.15	7.19	24.61	25.55
<b>Yolo silty clay loam:</b>										
577810-----	0-12	.41	.15	.55	8.94	17.70	36.23	10.42	25.60	25.26
577811-----	12-40	.07	.14	.13	8.42	17.14	36.20	9.42	28.48	24.48
577812-----	40-72	.08	.03	.24	10.40	20.88	34.39	8.64	25.34	23.85
<b>Clear Lake clay adobe:</b>										
577872-----	0-10	.00	.02	.03	.10	.12	20.53	33.92	45.28	45.55
577873-----	10-45	.04	.14	.44	1.45	2.17	17.26	16.80	61.70	60.45
577874-----	45-72	.00	.08	.16	1.49	2.20	22.04	31.78	42.25	59.29
<b>Columbia silty clay loam:</b>										
577803-----	0-15	.04	.14	.11	.65	4.55	56.76	9.98	27.80	33.42
<b>Egbert loam:</b>										
577801-----	0-14	.52	.75	.96	.56	.45	19.90	35.30	41.50	65.60

<sup>1</sup> Clay includes particles from 0.005 to 0.002 millimeter in diameter.<sup>2</sup> Colloid includes particles less than 0.002 millimeter in diameter.

## SUMMARY

The Suisun area is in the central part of California, about 40 miles northeast of San Francisco and midway between that city and Sacramento, the capital of the State. The area comprises the southern half of Solano County and Grand and Sutter Islands lying in Sacramento County. The included land comprises 550 square miles, or 352,000 acres.

The area is dominated by three main physiographic divisions—a hilly and mountainous section, an alluvial-fan and plains section, and an island and basin section. The hilly and mountainous section comprises the rougher western part of the area and the Montezuma and Potrero Hills in the central part, the alluvial-fan and plains section comprises the north-central part, and the island and basin section borders Sacramento River which serves as a drainage outlet for the area. The hilly and mountainous section constitutes 34.8 percent of the area, the alluvial fan and plains section 29.3 percent, and the island and basin section 35.9 percent.

The islands and basins range in elevation from a few feet below sea level to several feet above. The general elevation of the alluvial

fans and plains is about 25 feet. The hill lands under cultivation have an average elevation of about 200 feet, and included mountainous areas attain an elevation of 1,300 or more feet.

Water for domestic use is plentiful and generally of good quality, though in few places is it found in sufficient quantity for extensive irrigation. Wells range in depth from 80 to 120 feet, and water stands at a depth ranging from 15 to 25 feet from the surface in the Suisun and Green Valley sections and somewhat deeper on the plains.

Most of the soils are grass covered, except on the higher mountains where pines, oaks, and brush form a forest growth of varying density.

The first settlement in the area was made in 1841. In 1859 the population of Solano County was 580. In 1930 the county had a population of 40,834, of which 23,445 were rural and 17,389 urban. Suisun and Green Valleys and Grand and Sutter Islands are the most thickly populated rural sections of the area.

Solano County was created February 18, 1850, and Fairfield is now the county seat. Important towns in the area are Vallejo, Suisun, Benicia, and Rio Vista.

Solano County has 65 miles of water frontage on navigable deep waterways, the greater part of which is in the Suisun area. The Southern Pacific Railroad furnishes transportation to the western part of the area, and the Sacramento Northern Railroad (electric) and the various waterways afford good transportation to the eastern part.

The Pacific Coast Highway traverses the central part. Several paved or graveled roads make the rural districts accessible throughout the year. Other conveniences, such as telephones, electricity, schools, and churches, are available throughout the better-settled sections.

The climate of the Suisun area is best characterized as mild. The rainy season commences in November and continues into March. During this period 83 percent of the annual rainfall of approximately 20 inches is received.

Most perennial crops require some irrigation for maximum crop production, though many deep-rooted tree crops are not irrigated. The grain crops are produced under dry-farming practices.

Frosts are of frequent occurrence from the middle of November until about the middle of March, though fall-sown grain crops do not winter-kill. Hail, snow, torrential rains, or destructive winds are practically unknown. Under careful cultural practices to conserve moisture, crop failures are rarely experienced.

The early agriculture of the area consisted of the grazing of cattle for their hides and tallow. The present-day agriculture consists of the production of fruits on the alluvial fans and stream bottoms where soil conditions are favorable, the production of grains on the hill soils of good moisture-holding capacity, and the grazing of sheep and cattle on the grass-covered plains and hill soils not under cultivation. The islands and basins are used largely in the production of asparagus and other truck crops and to less extent for the production of general-farm crops.

Most of the people of the Suisun area are dependent on agriculture for an income. The total value of all agricultural products in

Solano County in 1930 was \$6,923,383, the total value of land and buildings was \$45,107,090, the average value of land and buildings a farm was \$30,498, and the average acre value was \$104.56.

The average size of farms in the county in 1930 was 291.7 acres. In the same year 1,129 farms were operated by owners, 260 by tenants, and 90 by managers.

The Suisun area is noted for the earliness of its fruits. Express shipments of fresh cherries generally begin the last of March or early in April.

Considered on the basis of acreage devoted to the industry, the grazing of sheep ranks first among the major agricultural pursuits of the area, grain production ranks second, and fruit production third. Considered on the basis of total revenue received, the ranking is reversed.

The leading natural factors affecting the distribution of crops in the area, aside from climate, are surface features, water supply, and soils. As the climate is fairly uniform over the area, its greatest influence on distribution of crops is through its influence on the soils. Water supply is not so important in this area as in the drier sections of the State. Character of the soil and adaptation of the crop to the soil is very important, as the margin of profit on many farms is such that the degree of crop adaptation to soil determines the difference between profit and loss to the farm operator.

The mountainous and hilly soils, classed in the Konokti, Los Osos, Hugo, Montezuma, and Denverton series, are underlain by consolidated bedrock or partly consolidated sedimentary materials. The Montezuma and Denverton soils are somewhat deeper than the other soils of this group and are used largely for grain production. Small bodies of the other soils in this group are under cultivation, though for the most part they are used only for pasture or for forestry.

The soils of the Columbia series are loose and permeable to a depth of more than 6 feet. They are well adapted to a wide range of crops, especially deep-rooted tree crops. The soils of the Conejo and Yolo series have slightly compact subsoils or subsoils slightly heavier textured than the surface soils. These soils are of good water-holding capacity, fertile, and adapted to a wide range of crops, though they are probably best suited to special fruit crops.

The soils of the Esparto, Zamora, Capay, and Lindsey series have heavy-textured subsoils developed through weathering agencies. The soils of the Esparto and Zamora series are permeable to plant roots, air, and moisture, and they are adapted to a wide range of crops. The soils of the Capay series have restricted subdrainage, though in general the lighter-textured soils of the series are well adapted to cultivation. The soils of the Lindsey series are poorly drained and suited only to grazing.

The soils of the Antioch, Olcott, and Solano series have loose, friable surface soils and compact, tight, heavy-textured subsoils. They are suited only to shallow-rooted crops and are largely used for grazing.

The soils of the Egbert series have friable, permeable surface soils and subsoils, containing a high percentage of organic matter. They are well adapted to vegetable crops where not too badly affected with alkali.

The soils of the Sacramento, Clear Lake, and Stockton series are heavy textured and difficult to handle under cultivation. They are utilized to some extent for general farm crops.

The principal agricultural industries of the Suisun area are the canning of asparagus, the canning and packing of fruits, and the feeding of sheep and cattle for market.

#### LITERATURE CITED

- (1) ANONYMOUS.  
1891. A MEMORIAL AND BIOGRAPHICAL HISTORY OF NORTHERN CALIFORNIA, ILLUSTRATED. CONTAINING A HISTORY OF THIS IMPORTANT SECTION OF THE PACIFIC COAST FROM THE EARLIEST PERIOD OF ITS OCCUPANCY . . . 834 p., illus. Chicago.
- (2) ALLEN, F. W.  
1929. PLUM GROWING IN CALIFORNIA. Calif. Agr. Col. Ext. Circ. 34, 65 p., illus.
- (3) BANCROFT, H. H.  
1888. HISTORY OF CALIFORNIA. v. 6, 787 p., illus. San Francisco.
- (4) HENDRICKSON, A. H.  
1930. PRUNE CULTURE IN CALIFORNIA. Calif. Agr. Col. Ext. Circ. 41, 39 p., illus.
- (5) HOLMES, L. C., and NELSON, J. W.  
1919. RECONNOISSANCE SOIL SURVEY OF THE SAN FRANCISCO BAY REGION, CALIFORNIA. U.S.Dept.Agr., Bur. Soils, Field Oper. 1914, Rpt. 16: 2679-2784, illus.
- (6) ———, NELSON, J. W., and party.  
1916. RECONNOISSANCE SOIL SURVEY OF THE SACRAMENTO VALLEY, CALIFORNIA. U.S.Dept.Agr., Bur. Soils, Field Oper. 1913, Rpt. 15: 2297-2438, illus.
- (7) HUNT, M., and GUNN, H. L.  
1926. HISTORY OF SOLANO COUNTY AND NAPA COUNTY. v. 1.
- (8) MILLER, R. F.  
1930. SHEEP PRODUCTION IN CALIFORNIA. Calif. Agr. Col. Ext. Circ. 49, 66 p., illus.
- (9) OVERHOLSER, E. L., and DURUZ, W. P.  
1930. PEACH CULTURE IN CALIFORNIA. Calif. Agr. Col. Ext. Circ. 42, 55 p., illus.
- (10) PHILP, G. L.  
1930. CHERRY CULTURE IN CALIFORNIA. Calif. Agr. Col. Ext. Circ. 46, 42 p., illus.
- (11) SHEAB, S. W.  
1928. PRUNE SUPPLY AND PRICE SITUATION. Calif. Agr. Expt. Sta. Bul. 462, 69 p., illus.
- (12) THOMPSON, R. C.  
1930. ASPARAGUS CULTURE. U.S. Dept. Agr. Farmers' Bul. 1646, 25 p., illus.
- (13) VOORHIES, E. C., and SCHNEIDER, W. E.  
1929. ECONOMIC ASPECTS OF THE SHEEP INDUSTRY. Calif. Agr. Expt. Sta. Bul. 473, 173 p., illus.
- (14) WATSON, E. B., GLASSEY, T. W., STORIE, R. E., and COSBY, S. W.  
1929. SOIL SURVEY OF THE CHICO AREA, CALIFORNIA. U.S.Dept.Agr., Bur. Chem. and Soils, Ser. 1925, Rpt. 4, 48 p., illus.
- (15) WELLMAN, H. R.  
1926. PEACHES. Calif. Agr. Col. Ext. Circ. 1, 64 p., illus.
- (16) ———  
1927. APRICOTS. Calif. Agr. Expt. Sta. Bul. 423, 42 p., illus.
- (17) ——— and BRAUN, E. W.  
1930. ASPARAGUS. Calif. Agr. Expt. Sta. Bul. 487, 41 p., illus.
- (18) ——— and BRAUN, E. W.  
1930. CHERRIES. Calif. Agr. Expt. Sta. Bul. 488, 38 p., illus.

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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](mailto:program.intake@usda.gov).

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