SOIL SURVEY AROUND SANTA ANA, CAL

By J. GARNETT HOLMES.

INTRODUCTION.

Orange County, though small, is for many reasons one of the richest and most fertile counties in southern California. The county town, Santa Ana, is but an hour's ride by rail from Los Angeles, and all the smaller towns can be reached almost as quickly. Bounded on the southwest by the Pacific Ocean, its ports are in direct communication with all coast-line steamers. Fringed on the north and east by oil-producing foothills, it has within its own borders a cheap and easily transported fuel. Its different agricultural districts produce in abundance the common field crops and semitropical fruits. Its chief agricultural exports are: Of the cereals, wheat, barley, and corn; of the fruits, oranges, lemons, apricots, raisins, grape fruit, and many smaller varieties of semitropical fruits. English walnuts are peculiarly adapted to the climate and form the most important special crop. Celery, onions, and potatoes, which are raised on the lowlands, form an important part of the yearly exportation. Train loads of celery are every winter shipped to the Eastern and Middle States, where it commands the highest market price.

Owing to its latitude and close proximity to the Pacific Ocean, Orange County enjoys a most equable climate and furnishes most favorable agricultural conditions. On account of its healthful climate and nearness to the ocean, the seaports of this county are favored summer resorts. During the winter months it is a favorite resort of the tourist and health seeker from the North and East. Wherever irrigation furnishes a permanent water supply flowers bloom continuously and vegetation of all kinds is most luxuriant.

On account of the diversity and importance of the crops raised and on account of the many different types and phases of soil, this area was selected as a desirable field for the soil-survey work of the Division of Soils. Consequently, early in September, 1900, a party was sent to this region to map the soils and study their physical properties and crop relations. An alkali map, showing the total salt content of the soils, was also made. Copies of these maps, showing the extent and elevation of the various soils and outlining the alkali areas according to intensity, accompany this report.

GEOGRAPHY AND TOPOGRAPHY.

The area surveyed by the Division of Soils includes that portion of the agricultural lands of Orange County found on the Anaheim and Santa Ana sheets of the United States Geological Survey. This amounts to about 300 square miles (192,000 acres). The Pacific Ocean on the south and the foothills on the east and north furnish natural boundaries to the agricultural lands. The 400-foot contour is the limit of cultivable lands. The western boundary is arbitrary, being a line north and south passing through Smeltzer, Westminster, and Buena Park. Santa Ana River enters from the northeast and flowing southwest down across the area to the ocean divides it nearly equally. Except in flood time, all of its waters are diverted for irrigation and this part of its course is merely a bed of sand. But during flood time all of the lower southwestern part of the area, known as the "Las Bolsas Country," is subject to overflow and much damage is done to property and growing crops. One mile north and 1½ miles west of Santa Ana, Santiago Creek joins the Santa Ana, and during flood times its waters greatly augment the overflow below. During very high water a part of the Santa Ana flows down the sandy wash (shown on the map) north of Anaheim, thus making the actual bed of the lower Santa Ana a matter for conjecture.

The topography of this area, without any reference to soils, divides it into two distinct agricultural districts. The 75-foot contour line, running from southeast to northwest across the area, is about the boundary line between these two districts. Very rarely is a fruit tree of any kind or description found below this line. East of the Santa Ana River these lowlands are either sown to alfalfa or the native vegetation is used for pasture. Dairying is the chief industry. West of the Santa Ana, too, there are lands devoted to dairying, but far the greater part of these lowlands are planted to celery and other truck crops. Above the 75-foot contour on each side of the river are found all kinds of semitropical and many tropical fruits and nuts. Although these crops of fruit and nuts may be grown, and in some instances are grown far up on the foothills, it is impracticable in most cases in this area to grow them any higher than the 300-foot contour line on account of the rolling nature of the land and the difficulty of obtaining irrigation water at these levels. The rainfall, occurring as it does in the winter months, affords sufficient moisture for the development of wheat and barley on these uplands. The foothills are of a rounded dome shape.

Lying along the coast east of the low swamp lands of Santa Ana River is an elevation known as the mesa. This rises abruptly, as a bluff, just north of Newport Bay and slopes gently back toward the north. Owing to its peculiar location, it is impossible to obtain water for irrigation, so it too is dry farmed to wheat and barley. To the west of

the swamp lands is a similar area much smaller in extent and only about 50 to 75 feet in elevation. This area is also dry farmed.

GEOLOGY.

The part of Orange County which was mapped is delta plain of very recent origin and the cultivable portion of the surrounding foothills. The entire plain has been reclaimed from the sea by the vast amounts of material brought down by Santa Ana River and Santiago Creek in times of flood and by an elevation of this part of the coast. The remains of a low range of foothills, which at one time must have been submerged some distance out at sea, can be traced along the present coast. That this range is continuous as a sub-formation is proved by the presence of an artesian belt continuing along the landward side of the ridge. At all points immediately on the land side of this low range artesian water is found in abundance at from 90 to 500 feet. Just over the divide, on the ocean side, wells to a depth of more than 1,000 feet have failed to strike artesian water.

Except in flood time, the waters of the Santa Ana sink at the upper margin of the Coastal Plain. It is this water that replenishes the supply of the sand and gravel of the artesian basin. A marked relation is seen in the flow of these wells and the supply from the river. In long seasons of drought, when most of the water is taken out for irrigation above the point of sinking, some of the wells cease to flow and have to be pumped.

The bed of impervious clay, which is from 40 to 80 feet thick and which prevents the escape of the artesian water, must have been deposited in quiet or slowly moving waters. The sand and gravel below the clay contain recent marine fossils, which indicate that the ocean once covered this plain. After the stratum of clay was deposited, there must have been a period of elevation, since now a part of the clay is above sea level. The river continued to bring down a great deal of material in flood times, but when it reached the rising low mud flat, which sloped toward the ocean and was submerged at its lower end, the swiftly moving waters were checked and spread out, depositing their coarser material close to the mouth of the canyon and carrying the finer silt farther down nearer the coast. The low-lying coast range of hills formed a protection against the destructive action of the waves. In this way the delta plain of the Santa Ana was built up.

As might be expected, the building up was much more rapid where the water was first checked, so that near the mouth the land is much higher, with a gradual slope toward the sea. While this plain was being elevated the river flowing out upon it was checked more on the sides, where the water was shallow and where the vegetation grew, than it was in the center, where the water was deep. Hence a greater deposit was made on the sides than in the center of the stream, so that

low banks were built on each side of the swifter moving current, and soon the bed became raised above the surrounding plain. In times of flood, the river broke out, and, in the same way as stated above, it found a new course to the sea, and the process of building up was repeated. Thus, the river has wandered over the delta until it has covered the whole with alternating strips of sand and fine sandy loam, all running in parallel lines southwest toward the ocean. The finer particles of clay were carried to the ocean and deposited years ago. After the lower part of the delta had been built up above sea level, the artesian springs brought about conditions which led to the formation of peat. As these peat beds now exist below the present sea level, conclusive proof is presented that this plain was at one time higher than at present.

This building up by the river of its own bed and banks may now be observed. When the Fifth street bridge west of Santa Ana was built across the Santa Ana River a few years ago the sands were far beneath

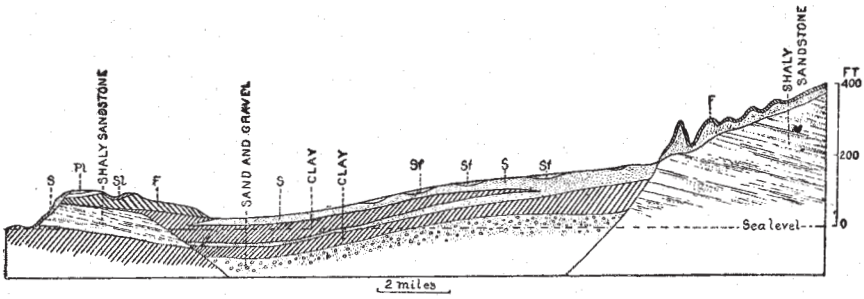


FIG. 42.—Section north and south from foothills to ocean, through Anaheim, Cal.: *S*, Fresno sand; *Sl*, Santiago sandy loam; *Pl*, Placentia sandy loam; *Sf*, Fresno fine sandy loam; *F*, Fullerton sandy adobe.

it; now they come up nearly to the ends of the approaches to the bridge, having been built up 9 feet since the bridge was constructed.

The banks of the river for a half mile or so on each side are covered with willows, which check the water as it tends to spread out and causes it to deposit its sediment. It is only a question of time until the Santa Ana shall again change its course, as even now the bed is in some places higher than the surrounding plains. A section is given in fig. 42 showing the relation of the soils to each other and to the underlying formation.

CLIMATE.

The part of Orange County included in the survey lies on the southern end of the coastal plain upon which Los Angeles is situated. The climate here is the well known, mild, equable climate of southern California. Seldom is it too warm for comfort, and it is never cold enough to injure citrus fruits. Roses, chrysanthemums, geraniums, and many other flowers bloom through the entire winter without any protection. The prevailing winds are from the west and southwest.

Under normal conditions, the most uncomfortable part of the day is in the early morning before the sea breeze sets in; however, when the wind blows all day from the desert, as it sometimes does, it is very warm. These desert winds are locally known as "Santa Ana's."

The following table gives the normal monthly and annual temperatures and monthly and annual precipitations at Los Angeles, Anaheim, Whittier, and Santa Ana; also the normal monthly and annual temperatures of Long Beach. Long Beach, Whittier, and Los Angeles are not in the area mapped, but they are so close that comparisons may be made. As may be seen in the table, the rainfall is in the winter, the summer months having practically none. During the winter much of the weather is cloudy and foggy, although it is not cold enough to make it very uncomfortable.

Monthly and annual normals.

Month.	Temperature.					Precipitation.			
	Anaheim.	Los Angeles.	Santa Ana.	Whittier.	Long Beach.	Anaheim.	Los Angeles.	Santa Ana.	Whittier.
	Deg.	*Deg.*	*Deg.*	*Deg.*	*Deg.*	*In.*	*In.*	*In.*	*In.*
January	54.1	53.0	54.3	56.7	53.6	2.16	2.93	2.31	2.54
February	56.3	55.0	57.2	51.1	54.4	2.38	3.27	2.46	2.13
March	59.1	57.0	59.3	61.1	56.4	2.34	2.98	2.49	2.67
April	62.9	59.0	64.9	65.7	60.4	.72	1.36	.25	.22
May	67.2	63.0	69.4	67.7	63.6	.34	.43	.34	.57
June	69.9	67.0	73.8	73.8	66.4	.06	.10	.00	.00
July	73.0	71.0	76.2	77.8	68.4	T.	.02	.00	.00
August	74.4	69.2	76.5	78.1	70.9	T.	.03	.07	.10
September	71.9	70.0	73.8	75.1	.....	.06	.08	.05	.02
October	66.8	64.0	68.0	68.4	64.2	.49	.74	.69	.93
November	60.8	59.0	61.8	63.5	56.6	.80	1.38	.45	.69
December	56.6	55.5	57.2	58.6	58.9	2.46	3.98	2.82	1.78
Annual	64.3	62.1	64.6	66.4	.....	12.04	18.20	10.93	11.63

SOILS.

The different soils have approximately the following areas:

Areas of the different soils.

Soil.	Area.	Per cent.	Soil.	Area.	Per cent.
	Acres.			*Acres.*	
Fresno sand	66,380	37.6	Santiago silt loam	14,349	8.1
Fullerton sandy adobe	31,334	17.7	Fresno fine sandy loam	11,552	6.5
Santiago sandy loam	17,100	9.7	Santiago loam	1,830	4.0
Placentia sandy loam	16,857	9.5	Peat	787	.4
San Joaquin black adobe	16,038	9.1			

FRESNO SAND.

Fresno sand, either as soil or subsoil, is spread over more than half of the area mapped and all of the delta of the Santa Ana. Wherever found west of Santa Ana River it is free from gravel and composed of coarse to medium sand. Wherever this sand is underlaid by clay or other heavy subsoil at 20 feet or less it forms an excellent land for fruit or nuts. Along the northern and eastern edges of the artesian belt, where the substratum of clay comes to within from 12 to 20 feet of the surface, is found the ideal soil for English walnuts. This area includes the Anaheim and Santa Ana walnut groves. In the former the sand is found on the surface, while in the latter it is overlaid by 3 or 4 feet of Santiago sandy or silt loam. The soils of the Fullerton walnut groves are to external appearances the same as those of the Anaheim district. The same sandy surface soil is found, but here the subsoil is adobe. The Santa Ana has deposited sand upon the base of the foothills. Since this area is near the mouth of the canyon the deposition has been very rapid and the sand is coarse. Between the Fullerton and Anaheim districts and northeast of Anaheim is a large area, barren except for prickly pear and desert annuals. This is between the lower edge of the adobe subsoil and the upper edge of the first layer of the artesian clay, so there is no heavy subsoil to hold the water. This is clearly indicated in fig. 42. Occasional attempts are made to farm this area of deep sand, but none of the attempts seem to be a financial success.

Other phases of the Fresno sand.—The Fresno sand, which is derived from the Santiago Creek, in many cases contains a high percentage of gravel.

In some cases Fresno sand occurs upon the higher levels. Where this occurs, except along the ocean, it is sand wash from small canyons in the adjacent foothills. The location of these areas can readily be seen by a reference to the soil map. The sand has been pushed out upon the predominating soil, forming a sort of flat sand hill or cone delta. When the small torrents which bring these sands down flow over very precipitous ground, gravel and small bowlders are mixed with the sand.

On the San Joaquin ranch, where the foothills front the ocean, sand is found capping the tops of the highest elevations a mile or more back from the ocean. This is wind-blown, and in most cases is less than 6 feet in thickness. Because of the location these lands are dry farmed to wheat or used as pasture lands, it being impossible to obtain water for irrigation.

The Fresno sand also occurs in the rich, low-lying swampy lands west of the Santa Ana, upon which, when drained, can be grown corn, pumpkins, sorghum, potatoes, and all varieties of truck crops. While it is not considered so good a soil for celery as the Santiago silt loam

or peat of the same area, yet many hundreds of acres of this soil are yearly planted to this crop, which returns a handsome profit. It possesses an advantage over the other celery soils in that celery grown in them must be harvested when it becomes bleached, while in the sand it may be allowed to stand for weeks.

Owing to its open, porous nature and slight capillary power, the sand is usually free from alkali, although between the 50 and 75 foot contour lines small alkaline areas are found.

Mechanical analysis of Fresno sand soil.

No.	Locality.	Description.	Soluble salts.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, .05 to .005 mm.	Clay, 0.005 to 0.0001 mm.
5077	One-half mile N. Anaheim station.	Sand.....	*P. ct.* 0.27	*P. ct.* 1.28	*P. ct.* 2.93	*P. ct.* 13.82	*P. ct.* 11.47	*P. ct.* 42.48	*P. ct.* 21.20	*P. ct.* 4.62	*P. ct.* 1.92

FRESNO FINE SANDY LOAM.

Only two small areas of this soil are found east of Santa Ana River. The remainder is found west of the Santa Ana, arranged in parallel strips northeast and southwest. In all cases it is underlaid by sand at a depth of 3 feet or less, and is itself only a finer, heavier phase of the sand, having the properties of a sandy loam. It is a better walnut land, and in the swamp area is a better celery soil than the Fresno sand. It is this soil which carries the greater part of the alkali in the alkali belt, and by a comparison of the soil and alkali maps a decided relation between the two is easily seen. Where the alkali is not present in too great quantities, this soil is often sown to alfalfa. On the lower levels no irrigation is necessary, and abundant crops are raised with a minimum of effort. On the lowest levels this soil is interspersed with very thin layers of silt, and sometimes coarser sand, corresponding to the different stages of flood. In some cases thin strata of peat 2 or 3 inches thick are interspersed.

Beginning about 2 miles southwest of Anaheim and running parallel to the other strips of this soil is a hardpan phase of the fine sandy loam. When dry it is very hard and it is almost impossible to plow or work it. On the application of water it softens, but hardens again upon drying. This soil is alkaline, but not enough so to exclude the growth of useful crops. If it were not for the cementing material, which so modifies its mechanical condition that the tender rootlets are unable to penetrate it, this soil could be used for the successful production of crops.

Mechanical analysis of Fresno fine sandy loam soil.

No.	Locality.	Description.	Soluble salts.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
5081	One-half mile SW. Anaheim.	Fine sandy loam.	*P. ct.* 0.34	*P. ct.* 2.37	*P. ct.* Tr.	*P. ct.* 3.00	*P. ct.* 3.74	*P. ct.* 16.46	*P. ct.* 34.41	*P. ct.* 35.30	*P. ct.* 4.57

SANTIAGO SANDY LOAM.

All of this type of soil is found east and south of Santa Ana River. Typically it is underlaid at 3 or 4 feet by sand to a depth of from 12 to 20 feet, when clay is encountered. This soil constitutes the larger part of the orange and walnut districts near Orange and Tustin. Walnut trees thrive upon it much better than oranges, because of their deeper root system; also on account of the altitude, because walnuts for perfect development require the moist fogs to aid in opening their hulls, while fogs are especially injurious to the orange, inasmuch as they give a most favorable condition for the growth of scale. Truck crops, peanuts, and all the smaller varieties of fruits do exceptionally well upon this soil. It is kept in good mechanical condition with very little effort, and there is an abundance of irrigation water for such crops. Like the sandy soil of this region, it is found occupying some of the higher elevations. In such cases it usually has for a subsoil the sandy adobe. These upland areas are dry farmed to wheat and barley, and the broken nature of the country will never admit of irrigation.

Mechanical analysis of Santiago sandy loam soil.

No.	Locality.	Description.	Soluble salts.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
5079	Three-fourths mile NE. Santa Ana.	Sandy loam.....	*P. ct.* 0.20	*P. ct.* 2.79	*P. ct.* 1.75	*P. ct.* 4.84	*P. ct.* 5.30	*P. ct.* 25.94	*P. ct.* 26.93	*P. ct.* 26.72	*P. ct.* 6.64

SANTIAGO SILT LOAM.

The greater portion of this soil is also east of Santa Ana River, though there are small areas on the western side. The largest area

is that which includes the city of Santa Ana. Like the Santiago sandy loam, it is typically underlaid by sand, but south of Santa Ana, where it grades into the San Joaquin black adobe, it has an adobe subsoil. When low lying, this soil is alkaline; such areas are planted to alfalfa rather than to fruit, which would be injured. It yields three or four cuttings per year without irrigation. That part, however, which is situated above the bottom lands is planted to much the same varieties of trees and shrubs as the Santiago sandy loam. Just south of McPherson a gravelly phase of the silt loam covers quite a large area. This gravelly phase is now planted to oranges, grapes, and smaller fruits, although before the grape disease killed the vines of southern California this soil was noted as exceptionally good for the production of raisin grapes. The pebbles range in size from coarse sand to bowlders as large as a man's head. The larger ones are removed from the field; the smaller ones do not seem to interfere with cultivation.

The silt loam west of Santa Ana River, with the exception of the one area in the most southerly part, which is very alkaline, is farmed to celery. This loam is in most cases only about 2 feet thick, is underlaid by sand and is considered the best land for celery. When next to the peat land, it shows the influence of standing water, and is rather heavier than that east of Santa Ana River. With the exception of the large swampy area on the extreme south, almost every acre of Santiago silt loam west of the Santa Ana is now farmed to celery. The swamp areas were originally covered with a dense growth of willows, nettles, and tules, so that it required a great deal of labor to prepare them for cultivation, but now they amply repay the owners for all the time and money expended in reclaiming them.

Mechanical analysis of Santiago silt loam soil.

No.	Locality.	Description.	Soluble salts.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
5083	1 mile NE. Santa Ana.	Santiago silt loam.	0.26	3.65	Tr.	3.78	1.83	13.53	23.75	43.68	9.56

SANTIAGO LOAM.

Santiago loam is a true loam. The largest area is found about a mile and a half north of Orange, while another area includes the little town of El Modena. There are only about 3 square miles all told of this soil. It is characteristically barren, or nearly so. In no case was a

first-class crop found growing upon it. It is underlaid by sand and gravel at a depth of from 3 to 6 feet. From the surface down it gradually becomes a heavier loam until a depth of about 3 feet is reached; then the lower sands begin to have effect, giving rise to a sandy loam. Native vegetation is sparse, and when wheat and barley have been sown only an indifferent crop is grown. The surface of the area north of Orange is comparatively level, except for a few small "arroyas," while at El Modena it is rough and broken, containing some gravel, which is not the smooth, rounded gravel found in the adobe and silt loam, but is sharp and angular. No cause can be assigned for the barrenness of this soil.

Mechanical analyses of Santiago loam.

No.	Locality.	Description.	Soluble salts.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
5086	1½ miles N. Orange.	Loam, 0 to 12 inches.	0.14	3.04	Tr.	2.55	1.61	8.88	24.75	43.07	15.91
5087	....do....	Subsoil.....	.33	3.54	Tr.	2.67	.85	6.39	23.52	41.60	20.89

SAN JOAQUIN BLACK ADOBE.

This soil has the largest area of any soil east of the Santa Ana. It lies principally east and south of Santa Ana. Almost all the low-lying part of the San Joaquin ranch south of Tustin to the Laguna road is of this soil, which is the heaviest type of the Santiago soils. It extends from less than 25 feet above sea level to the 400-foot contour line. In the higher levels it is planted to fruit trees of various kinds and varieties. It is not so good a soil for trees as the lighter soils, since the roots find difficulty in penetrating it. When dry it breaks up into little cubes, forming a sort of mulch on the surface, and as the dry season advances this mulch gets thicker, giving rise to the peculiar phenomenon known as "dry bog." Great care must be exercised in plowing or the soil will be puddled and become absolutely impervious to water. For dry farming it is usually plowed dry and, to avoid puddling, the wheat is sown after the rain. In the orchards it requires constant watching after irrigation to determine the proper time to cultivate in order to keep it from baking.

Some of these upland black-adobe soils have gravel mixed with them in much the same proportion as the gravelly phases of the sandy and silt loams. This gravelly phase of the black adobe is better for fruit trees than the typical adobe, since the gravel somewhat relieves its sticky, compact nature and makes it more easily penetrated by the

roots. The low-lying areas of this soil are very heavy and sticky and usually carry alkali. These lands when alkaline are used for pasture only. The native vegetation is salt grass, pickle weeds, and other saline plants. Where this soil is less than 20 feet above sea level the ground water comes within less than 6 feet of the surface, and thus keeps the ground moist the year round. Some areas that were originally under water and have been recently drained are free from alkali. These areas are planted to corn and other shallow-rooted crops, and give an excellent yield.

Mechanical analyses of San Joaquin black adobe.

No.	Locality.	Description.	Soluble salts.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
5092	½ mile E. 4½ miles S. Santa Ana station.	Black adobe	3.29	10.60	1.86	4.28	2.86	4.44	8.49	41.34	23.25
5093	do	Subsoil	.....	3.67	2.52	1.52	.74	1.94	6.30	55.84	26.98

FULLERTON SANDY ADOBE.

Usually this soil is known as the "foothill soil." It comprises the covering for all of the foothills surrounding the Santa Ana Valley. The largest area mapped is found in the rolling country north of Fullerton. Unlike the black adobe, this soil contains quite a high percentage of sand, as the analyses show. When dry it cracks open and breaks up into cubes, giving rise to a condition similar to that found in the black adobe, but not so marked. Because of its elevation and the usual rolling nature of the surface this soil is only dry farmed. In no case is any considerable area irrigated. All of the foothills that are not too steep for cultivation are sown to wheat and barley. This foothill soil is the greatest grain producer of southern California. Owing to its peculiar method of breaking up when dry, it is at each succeeding rainy season in an excellent condition for receiving moisture, with which it parts very slowly, hence furnishing a storage for the dry months. It is underlaid at a depth of from 3 to 6 feet by sand, gravel, or shaly sandstone, but with the present methods of farming the subsoil has little influence upon the crops cultivated. As the Fullerton sandy adobe soil packs hard and does not become dusty so soon as the other soils of this region, it is much used as a covering for the roads where they are formed of a lighter soil. Roads thus made and sprinkled are, except in rainy weather, as firm and compact as the pike roads of the East. Where streams cut gullies and small canyons

through this soil the sides stand up perpendicularly, showing seams and cracks the entire thickness of the soil.

Mechanical analysis of Fullerton sandy abode.

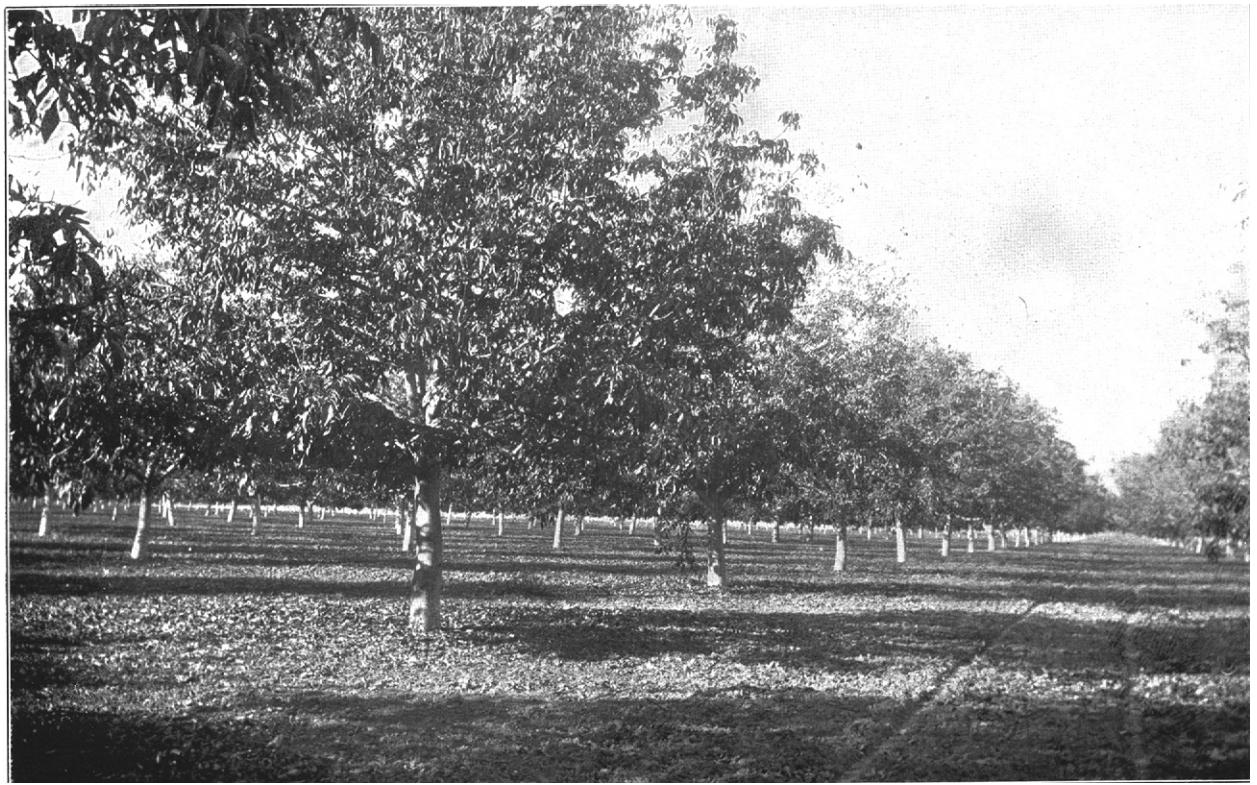
No.	Locality.	Description.	Soluble salts.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
5094	2 miles S. Smeltzer Station.	Sandy adobe....	0.38	29.4	1.54	3.49	3.90	11.82	32.18	32.04	12.10

PLACENTIA SANDY LOAM.

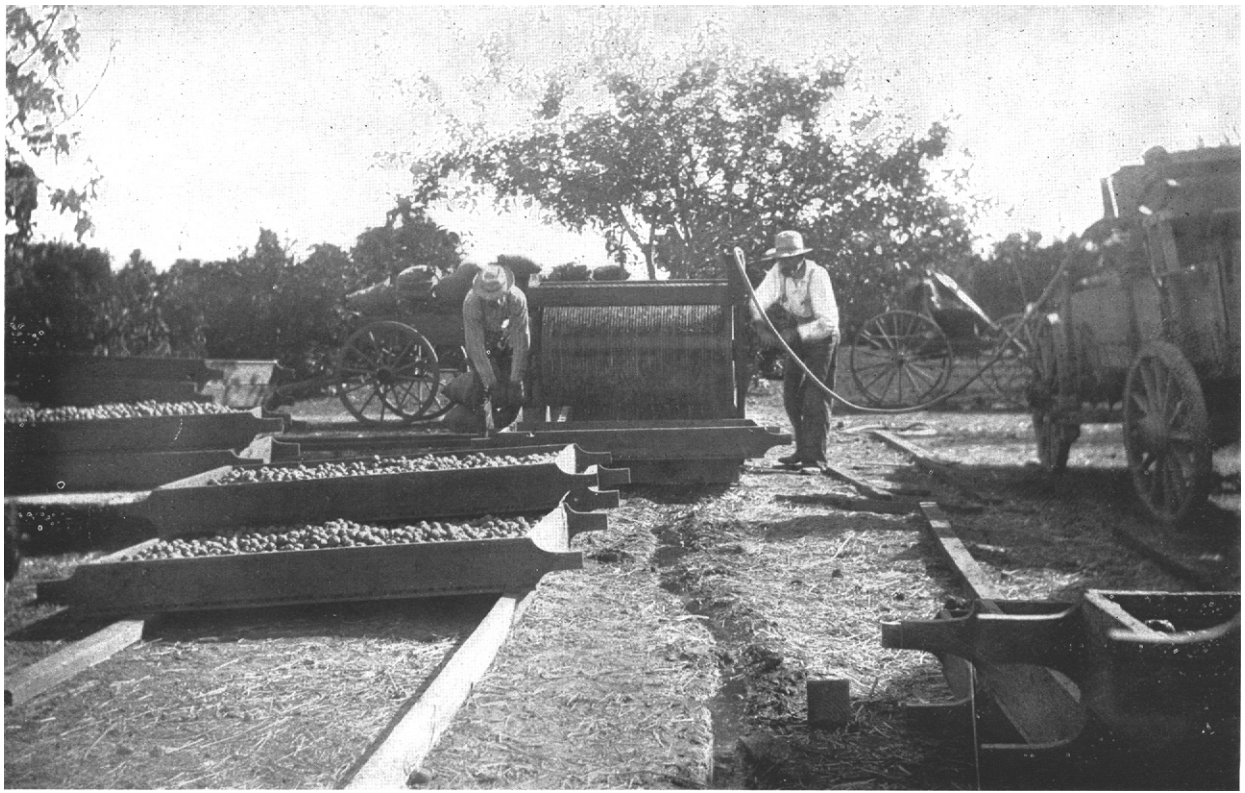
The largest area of this soil covers what is called The Placentia Country. It differs from the Santiago sandy loam in that it is partly wind-blown soil and has a heavy subsoil. The Placentia Country, lying northeast of Fullerton, is the only area of any considerable size that is level enough for irrigation. The rest is like the sandy adobe, rolling and broken, and is dry-farmed to wheat. This level Placentia tract is considered the best soil for oranges in Orange County. The soil is from 2 to 3 feet in thickness, of a light loamy texture, and is composed principally of very fine sand and silt. Underlying this is the sandy adobe. Where not of so compact a nature as to be impervious to water this subsoil acts as a storage and preserves moisture which may be used in seasons of drought. The roots of the orange penetrate this subsoil and use this store of moisture. To some plants it is quite impervious. English walnuts, for instance, when planted upon this soil soon die, because the taproot is unable to penetrate the subsoil. Practically all the first-class oranges shipped from Orange County come from this area.

In small areas this soil is found with a subsoil of sand underlaid by adobe, forming a loose soil and subsoil from 12 to 15 feet thick. On these areas English walnuts thrive especially well, the heavy adobe keeping the water from seeping away below and the loamy soil on the surface being easily tilled, while the sand is readily penetrated by the spreading roots.

The mesa land, which rises as a bluff along the coast south of Santa Ana, is of this same kind of soil. There is no irrigation, it being impossible to obtain water in any other way than by pumping.



ENGLISH WALNUT GROVE NEAR FULLERTON ON PLACENTIA SANDY LOAM, UNDERLAID BY FRESNO SAND SUBSOIL.



WASHING AND DRYING ENGLISH WALNUTS.

Mechanical analyses of Placentia sandy loam.

No.	Locality.	Description.	Soluble salts.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
5096	4 miles E. three-fourths mile N. Fullerton.	Sandy loam, 0 to 30 inches.	0.091	1.75	1.65	5.83	8.04	22.53	34.40	17.38	8.15
5097	.....do.....	Subsoil sandy loam, 30 to 72 inches.	0.19	2.73	1.65	4.00	5.00	20.22	23.98	24.34	17.64

PEAT.

Perhaps the most interesting soil of the Orange County region is this peat land. It varies in depth from a few inches to 30 feet, and is found along the low-lying artesian belt. The district mapped does not include all of the peat lands of Orange County, but typical areas were encountered which gave a working knowledge of the whole. Most of this soil lies west of Santa Ana River, though two small areas were found on the eastern side. One of these, on the San Joaquin ranch, is very deep, 10 to 30 feet. The other, which is found south of Santa Ana on the ranch of Mr. William McFadden, is not so deep, being at its deepest part only 23 feet. Both of these areas are much deeper than the average, and, when properly "subdued," will be valuable tracts. They have been drained and cultivated for two years only, so as yet do not yield full crops. The tracts west of the Santa Ana have nearly all been cultivated for several years and are now yielding full crops. Wherever the peat is continuous for a foot or more, peat springs are found and the overflow waters of the rivers have deposited their sediment before reaching this district. The whole county, being of a low swampy nature subject to periodic overflow, is continuously wet a few inches below the surface. Where springs occur an actual swamp is found the year round. Here the tules, nettles, hummock grass, wild celery, and other swamp plants have grown up, made their yearly deposit of vegetable matter, the roots always keeping near the surface and the old roots dying below, until there is a mass of decayed vegetable matter which is known as peat. In these patches of peat, if small, there is usually but one spring, and this spring is found in the center. As it comes up from below it brings silt and fine sand, which it deposits at the surface. Fig. 43 gives an idea of the formation of these peat lands.

From their peculiar method of formation these peat lands are higher than the immediate surrounding country. After they are thus built up for a time the spring seeks another outlet, breaks through the peat at some point lower than the central cone and here deposits its silt, so that in all areas of peat these patches of silt and fine sand are found. The larger areas are formed by several springs operating

near enough together to flood the entire area. Some of these springs are situated in the line of waters heavily charged with sediment. Here are found layers of peat alternating with layers of silt and fine sand. A period comes when no great floods occur and the peat is deposited, then comes the flood and deposits its layer of sediment. This process has been going on for a great number of years. In some places these thin layers of peat are found 30 feet below sea level.

A few years ago the entire country known as the "Bolsa Country" was a swamp, and considered of no practical value. Willows, tules, nettles, and other swamp growths were the only vegetation. A few enterprising farmers organized what is known as the Bolsa Drainage Ditch Company, and put in a small ditch, which drained a limited area near where Smeltzer is now situated. In a short time it was demonstrated that it would pay to drain and farm this land, so this ditch system was enlarged and extended until it now has three branches, known as the Bolsa, Blue Channel, and South Branch. They have an aggregate of 13 miles of main ditch, with a common outlet to the ocean. Narrow trenches, emptying into these main

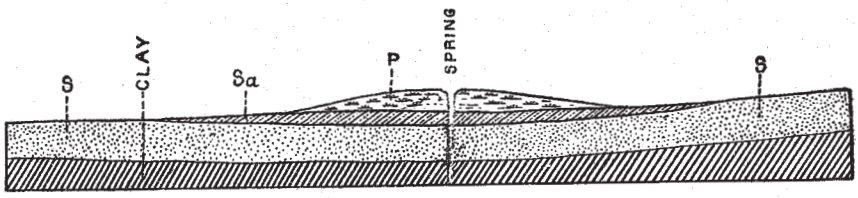


FIG. 43.—Section through peat land, showing artesian spring and cause of the accumulation of peat: *S*, Fresno sand; *Sa*, Santiago silt loam; *P*, peat. These peat lands owe their origin to springs of artesian source, which give rise to swamps, in which vegetable matter has accumulated, so that these peat lands are higher than the surrounding areas. They are found only in low places which are not subject to overflow from the rivers.

ditches, are cut through the peat with hay knives or peat spades, which with the exception of the trenches carrying off the waters of the springs, are filled so soon as the surplus water is drawn off. Great difficulty is experienced in plowing the first time. The lands are boggy and are filled with the roots and stumps of plants and willows. The stumps have to be first grubbed, and the peat tussocks, great bunches of grass roots, have to be cut off. Peat shoes are then placed upon the horses and the difficulty really begins. Peat shoes are usually made of the two ends of a tobacco box securely nailed together, the corners rounded, and clamped to the hoofs of the horses. Horses soon learn the value of these shoes and venture fearlessly upon the boggy land. Without them they would immediately be submerged. Occasionally a horse that does not understand the use of these shoes will get "bogged." No attempt is made at subsequent cultivation the first year. Usually corn is dropped in one furrow and potatoes in the next, thus alternating until the whole field is planted. In this way, and with no further cultivation, often 100 bushels of corn and 300 bushels of potatoes are raised on the same acre of ground at the same time. So soon as the surface covering has become suffi-

CELERY FIELD NEAR SWELTZER STATION.

ciently rotted to admit of cultivation the land is planted to celery, the staple crop of the peat lands.

The Bolsa Drainage Ditch Company is a cooperative corporation owned by the farmers benefited by it. The cost for the next ten years has been estimated by the board of directors at $15,000 for the draining of 5,000 acres. A part of this sum was immediately assessed the owners benefited by the ditch, the assessment being according to the value of their land and the degree of benefit derived from its drainage. This amount is decided by the board of directors, and is to be used in immediate improvement of the system. The remainder, included in the general assessments, is paid when the farmer pays his yearly taxes. This method occasions some discontent, as it is impossible to estimate just how much each is benefited, but on the whole it is perhaps the best known method of administrating such cooperative companies.

In 1898 a few enterprising men, encouraged by the success of the Bolsa drainage system, organized what is known as the Willows Drainage Ditch Company. This company was to drain that portion of the delta of the Santa Ana situated between the two bluffs near its mouth and back about 6 miles from the ocean. The original cost was to be $1 per acre for all lands benefited by the ditch, and subsequently a small tax was to pay the expenses of maintaining the ditch. Enough money was raised to put in the ditch, but this indiscriminate tax worked a hardship upon some who were not so greatly benefited as were their neighbors, so they refused to pay as much tax as their neighbors paid. Then all refused to pay tax, and the result is that after a period of three years' drought the ditch is now barely capable of carrying off the surplus water. What the condition will be if a flood shall occur is a matter for speculation. Many of the lowest farms, at least, will be submerged, the crops ruined, and the families compelled to seek higher ground until the waters subside. It is hoped that the matter will be so adjusted that an adequate permanent system will be inaugurated. The land is valuable enough to support an extensive system. From a tule swamp, practically valueless, it has been advanced to land now worth from $100 to $250 per acre, and when a reliable system of drainage is permanently instituted the land will be worth even more.

Under this drainage ditch there is no very deep peat. It is here that the layers of peat alternate with those of sand and silt, making soils fully as valuable as the peat lands, since they are much more easily cultivated and grow practically the same crops. Their greatest disadvantage is their location in the flood path, but this will be partly overcome by a first-class system of drainage.

Peat when cut in chunks and dried makes a good fuel. The tussocks and the poorly-rotted peat from the ditches are often burned as fuel. The well-rotted peat is much desired by florists and greenhouse men, who use it to mix with heavier soil for potted plants. For this purpose considerable is barreled and shipped away, bringing about $1 per barrel.

After being farmed for a number of years, peat lands pack down and become noticeably lower in elevation than before. They also get

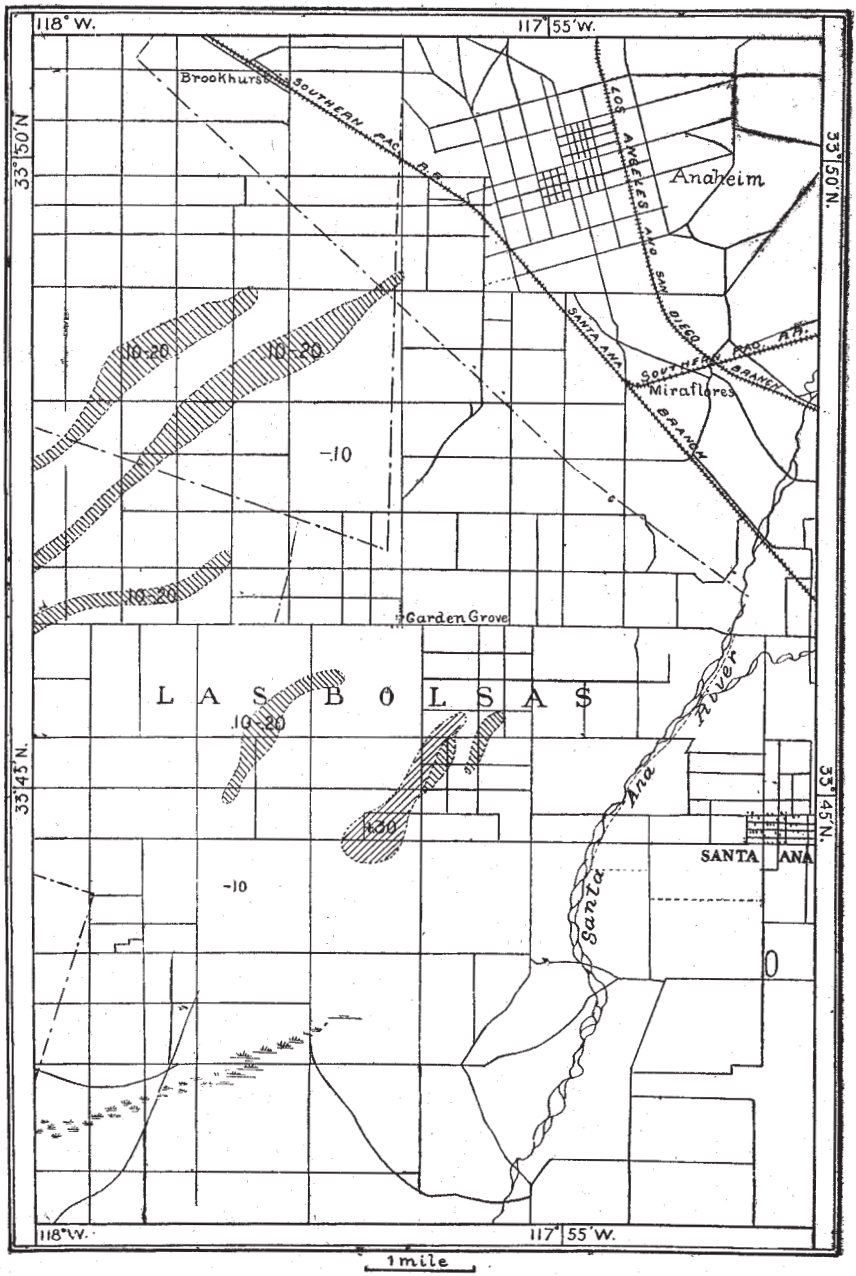


FIG. 44.—Black alkali lands of Santa Ana sheet, showing lands containing less than 0.10 per cent, from 0.1 to 0.2 per cent, and more than 0.3 per cent of sodium carbonate.

correspondingly heavier until, in some cases of lands that have been farmed for a number of years, the aid of a microscope is required to

detect their origin in the small amount of fibrous matter remaining. Some of the deepest peat, and therefore that which will settle the most, is only a little above tide water. It is a question whether this land will not some day be lower than the level of high tide.

First-class peat land, thoroughly "subdued" and situated above flood line, is now worth $500 per acre, and will pay interest on even a larger investment.

ALKALI.

A reference to the alkali map will show that the alkali east of the Santa Ana, of this region, occurs as a large and continuous area of varying intensity, in all 13,150 acres. On the western side it is in narrow strips. There is about 9,600 acres in these small areas. In only a few places do any of these strips or areas extend above the 100-foot contour line, the lands above this line being practically free from alkali.

These alkali lands have never been irrigated, but are always moist through subirrigation. The alkali is all found accumulated in the first two or three feet of the soil, with the greater part as a crust on the surface. A number of chemical analyses of these crusts, made in the Division of Soils, show the salts to be principally white alkali, in this case the sulphates with the chlorides—common salt and magnesium chloride. But a few isolated spots of black alkali (sodium carbonate) occur, which are shown on the sketch map, fig. 44.

Chemical analyses of alkali crusts of Orange County.

Constituent.	5102. One-half mile E., 1 mile S. Smeltzer.	5103. 6 miles S. Santa Ana.	5104. San Joaquin Ranch.	5105. 2¼ miles SW. Tustin.	5106. 1¼ miles SW. Red Hill.	5107. 2 miles NW. Santa Ana.	5108. 2 miles S., one-half mile W. Santa Ana.	5109. 2¼ miles SW. Tustin.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ca	0.49	.....	1.80	1.46	3.02	2.80	1.79	1.32
Mg	.70	.....	2.71	7.71	2.21	3.11	4.65	7.94
Na	34.93	25.73	32.21	19.46	26.28	25.04	22.93	18.09
K	.18	.22	.44	.54	1.40	.78	1.35	.29
NO_3	.....	.....	.....	.....	10.93	18.14	.....	.....
SO_4	25.52	27.76	6.27	50.74	27.93	24.74	59.84	70.48
Cl	37.85	10.39	56.14	18.46	24.96	23.57	7.73	1.22
CO_3	.....	15.36	.....	.....	.....	.....	.....	.....
HCO_3	.33	10.54	.43	1.63	3.27	1.82	1.71	.66
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
$CaSO_4$	1.67	.....	6.13	4.93	10.25	9.53	5.61	4.49
$MgSO_4$	3.49	.....	2.45	38.18	10.96	15.39	23.03	39.37
$MgCl_2$	.....	.....	8.68	.....	.....	.....	.....	.....
KCl	.34	.41	.84	1.03	2.66	1.49	2.58	.55
Na_2SO_4	31.94	41.11	.....	24.00	17.71	8.46	55.69	53.11
NaCl	62.10	16.81	81.31	29.61	39.03	37.68	10.73	1.57
$NaNO_3$	.....	.....	.....	.....	14.99	24.95	.....	.....
Na_2CO_3	.....	27.16	.....	.....	.....	.....	.....	.....
$NaHCO_3$	.46	14.51	.59	2.25	4.40	2.50	2.36	.1
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Per cent soluble	50.56	33.34	27.92	19.22	10.59	13.27	12.73	54.92

Sample No. 5104 was collected on the San Joaquin ranch, about a mile back from the head of San Joaquin Bay, but on land that is only a few feet in elevation above tide, and which evidently has been affected at some recent time by tide water. Chemical analyses of the salts of the sea water and of this sample of alkali crust follow. The composition of the salts of the sea, as determined by Regnault, is the mean result of over twenty analyses.

Composition of salts of the sea and of crust 5104.

Salts.	Ocean salts.	Crust 5104.	Salts.	Ocean salts.	Crust 5104.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Sodium chloride	77.04	81.31	Magnesium bromide	0.06	.....
Potassium chloride	1.99	.84	Calcium carbonate	.08	.....
Calcium sulphate	3.99	6.13	Sodium bicarbonate	.....	0.59
Magnesium sulphate	6.56	2.45	Total	100.00	100.00
Magnesium chloride	10.28	8.68			

The striking similarity of the composition of sea water and of the alkali of this crust leads to the belief that at least a part of the alkali here owes its origin to the evaporation of ocean water.

Taking the other extreme of the alkali lands, that is, the crusts from near the highest elevation (No. 5108), its composition is—

	Per cent.
Sodium chloride	10.73
Potassium chloride	2.58
Calcium sulphate	5.61
Magnesium sulphate	23.03
Potassium bicarbonate	2.36
Sodium sulphate	55.69
Total	100.00

This crust was collected from the San Joaquin black adobe land 2 miles south of Santa Ana Station and a half mile west. A comparison of this sample with the one from near tide water (No. 5104) shows a difference in the composition of the alkali; here it is mainly the sulphates. Thus, the alkali varies from a predominance of the sulphates on the higher parts of the alkali lands to a greater percentage of the chlorides on the lowest. Between these two extremes varying proportions of the two are found.

The large area of alkali south and southeast of Santa Ana occurs mainly in the San Joaquin black adobe soil, being the largest continuous area of alkali in this region. All the land which carries more than 0.60 percentage of alkali is used for pasture land, no attempt being made to grow crops other than the native saline vegetation. But where a less percentage of the alkali is present alfalfa forms a very productive and remunerative crop.

In no place is there any irrigation upon this alkali land, except in

very small plots, where the water from artesian wells is utilized. The irrigation company does not include this land in its district.

West of the Santa Ana the alkali occurs in strips. In most cases it is the Fresno fine sandy loam that carries the alkali, as will be seen by a comparison of the alkali and soil maps. Here, too, all of the alkali lands are used for pasture. The country is divided into farms of from 40 to 100 acres, and on almost every farm there is some land that will produce alfalfa. This, with the native vegetation, furnishes sufficient feed to maintain the dairying industries to which these farms are devoted. Very few attempts are made to raise anything but alfalfa, which once seeded grows luxuriantly without irrigation.

It was found to be extremely difficult to establish the amount of alkali that the different fruit trees could withstand, for in most cases no attempts are made to grow trees upon the alkali soils. Then, too, the nearness of the water table to the surface in these low lands makes it impossible to distinguish between the effects of alkali and of standing water. Enough was learned to know that English walnut trees are always excluded by more than 0.15 per cent of alkali. This amount does not appreciably affect pear trees or apple trees, as they will grow in soil that has as much as 0.50 per cent, but are measurably affected by it, and as this amount increases they rapidly die. Asparagus, alfalfa, onions, corn, and celery are able to withstand varying amounts from 0.20 to 0.60, in the order in which they are named, asparagus being the most resistant and celery the least. Nothing but saline vegetation grows upon a soil having more than 0.60 per cent, although much of this vegetation is good pasture for stock.

Knowing the kind and amount of the alkali, the nature of the soil and subsoil, and the kind of crops best adapted to such alkali soils, the landowner can proceed intelligently in the treatment of such soils, having in view their ultimate reclamation. For the alkali soils west of Santa Ana River this reclamation is practicable and should be accomplished at slight cost. If the surplus of ground water can be carried off in drains and not allowed to evaporate from the surface, no more alkali will be accumulated. Since the whole country has an open, porous, sand subsoil, and much of the surface soil itself is sand, a few irrigations with proper drainage would suffice to entirely reclaim that which now has only a small amount and to relieve even the worst spots so that the alkali-resisting plants may be grown upon them. The Willows and Bolsa drainage ditches even now drain much of this country, and if they were enlarged and extended so as to take in all of the country affected by alkali the expense to the present owners of the ditches would be much less, because of the division of expenses, while it would be cheaper for the owners of the alkali lands to thus make use of these outlets than it would be to dig ditches to the sea.

Mr. Frank Hazard, near Westminster, has demonstrated that tile drainage when practiced on isolated spots is very beneficial. On

spots where a few years ago nothing of value would grow he now has a good stand of alfalfa, the change being brought about by the use of tile drains, with the Bolsa drainage ditch as an outlet.

The alkali east of Santa Ana River occurs in a heavy soil, mainly the black adobe, so its reclamation will be more difficult than that of sandier soils, because the alkali is not so easily washed out, as water travels slowly through a heavy soil. With plenty of irrigation water and with proper tile drainage this soil might in time be made valuable for alfalfa and other alkali-resisting plants.

HISTORY AND PRESENT SYSTEMS OF IRRIGATION.[1]

The earliest canal in this section of which there is any authentic record is the Yorba ditch, which was built by Bernardo Yorba in 1835, Mr. Yorba being at that time sole owner of the rancho Cañon de Santa Ana. Two other ditches were also constructed by him about this time, but in a flood of 1862 all three of these ditches were destroyed. After this destruction the present Yorba ditch, based upon the rights of the old ones, was constructed. This ditch has the oldest water rights on the river, and such rights are respected by the owners of the other ditches. It irrigates only about 600 acres of land and carries on an average 450 inches of water.

A few years after the Yorba was built the Kramer ditch was constructed, its purpose being to irrigate that part of the rancho San Juan y Cajon de Santa Ana, known as the Kramer tract. After the construction of the Anaheim ditch the Kramer received its water through the head works of this canal. When the western companies were finally consolidated into the Anaheim Union Water Company, this ditch received 20 shares of nonassessable stock as a recognition of its prior rights.

In 1856 the organization generally known as the Anaheim Colony was formed in San Francisco, under the name of the Los Angeles Vineyard Association. The association secured 1,165 acres of land from the rancho San Juan y Cajon de Santa Ana, with water rights based on the riparian rights of this ranch, and with additional water rights purchased from the owners of the rancho Cañon de Santa Ana, which was also riparian to the river.

In 1857 the first ditch of this company was dug and enough water diverted to irrigate the 1,165-acre tract. At first there was no separate incorporated water company, but in 1859 the Anaheim Water Company was incorporated. The stock was divided into 50 shares, and was appurtenant to the 50 lots of the Los Angeles Vineyard Association. In 1878 the Anaheim Water Company purchased a half interest in the Cajon Irrigation Company's ditch, which was then in process

[1] The information in this chapter was obtained from officials of the Santa Ana Irrigation Company, the Anaheim Union Water Company, and "Irrigation in Southern California," by William H. Hall.

of construction. A flume about 7,000 feet long was constructed the following year, connecting the Anaheim with the Cajon Canal. For several years the Anaheim received all its water in dry seasons from the Cajon, but this joint use of the same canal led to friction. In 1882, pending the decision of the courts, the Anaheim constructed what was known as the Anaheim New Canal, tapping the river at a point almost opposite the Santa Ana Canal of the south side, and thus getting a permanent supply from the river itself. The Cajon Canal was begun in 1875 by the commissioners of a local district, formed under irrigation district laws, and was to irrigate the country now known as The Placentia Country, and that north of the old sand wash between Anaheim and Fullerton. The tax, however, was too great and many of the landowners refused to pay it, so great difficulty was experienced in getting funds, as well as in the litigation which was started. This led to general dissatisfaction, and in 1884 the Anaheim Union Water Company was formed. To this company was conveyed the interests of all the canals on the north side, except the Yorba.

This Anaheim Union is the company that now supplies the Anaheim, Fullerton, and Placentia districts with water. Since this union was effected great improvement has taken place in the service of the company. The main ditch, where it flows over the sandiest portion of its course, has been cemented for 2 miles at a cost of $4 per linear foot. This greatly augments the amount of water that formerly reached the district. The company also has 33 miles of cement laterals and distribution ditches, which cost from 25 cents to $1.50 per linear foot. The rates charged for water are decided upon from month to month by the board of directors, being more when the water is scarce than when the supply more than meets the demand. For the year 1899 the rates were, for 100 inches one hour, during January, February, November, and December, 30 cents; for March, 40 cents; for April and October, 50 cents; for June, July, and August, 80 cents; for September, 60 cents. At this rate it costs about $4 per year per acre to irrigate walnut orchards and $6 per acre for irrigating orange trees and alfalfa. A list of prices is prepared for the filling of cisterns, watering of stock, sprinkling of lawns, etc.

Except for the small amount diverted by the Yorba Canal the Anaheim Union now has one-half of the water of the lower Santa Ana River. Its main head gate and that of the Santa Ana Valley Irrigation Company are situated on opposite sides of the river, so that one dam is all that is necessary for the two. No permanent dam has been put in, only a brush dam, which is washed out in time of flood and again replaced when the water subsides.

Irrigation on the south side of the Santa Ana begun with the Semi-Tropical Water Company, formed in 1873. This was solely a water-supplying company, owning no land, but simply selling water for irrigation purposes. This company diverted water with the consent of

the owners of the rancho Santiago de Santa Ana, who claimed that by their original grant and riparian rights they were entitled to half of the water of the Santa Ana. In 1877 a suit occurred between the Semi-Tropical and Anaheim Union companies that was carried to the United States Supreme Court, where the decision of the lower court, which had decided in favor of the Anaheim Union, was reversed, and an equal division of the water advised. This advice was followed, and since that time, 1883, no friction has occurred. In 1877 the present corporation was formed—the Santa Ana Valley Irrigation Company. It immediately acquired all of the interests of the Semi-Tropical Company, and it is the irrigation company which provides all the water east and south of the Santa Ana River. While nearly all southern California has been suffering for water during the last two or three years, this company has had sufficient. Instead of the price of water advancing, as it has in nearly every other section, it has been diminished. Before the dry season the ditch had to be kept up and employees' salaries paid, and all the water was not sold; but now all the water available is sold, and the consequence is that it costs less to irrigate than it did in seasons of greater rainfall. During the past year, under the Santa Ana Irrigation Company's works, it cost but $1 per year to irrigate walnut orchards and $1.75 for orange trees and alfalfa. This is somewhat less than the cost of irrigating similar lands on the other side of the river, which is partly due to the more open, porous nature of the soil on the north side. This company has about 100 miles of ditch, including laterals and distributing ditches, and 26 miles of this is cemented, at a cost of from 25 cents to $1.50 per foot. The policy of the company is to have eventually its entire system of ditches cemented, so that there will be a minimum loss in transmission.

Neither the Santa Ana Valley nor the Anaheim Union districts extends into the low-lying land. All the irrigation water used on these lowlands comes from artesian wells. Of these wells, there are a great number of different sizes and capacities.

CONDITIONS OF AGRICULTURE.

Forty years ago practically all of what is now Orange County was thought valuable only for grazing land. The whole county was owned by a few men who held the titles to the original Mexican grants. Gradually it dawned upon these owners that their land was valuable for crop raising, and, with the help of irrigation, the county has undergone rapid changes. From isolated sheep camps the county has become a densely populated district, dotted with towns, and honeycombed by railroads. Santa Ana, the county seat, is a growing town of more than 5,000 inhabitants. A new court-house and high-school building have been erected recently and add materially to the general appearance of the town. Almost every denomination of the

ANAHEIM UNION CANAL WITH CEMENT SIDES AND BOTTOM.

The main canal is cemented for 2 miles along the sandy bottom land to prevent loss of water by seepage.

LATERAL DITCH, WITH CEMENT BOTTOM AND SIDES TO PREVENT LOSS OF WATER BY SEEPAGE.

Christian religion has a separate church, and there is no lack of civil, educational, and religious influences.

In the valley are the towns of Orange, Tustin, McPherson, El Modena, Olive, Anaheim, Fullerton, Gardengrove, Westminster, Smeltzer, and Buenapark. All of these towns, with the exception of Gardengrove and Westminster, are situated on the railroad. There are many other small post offices in the county, most of them being kept in connection with country stores. The county has two ports or landings where coast-line steamers touch—Anaheim Landing and Newport Beach.

The farms, or ranches, as they are called, are of all sizes, from 5-acre tracts to the San Joaquin ranch, which has 96,000 acres. The farmers are, as a rule, men of means, who have gone there to live because of the climate or have been attracted by one of the many different lines of agricultural pursuits. They have modern houses, many of which are elegant in structure and design. Every yard has a profusion of flowers and semitropical plants, which grow with but little attention. Nearly all of the country near Santa Ana, Tustin, and Orange is divided into small tracts of land of 5, 10, 15, or 20 acres, each tract having a good house and grounds. The roads are sprinkled, and a finer community or pleasanter place for residence would be hard to find. The remainder of the area is in larger tracts and is less thickly settled.

Every agricultural area in California has some special crop adapted to it. As before mentioned, Orange County is divided by elevation into two distinct agricultural areas, the uplands and swamp lands, or lands that will grow fruits and nuts and lands that will not. On the lands that will grow fruits and nuts are found English walnuts, oranges, lemons, grape fruit, grapes, apricots, peaches, peanuts, all of the smaller varieties of fruits, such as strawberries, blackberries, etc., also many different varieties of semitropical fruits, some of which will be mentioned later.

English walnuts reach a degree of perfection there that is attained in no other place in the United States, and they occupy a larger area than does any other one crop. The young trees are planted in rows 60 feet apart, so that there will be ample room for the spreading branches. Between these trees are often planted other trees, which will be cut down as the walnuts grow. Sometimes small fruits and vegetables are cultivated among the walnut trees. Walnut trees begin to bear when 5 or 6 years old and continue to do so to a great age. The trees are irrigated only during the growing season. As yet little commercial fertilizer has been used in the orchards, but stable manure has been applied with appreciable results.

The walnut is very sensitive to alkali and is one of the first trees to suffer from its presence; neither will it grow where the ground water approaches the surface, 15 feet being in all cases close enough

to injure it. The walnut tree sends down a long taproot, which, if it encounter any very hard substance, such as a heavy adobe subsoil it is unable to penetrate, a stunted growth results. Because of this sensitiveness great care should be exercised in the selection of land for walnut orchards. When the proper kind of soil is planted to walnuts and the trees are in good bearing condition, $1,000 per acre is about the exchange price, the price being based on the yield.

While walnut trees will grow and bear in other districts, they do not reach the degree of perfection attained here. The fogs which come in the fall nights take the place of frosts in the Eastern States, and help to break open the hulls, so that the walnuts fall from the trees ready to be gathered. On higher levels and farther from the coast, where fogs do not occur, they drop from the trees with the hull on, and, if not gathered and hulled immediately, they spoil. About the middle of September the nuts begin to ripen, the hulls split, and the walnuts continue falling to the ground until nearly the middle of November. Some growers gather them every day and others gather them every two days during this time. The nuts are picked up from the ground, placed in bags, and hauled to the ranch house, where they are washed in a revolving, wovenwire cylinder, as shown in Pl. XLV. After being dried they are again sacked, and in this condition are sold to the packing houses. Here they are dipped (immersed in a solution of chemicals) and sulphured in order to bleach them before being placed upon the market.

Recently the growers, thinking they did not receive enough for their walnuts, formed an association to regulate prices, and have almost doubled their receipts. During the past season walnuts brought to the grower 10 cents per pound for first class and 8½ cents for second class. If these prices become permanent every available acre of land in Orange County will soon be planted to walnuts. Within the last few years a disease has attacked the walnut trees, and in some localities has done much damage. It attacks the tender shoots and the nuts themselves, causing the nuts to fall from the tree before ripening. Prof. Newton B. Pearce, of the Division of Vegetable Physiology and Pathology, located at Santa Ana, is now working on this disease, and in another year, no doubt, will be able to recommend methods of controlling it.

Oranges and lemons are pretty generally grown in a small way throughout the area, but only along the highest levels are they a commercial success. The grape fruit or pomelo as yet is little known to consumers, and therefore is only raised in small amounts. The highest irrigable lands are nearly all planted to one or other of these citrus fruits, because the fogs are not so heavy on the higher levels. The same fogs that make English walnuts a success tend to make citrus fruits a failure.

ORANGE GROVE NEAR FULLERTON.

The scale is the greatest enemy of the citrus-fruit grower, and these scales thrive especially well in places where fogs occur, so the grower must be always fighting this pest. In some localities this is the greatest single item of expense. The most effective way to fight the scale is to fumigate the trees with potassium cyanide. This is done once a year, and when practiced regularly will be sufficient for relief. The cost is considerable, being about $12.50 per acre.

Northeast of Fullerton is an area known as The 'Placentia Country,' where oranges thrive and are a commercial success. This is due principally to the elevation and the consequent small amount of fog, but it is also in a measure due to the soil, which is a sandy loam underlaid by a heavy adobe. The roots of orange trees have great penetrating power and readily enter the heavy soil, where moisture is always found; therefore oranges planted on this soil require less irrigation and are able to withstand longer seasons of drought than where the subsoil is lighter. Oranges require much more water than do English walnuts, because they grow throughout the entire year. They are irrigated seven or eight times during the twelve months. Ridges are thrown up between the rows and the entire surface of the ground flooded, and as soon as the water subsides and the ground becomes dry enough it is cultivated again in order to prevent the escape of the moisture. The soil requires fertilizing, and a great deal of money is expended annually for commercial fertilizer. The trees bear so heavily that props are required to support the branches. A sort of wire hook has been invented for this purpose, which fastens to a narrow board and makes a rest for the limb. The expense for this "propping" of the trees is about the same as it is for fertilizer, and usually varies in direct proportion.

The greatest expense of an orange grower, aside from the natural expenses of irrigation and cultivation, are for fumigation, fertilization, and for propping the trees. When ripe the oranges are picked and hauled to the packing houses where they are wrapped and packed in boxes for shipment to the various distributing points.

What is true of oranges is in a general way true of lemons, except that lemons do not all ripen at the same time of year. The lemon tree is continually blooming and ripening fruit, hence there is at no one time an excessively heavy crop, and the trees need no props. Before being shipped the lemons are "cured;" that is, they are subjected to a process which will make them keep a longer time than they would if shipped immediately after being picked. Like oranges, lemons are grown principally along the highest levels. In some places they are grown on land higher than can be irrigated from the canals, water in these cases being pumped for irrigation purposes. At one time almost the whole of Orange County was planted to vineyards, but about ten years ago the vineyards of the entire county

were killed by a disease. Since that time attempts have been made to raise grapes, but only a partial success has been attained.

The other fruits mentioned in the beginning of this article are grown, but are so widely known that they need no special mention. They are grown in a commercial way, but not on so extensive a scale as oranges, lemons, and walnuts. Perhaps it would be well to make special mention of peanuts. They are usually grown between the rows in newly planted orchards and perform the twofold office of yielding a revenue and "green manuring" the soil.

Of the many varieties of tropical and semitropical fruits introduced into southern California, the loquot is one which bids fair to gain a permanent hold. This fruit is pear-shaped, grows in clusters, and has a delicate flavor. As introduced it was not a success, but Mr. C. P. Taft has developed several varieties which are as large as small pears, and for which he receives 7 or 8 cents per pound, finding a ready sale in the markets of Los Angeles.

The swamp lands, or what is commonly known as peat lands, have been cultivated for only a few years, but even now they furnish no inconsiderable part of the exports of the county. Celery is the principal crop. It is found growing wild over the greater part of these lowlands, this wild celery being edible but much stronger flavored than the cultivated varieties. The celery seed is planted in beds, and when the plants are large enough they are transplanted in rows 4 feet apart, with the plants 9 inches or a foot apart in the rows. It is better to transplant twice, cutting the taproot off each time so that the surface roots will develop, but the common practice is to transplant but once. The plants are set in the bottom of furrows made by a plow, and as they are cultivated the earth is gradually filled in around them. Although planted on land which has to be drained because the ground water is close to the surface, the celery must be irrigated, as it requires a great deal of water. Artesian wells are put in for this purpose, and furnish an ample supply of water. A great deal of labor is necessary to keep the weeds down, most of the crop requiring hoeing at least once during growth. When the celery is large enough to harvest it is ridged, a machine designed especially for this work being used. After the celery becomes bleached it is harvested, washed, and tied up in bunches of one dozen each, which bring from 15 to 20 cents each at the station. At this rate the crop from an acre will bring from $125 to $200. This gives the grower a handsome profit over all expenditure of money and labor.

There are few modern houses in this district, most of the people living in small frame houses hurriedly constructed when the country was first settled. Many of the owners and farmers live on the higher land surrounding this area. In some parts that are subject to overflow the reason for this is obvious.

ARTESIAN WELL NEAR EDGE OF PEAT LAND.

Water used to irrigate celery. Artesian wells furnish all water for irrigation in these lowlands.

ORANGE GROVE, SHOWING METHOD OF COMBINED FURROW AND BASIN IRRIGATION COMMONLY USED.

Because of the great profit in celery growing little effort has been made toward the growing of other crops on these lowlands. Onions are grown by some and yield, on an average, 200 sacks per acre for each crop, and two crops a year may be grown. Well-decomposed peat or the surrounding Santiago silt loam is the best soil for this crop. The crop is sold at an average price of 70 cents per 100 pounds. At this price onions pay better than celery, but as the market is limited only a limited acreage will pay.

Asparagus will grow on moderately strong alkali lands; in fact, it will grow after all other edible plants have been killed. For this reason it bids fair to become a crop of value to this region. A sample of the soil from an asparagus bed on the ranch of Mr. S. J. Murdock, near Westminster, showed 0.2 per cent of alkali. Before sowing the asparagus, salt grass had been allowed to grow on this land. From two-thirds of an acre he now sells each year $100 worth of asparagus. Much of the land that is now grown up in saltbushes, salt grass, etc., in the vicinity of Westminster, Gardengrove, and Buenapark, could, with a little care, be transformed into paying fields of asparagus. There is an increasing demand for canned asparagus, as the plant loses little of its flavor when canned. If a canning factory were there, raising and canning this crop would seem to be the best solution of the alkali problem for that area.

During the first stages of cultivation the lowlands are planted to corn, potatoes, and pumpkins, but when these lands are fully "subdued" these crops are not so valuable as the ones above mentioned.

Between these lowlands and the fruit country is a belt that is partly alkaline and partly free from alkali. This belt is given over principally to dairying. On the spots where there is not an excess of alkali the land is sown to alfalfa. The alkali spots are allowed to produce what they will of native saline vegetation, which is used for pasturage. This portion of the country is quite valuable, land being worth from $40 to $100 per acre. Little labor is required here for cultivation. Alfalfa is not irrigated, the roots going deep enough to bring water from below. Butter and cheese are made in the creameries, which products find a ready sale in the markets of southern California.

The Southern Pacific Company and the Santa Fe Company each has railroads in Orange County, the Santa Fe road going on to San Diego, while the Southern Pacific stops in the county. These have branches going to nearly all the small towns, and thus furnish a rapid means for transporting the products of the county, most of which are perishable and must be placed upon the market as quickly as possible after being gathered. For short distances, as from Los Angeles to points in this county, the freight rates are high on these railroads, consequently much of the nonperishable products which are used in Los Angeles

are hauled there by teams of horses. These teams usually consist of 6, 8, or 10 horses, drawing 4 or 5 tons of material. On their return trip they bring materials from the wholesale houses in Los Angeles, these materials being used in the valley. Such bulky material as lumber, lime, etc., is usually shipped by steamers to the ports of the county, and some of the nonperishable and cheaper products of the county are shipped in this way. This method is much cheaper than the railroad rates, the principal drawback being its slowness.

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