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Soil Survey

of the

Yuma-Wellton Area, Arizona-California

By

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Bureau of Chemistry and Soils
In cooperation with the
University of Arizona Agricultural Experiment Station

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SOIL SURVEY

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AREA SURVEYED

The Yuma-Wellton area is in the dry, hot, desert country known as the arid Southwest. The greater part of the area surveyed is in Yuma County, in the extreme southwestern corner of Arizona, but a small part (41 square miles) extends across Colorado River into Imperial County, Calif. The international boundary line separates the southwestern part of the area from the State of Sonora, Mexico, and the Colorado River separates it from the State of Baja California, Mexico, on the west. The boundaries of the area surveyed are so drawn as to include the entire Yuma irrigation project of the United States Department of the Interior, Bureau of Reclamation, and the adjoining land to the east along Gila River where agricultural development seems probable. Small intervening areas of nonagricultural desert and mountainous land are also included within the boundaries of the survey. The total extent of the area surveyed is 631 square miles, or 403,840 acres (fig. 1). It covers a more extensive area and includes the area covered by the earlier soil surveys of the Yuma area (*5*, *6*)[1] in 1902 and 1904.

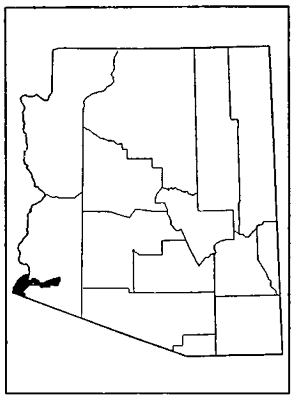

FIGURE 1.—Sketch map showing location of the Yuma-Wellton area, Ariz.-Calif.

Southwestern Arizona, of which this area is typical, is largely a comparatively smooth plain, interrupted by rather numerous and very rugged but comparatively low and narrow mountain ridges, which have a general northwest-southeast trend, separated by broad lowland belts. The mountains are composed largely of bare rock, and the intermountain lowland belts (broad alluvial fans) are underlain by thick deposits of rock debris washed down from the mountains by the infrequent rains and carried out by small intermittent streams or washes. The fans slope rather steeply down from the mountains for a short distance, and thence the slope becomes gradual and very smooth, the surface in many places becoming flat, or nearly so, near the axial lines of the intermountain belts where fans from opposite-lying mountains approach or meet and merge. Along many of these

[1] Italic numbers in parentheses refer to Literature Cited, p 36.

belts, large intermittent desert washes and, through a few of them, rivers make their way, cutting and filling and building flood plains and terraces of different width and extent.

In this area, two rivers—Colorado and Gila—have formed valleys mainly along, but partly across the intermountain plains. Each has a flood plain bordered by strips of higher terrace lands, or mesas. The Colorado River bottom land, commonly known as the Yuma Valley, is comparatively wide, ranging from 5 to 6 miles in width below Yuma, tapering to a point at Laguna Dam on the north and narrowing to less than 2 miles at the Mexican border on the south. It is a typical river flood plain, broken in places by sand dunes. Sloughs and abandoned stretches of old river channels with their enclosing natural levees are present in typical development. Because of the high ground-water table in places, considerable areas are poorly drained.

The Yuma Mesa is a smooth Colorado River terrace ranging from 5 to 12 miles in width and extending along the east side of Yuma Valley from the alluvial plain of the Gila River to the Mexican border. This mesa lies from 40 to 70 feet above the recent-alluvial plain of the Colorado and is in most places separated from the valley by a well-defined bluff. In many places along its outer edges it is severely dissected, forming a strip of rough broken land of varying width but in most places narrow. Farther back from the edge the mesa has a smooth surface, broken by a few small, partly buried, rocky hills, or buttes, and a few small sand dunes. The eastern edge of the mesa is marked by a rather abrupt rise marking the edge of a similar but higher terrace. A belt along the eastern side of the mesa has a hummocky or even dunelike surface. No system of natural drainage ways exists except close along the edge of the bluff. A number of rather large basinlike depressions occur. It is doubtful, however, whether poor drainage will ever develop on the mesa, even under intensive development of irrigation farming, as the surface soils and subsoils are in most places very loose and open.

The alluvial plain of the Gila River ranges from one half mile to more than 4 miles in width. At the mouth of the river, the flood plain is wide, but it becomes very narrow between Blaisdell and Dome where the river swings around the northern end of the Gila Mountains. This mountain range, which protrudes into the area from the south, is very rugged, and on its eastern and western flanks lie steep stony alluvial fans. East of the mountains a large valley opens out south of the river, but here, also, the alluvial plain is rather closely hemmed in on the north by rough or mountainous areas. Along the south side of the plain lies a terrace which is badly dissected along the edge and in many places dotted with small sand dunes. West of Wellton this terrace is narrow and poorly defined, but it increases in width east of that town and is rather wide between Tacna and the Mohawk Mountains which lie just outside the eastern boundary of the area. Back from the bluff it is fairly smooth and resembles the Yuma Mesa, although sand dunes are of more frequent occurrence. It is commonly known as the Wellton Mesa.

Alluvial fans rise gently from the southern edge of the terrace and blend almost imperceptibly with it. Most of these fans are fairly smooth on their outer ends, but as they approach the mountains they become steeper, more deeply cut by washes, and, in places, somewhat ridgy.

Like the Colorado River bottom land, that along Gila River has a smooth surface, broken in places by small dunes and old river channels.

With the exception of parts of the river flood plains, the area is, in general, well drained.

This area lies at a slight elevation above sea level. The lowest point—in the Yuma Valley at the Mexican boundary—is between 80 and 90 feet. At Yuma the elevation is 141 feet. The Yuma Mesa to the south and east has an elevation of 190 to 220 feet, and it slopes to 150 feet at the Mexican border. At the eastern edge of the area, the mesa land attains a height of 430 feet above sea level; and the highest point in the area, which is in the Gila Mountains, has an altitude of 1,735 feet.

The Yuma-Wellton area is part of a sparsely settled region. It includes the greater part of the population of Yuma County, which in 1930 numbered 17,816,[2] of which 4,892 were urban and 12,924, rural. Most of the population is concentrated in Yuma and the irrigated Yuma Valley. That part of the area lying in California has only a small rural population. A fairly large percentage of the population consists of Mexicans and Indians, though the whites predominate. The 1930 census lists 10,725 as native white, 392 foreign-born white, 783 Negros, and 5,916 of other races, including Mexicans, Indians, Chinese, Japanese, and other nonwhite races. Mexicans, Negroes, and a few Indians furnish most of the unskilled labor, although whites are employed to some extent in cotton picking.

Yuma is the county seat of Yuma County and the only important city in the area. It has a population of 4,892. It is a trading and shipping point of some importance and enjoys a considerable tourist trade. Somerton is a small town and trading center located in the Yuma Valley. It is the site of several cotton gins. Wellton, Gadsden, Roll, Tacna, Dome, and Bard are all small trading centers and post offices.

The area is served by the San Francisco-New Orleans line of the Southern Pacific Railroad. The Bureau of Reclamation operates two short branch lines which run on the crowns of the levees—one north to Laguna Dam and the other south to the Mexican border. They are used mainly for hauling Government supplies and material for building and maintaining levees. United States Highway No. 80, also called the "Old Spanish Trail" and the "Bankhead Highway", crosses the area from east to west. It is paved or surfaced with oiled gravel the entire distance. Yuma Valley is crossed by a network of paved highways. Most of the other roads in that part of the area

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[2] Soil survey reports are dated as of the year in which the field work was completed. Later census figures are given whenever possible.

under cultivation are graded and are of earth construction. Desert sections are provided only with trails, in some places so sandy as to be impassable or nearly so.

Good graded schools and high schools are maintained under a centralized school system. Telephone service and electric power and light are available in the towns and over parts of the better-developed rural districts.

Cities along the Pacific coast, especially Los Angeles, are the chief markets for the products of this area, but fruits and vegetables are also shipped to middle-western and eastern markets.

That part of the area not under cultivation or close to the rivers is a true desert, in which the chief vegetative covering is a sparse growth of brush. Creosote bush, called "greasewood" by many people, is the most common plant on the dry desert uplands. Bursage—false ragweed—also is common, and in the looser hummocky sandy soils a coarse bunch grass called "galleta grass", or "crackers grass", and jointfir, a bush locally called "Brigham tea", or "Mormon tea", are characteristic. Mesquite, paloverde, and ironwood grow along the desert washes. Giant cacti, cholla cacti, and ocotillo grow on the higher fan slopes near the mountains. The bottom lands or flood plains of the rivers support a growth of cottonwood, willow, mesquite, arrowweed, saltbush, seepweed, pickleweed, and desert sage, with some creosote bush in unusually well drained locations (*10*).

CLIMATE

The Yuma-Wellton area lies at a low altitude in the arid Southwest. It is cut off from the moderating influence of the Pacific Ocean and its moisture-laden winds by a range of mountains in California, west of the area; and, as a result, it has a so-called "continental" or "inland" climate, such as characterizes much of Arizona, southern Nevada, and inland parts of California. The climate is very dry, with little rainfall, a dry atmosphere, rapid evaporation of moisture, and an unusually large proportion of sunny days, in fact, a day without some sunshine is extremely rare. The mean annual temperature is high, the summers long and very hot, and the winters short and mild. Snow is unknown. In general, the daily range of temperature is great, and sudden temperature changes are frequent. Strong winds are common, and dust and sand storms often occur. The prevailing winds are from the northwest.

The average length of the frost-free season at Yuma is 354 days, which is very long as compared with that at most other Weather Bureau stations in the United States. The average date of the first killing frost is December 24 and of the last is January 4. Frost has been recorded as early as November 27 and as late as February 18. Some winters are frost free, especially on the mesa or bench lands. The lower valley lands are more subject to frost, and the average growing season is shorter. The location of commercial plantings of citrus fruits is largely governed by local differences in temperature.

The average annual precipitation is very low—only 3.10 inches. This is, of course, not enough to be of much practical value in the growing of farm crops. Most of it occurs during the winter months.

Table 1 gives the normal monthly, seasonal, and annual temperature and precipitation at Yuma.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Yuma, Ariz.*

[Elevation, 141 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1899)	Total amount for the wettest year (1905)
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*
December	55.2	83	22	0.45	(1)	0.34
January	54.4	84	22	.43	0.01	1.15
February	58.6	92	25	.60	.01	3.43
Winter	56.1	92	22	1.48	.02	4.92
March	64.1	100	31	.35	(1)	3.33
April	69.5	107	38	.10	.00	.16
May	76.2	120	39	.03	.00	.00
Spring	69.9	120	31	.48	(1)	3.49
June	84.7	119	50	.00	(1)	.00
July	90.8	118	61	.12	(1)	(1)
August	90.4	117	58	.35	.06	.02
Summer	88.6	119	50	.47	.06	.02
September	83.7	113	50	.16	.00	.52
October	73.3	108	38	.19	.02	.02
November	62.4	94	29	.32	.50	2.44
Fall	73.1	113	29	.67	.52	2.98
Year	71.9	120	22	3.10	.60	11.41

[1] Trace.

In 1905, having a total rainfall of 11.41 inches, the precipitation in February was 3.43 inches and in March, 3.33 inches. A precipitation in excess of the mean annual amount has been recorded at Yuma within a single 24-hour period (*1*).

The University of Arizona Agricultural Experiment Station has made a study of the effect of the climate of southern Arizona on various crop plants and has amassed some interesting and valuable information along this line (*8*).

It is stated that aridity or low relative humidity of the atmosphere is not generally favorable to plant growth. Not many plants thrive so well in a dry atmosphere as in a more humid one, and only a very few grow better under such a condition. The effect of the intense sunlight in this area is also detrimental to some plants, causing sunburning. The great heat of summer and the frosts of winter also render the climate unsuitable to many plants. Some seeds will not germinate in the hottest weather, some plants remain dormant in such weather, others are brought to maturity, and still others are killed outright. The frosts kill many tender plants, otherwise tropical plants might thrive. In effect the growing season for most crops is divided into two parts, spring and autumn.

Of the staple-crop plants considered as well adapted to this climate, alfalfa and cotton are the most important. Even alfalfa has a period of little growth in the hottest part of the summer as well as in midwinter, and cotton must be carefully and frequently irrigated in the hottest weather if the fruiting stage has been reached. The grain sorghums—milo, kafir, hegari, feterita, and others—are very well adapted to the hot dry summer climate. Bermuda, Johnson, and Sudan grasses thrive in the summer, but such temperate-climate grasses as Kentucky bluegrass, bromegrass, orchard grass, and Australian ryegrass are killed by the heat. The date palm is especially well adapted to this climate; and the European, or viniferous, varieties of grapes, and olives, figs, and pomegranates also do well. Of the citrus fruits, grapefruit and oranges are adapted to a few comparatively frost free belts. They are occasionally damaged by winter weather, and in summer the trunks of the trees are apt to sunburn badly if not shaded. A number of crops do very well in fall, winter, and spring, but cannot be grown in summer. Among these are lettuce, peas, spinach, carrots, cabbage, and many other vegetables. Tomatoes produce a crop in the spring, lie dormant through the summer, and produce a second crop in the autumn. Sweetpotatoes grow well throughout the summer, and produce good yields. Potatoes are very difficult to grow, as growth is checked by early hot dry weather and yields are normally light. Corn may be satisfactorily grown only in the late summer and fall, and early varieties must be grown in order to mature before cold weather. The small grains are sown from November to February and make a good growth during winter and early spring. They cannot endure the hot dry weather of late spring and summer, and regardless of the time they are sown they come to maturity in April or May. Yields are generally lower than in a cooler climate.

AGRICULTURE

Settlement in this area started in the Gila Valley in the early eighties when several thousand acres were put under cultivation. The land was abandoned, however, after floods had destroyed the irrigation-diversion works. Prior to the construction, by the United States Bureau of Reclamation, of the Laguna Dam and the system of irrigation canals and laterals and protecting levees of the Yuma irrigation project, agricultural development was very limited and attended by considerable risk of failure, owing to flood or drought. A few thousand acres were irrigated by pump ditches from Colorado River. Alfalfa hay was the main crop grown.

The Laguna Dam was completed in 1908, and a part of the valley land on the California side of Colorado River was irrigated that season. The siphon across the Colorado River at Yuma was completed in 1912, and the Yuma Valley on the Arizona side was irrigated thereafter. Settlement and development of the area were rapid, and most of the irrigable valley land in the project is now under cultivation. In 1928, approximately 53,700 acres were irrigated in the reservation and valley divisions, exclusive of roads, ditches, and farmsteads. Of the 45,000 acres in the mesa division, only 1,256 acres were irrigated, though pumping and distributing works were completed to supply water for a total of 3,810 acres.

The North Gila Valley obtains its water supply from Colorado River at Laguna Dam. Its development was coincident with that of the Yuma project. Probably about 5,000 acres are cultivated here, and a few hundred acres more may be developed.

The land in the Antelope and Mohawk Valleys and on the Wellton Mesa is in the Gila Valley power district, which comprises a total of 97,722 acres. Development was started here in 1921, and in 1928 approximately 5,000 acres were under cultivation. The land is irrigated by pumping from wells. A slow expansion of the cultivated acreage is taking place and further development is expected.

Several hundred acres in the South Gila Valley, which are irrigated by pumping from wells, are also farmed.

The total acreage of cultivated land in the Yuma-Wellton area amounted to approximately 66,000 acres in 1928.[3] This amounts to 16.3 percent of the total area surveyed.

Cotton is the most important crop grown in the area, both in regard to the acreage occupied and the total value of the product. In 1928, 34,342 acres on the Yuma irrigation project were devoted to cotton, and in addition perhaps 5,000 acres in North Gila Valley, South Gila Valley, Mohawk Valley, and Antelope Valley, making a total of more than 39,000 acres, or about 60 percent of the cultivated land in the area. The total value of cotton lint produced on the Yuma project in 1928, at an average price of 20½ cents a pound, was $3,104,341.26, or $90.34 an acre. The value of the seed, at 1.3 cents a pound, was $393,761.92, or $11.47 an acre. Good yields of a high-quality fiber are produced, and the crop is comparatively free from injurious insect pests.

Cotton yields averaged about 441 pounds (nearly nine tenths of a bale) an acre in 1928, the yields ranging from 100 pounds to 1,125 pounds. The yield of cottonseed was about twice the weight of the lint. In general, the best yields were obtained on the medium-textured Gila soils. Gila fine sand and the light-textured subsoil phases of the Gila soils gave yields considerably below the average. They are not only less productive than the finer-textured soils but it is more difficult to maintain a favorable moisture content in these soils at the critical fruiting period which occurs in the hot summer *(9)*. Gila clay also returned considerably lower average yields than did soils of medium texture, though on a few farms where this soil was skillfully handled it produced very large crops.

Acala and Mebane are the principal varieties of cotton grown. They are classed as upland, or short-staple, varieties, though the fiber is longer than that in some short-staple varieties. Pima, a long-staple cotton, is grown to some extent. Cheap Mexican and Negro labor are available for thinning and picking the cotton.

As previously stated, this district is fairly free from insects injurious to cotton. Neither the cotton-boll weevil nor the pink bollworm have been found here, but a number of cotton diseases are present. Root-rot *(11)* is the most serious disease affecting the crop in the Yuma Valley. It is a bacterial disease which attacks the roots of taprooted plants and lives from year to year in the soil, the infected spots spreading slowly. The only known control is crop rotation including the growing, for at least 2 years, of fibrous-rooted plants—such as the grain

[3] The census figures are hardly applicable, as this area covers only a part of Yuma County, Ariz., and includes a small acreage of the cultivated land of Imperial County, Calif. The figures given throughout this section were obtained from the U.S. Bureau of Reclamation crop report for 1928 on the Yuma irrigation project and from estimates by officials of the Gila Valley power district and the Mohawk municipal water conservation district.

sorghums, corn, and small grains—which do not serve as hosts for the disease. Alfalfa and other taprooted plants, including weeds, are affected by and carry over the disease from year to year. This disease was observed on cotton growing on all types of soil in the Yuma Valley but was probably worse on the lighter-textured soils or those with very sandy subsoils. Black arm, or angular leaf spot, is also a rather common disease. It is controlled by treating the seed with a disinfecting solution.

Alfalfa, grown for hay and seed, is the second crop in acreage and also in total value. The area devoted to alfalfa on the Yuma irrigation project in 1928 was 12,207.81 acres. The production was 28,625.5 tons of hay, 2,749,040 pounds of seed, and 6,978.5 tons of straw. The total value of these products was $754,307, or $61.79 an acre, with hay valued at $11.76 a ton, straw at $6.54 a ton, and seed at 13½ cents a pound. In addition, valuable winter pasturage is afforded by this crop. In North Gila Valley, South Gila Valley, Antelope Valley, and Mohawk Valley, probably about 5,000 acres were devoted to alfalfa.

In alfalfa production, the common practice is to cut one crop of hay in the spring and then let the plants go to seed. One or two cuttings of hay may be made after the seed crop is removed, and the land is pastured in the winter. About 75 percent of the alfalfa acreage on the Yuma project and a still larger percentage in the other irrigated sections of the area were used for seed production in 1928. The average hay yield for the Yuma project was nearly 2½ tons an acre, though yields as high as 9 tons an acre were reported where the crop was used for hay alone. The average seed yield on the Yuma project was 304.43 pounds an acre. The highest yield reported was 1,200 pounds, produced in Antelope Valley. As low as 50 pounds an acre was obtained on some fields. Where cut for hay alone, from 5 to 7 cuttings, or occasionally more, are made.

Another valuable feature of alfalfa is its place in the crop rotation to maintain or increase soil fertility. Other crops almost invariably yield more heavily following alfalfa.

Alfalfa is grown on a wide range of soils and yields satisfactorily on most of them. It is more tolerant of alkali than cotton and most of the other crops grown in this region. The medium-textured Gila soils give the largest yields as a rule, though as these are more highly valued for cotton, alfalfa is grown most extensively on the heavier soils where it is generally more profitable than cotton. Another reason for its being grown on these soils is that the land is hard to plow and cultivate, and after it is once seeded to alfalfa it requires less labor and expense than do cultivated crops.

In 1928, tame pasture occupied 2,984.57 acres on the Yuma project. This had an estimated total value of $63,725.50, or $21.61 an acre. In addition to this, livestock were pastured on large areas of cotton, alfalfa, and grain land after the crops were removed.

The grain sorghums, of which milo is the most important, occupied 2,375 acres in 1928. They produced an average yield of about 1.2 tons of grain an acre besides a small quantity of fodder and some pasture. The value of this crop was $68,577, or $29.87 an acre. It is used as feed for farm cattle, horses, sheep, hogs, and poultry, and for feeding range cattle and sheep brought in for fattening during the winter. It takes the place in this area that is occupied by corn in the Middle West and South. It is a quick-maturing crop, grown in the summer, and is often used in a double-cropping system on land occupied by lettuce, cantaloups, or small grains in the winter and spring. It is grown on most of the Gila soils, but the heaviest yields are generally obtained on the medium-textured soils (fine sandy loams to silty clay loams) with fine-textured friable subsoils.

Lettuce ranked fifth in acreage on the Yuma project, occupying 1,410 acres in 1928. In value it ranked third, being exceeded only by cotton and alfalfa. It produced 178,167 crates, valued at $176,448.50. The average yield was 126.36 crates an acre, which, at a price of 99 cents a crate, were worth $125.14 an acre. Yields range from 100 to 250 crates an acre.

This crop is grown in the winter season. It comes on the market in competition with lettuce grown in the Imperial Valley, Calif., and the Salt River Valley, Ariz., and as a consequence the price received is not always sufficient to give satisfactory financial returns. It is marketed largely in the large eastern and middle-western cities. The expense of growing, packing, shipping, and marketing is high, and a high price must be obtained to make growing profitable. In some years a handsome profit is realized. The variety of lettuce most commonly grown is the New York, or Los Angeles, often called "Iceberg."

Lettuce is grown on the Gila soils. The lighter-textured soils afford quicker maturity when the weather is cool, and the heavy ones generally give larger yields and quicker maturity when the crop is started in warmer weather for the early December market. As the crop is bulky, distance from the shipping point determines its distribution to some extent.

Cantaloups occupied 1,112 acres in 1928 and produced a crop worth $129,281.25. The average yield was 146.32 crates an acre, with a value of 79½ cents a crate, or $116.26 an acre. This crop is started in the field during January or February under wax-paper covers, and most of the crop comes on the market in June, when it comes into competition with cantaloups grown in the Imperial Valley and the Salt River Valley. As it is an expensive crop to grow and ship, it must bring a high price on the distant eastern or midwestern markets if it is to return a profit to the grower. In some years good returns are received.

Cantaloups are grown and produce good crops on the Gila soils. They mature earlier on the fine sandy loam and very fine sandy loam but may yield slightly more on the silty clay loam and clay. They are often used in a double-crop system with lettuce, milo, or some other crop.

Wheat and the other small grains are not important crops in this area. Only 624 acres of wheat were grown in 1928 on the Yuma project. The average production was 11.84 bushels an acre, with an acre value of $17.97 and a total value of $11,214.77. Barley occupied only 240 acres and produced 24.49 bushels an acre, worth $20.78, or a total of $4,986. The small grains are grown on any of the medium- or heavy-textured Gila soils, more commonly on the latter. That they do not yield better is probably owing partly to the hot climate and partly to the lack of organic matter in the soil. They are often used in a double-cropping system with milo or corn. Barley is sometimes sown for winter pasture or hay in fields of alfalfa or in Bermuda-grass pastures.

Pecans occupied a total of 478.5 acres in 1928. The trees on 166.5 acres had reached bearing age, though all are still comparatively young. The bearing trees produced 29,530 pounds of nuts, with a total value of $16,158, at an average price of 54.4 cents a pound. The average production was 177.36 pounds an acre, worth $96.45.

Pecan growing (*7*) is in its infancy in this area. It is thought to have considerable promise, though perhaps it should not as yet be considered a proved industry. A number of young groves have returned good yields of high-quality nuts and are as yet fairly free from insect pests and diseases. Texas root rot has killed a few young trees. It seems probable that the trees will make a more healthy growth on the typical Gila soils, which have a friable medium-textured subsoil, than on the heavy-subsoil phases of these soils, in which root penetration and drainage are somewhat retarded, or on the coarse upland soils of the Superstition and Mohave series. They will probably do fairly well on the light-subsoil phases of the Gila soils, though they may not make quite so rapid growth as on the typical Gila soils. Permeability, freedom from alkali, and good drainage are the essential characteristics of a good pecan soil.

Watermelons were grown on 165 acres in 1928, producing 1,419.4 tons, worth $15,643. The average yield was 8½ tons an acre, and, at a price of $11.02 a ton, they had an acre value of $94.81.

Small acreages are devoted to the production of Bermuda-grass seed, miscellaneous hay crops, garden peas, grapes, dates, nursery stock, corn, oats, deciduous fruits, strawberries, pears, pomegranates, figs, flowers, peppers, sweetpotatoes, potatoes, sugarcane, and other crops.

The Yuma Mesa (*12*) is a large tract of land which is considered of great promise in the profitable production of citrus fruits. Its climate gives it an advantage over other localities in this respect. It is said to have the least rainfall, the lowest relative humidity, and the greatest percentage of sunshine of any citrus district in the United States. These conditions are probably nearly matched in the Imperial and Coachella Valleys in California and perhaps on the Wellton Mesa. They are conducive to the production of sweet, highly-colored, and early maturing fruit (pl. 1, *A*). Frost seldom occurs on the mesa. The lowest temperature recorded in 7 years, when records were kept at the Blaisdell orchard near Yuma, was 28° F.

In 1928, a total of 1,256 acres was under cultivation on the Yuma Mesa and about 350 acres on the Wellton Mesa, nearly all of which was Superstition sand and its silted phase. This acreage was largely devoted to the production of grapefruit and oranges, with small areas in grapes, alfalfa, lemons, dates, and a few fig and olive trees.

The citrus fruits occupied an aggregate acreage of 1,133 acres on the Yuma irrigation project in 1928. All of this, with the exception of 16 acres, was on the Yuma auxiliary or Mesa division. In addition to this, an additional area of perhaps 200 acres of young nonbearing citrus trees was on the Wellton Mesa. Bearing grapefruit trees, ranging in age from 3 to 12 years, which produced 1,268,626 pounds of fruit, with a total value of $92,269.25, occupied 507 acres. The average acre yield was 4,475 pounds which, at an average price of 4.1 cents a pound, had a value of $182. The acreage of nonbearing grapefruit trees on the project was given as 413 acres.

Bearing orange groves totaled 76 acres; and 310,370 pounds of fruit, with a value of $13,718, were produced. The acre production averaged 4,083 pounds, and the acre value $180.51 at 4.4 cents a pound. A small area of lemons (16 acres) gave a small total return and a low acre return.

Citrus growing is in its infancy here, but it has great promise. Marsh Seedless is the most important variety of grapefruit, and the Washington Navel is the most popular orange variety. Valencia oranges are also grown. Most of the groves are young, many of the trees being not yet of bearing age, and plantings are constantly being increased. The feasibility of citrus growing has been definitely proved by some of the older orchards which have yearly borne good crops of fruit. The Blaisdell orchard, planted in 1896, is still producing profitably.

On account of the high cost of water and the large water requirement of the soils on the mesas (the Superstition, Mohave, and Cajon soils), only crops yielding a high cash return are considered economically suitable for crop production. Another factor which makes these soils less adapted to the growing of the common field crops is their low productivity as compared with the Gila soils. Fertilization is essential, and this is feasible only with high-priced crops. Where water is available, small acreages of alfalfa have produced good crops, but cotton, the small grains, and milo have never yielded well.

Grapes (*2*) and dates, though occupying only a very small acreage, give promise of future importance. Early table grapes, of which the Sultanina (Thompson Seedless) variety is the most important, mature very early here and have a high sugar content. They mature earlier than the grapes of most competing districts in California and Arizona and when marketed early bring good prices. In 1928 about 50 acres were devoted to grapes on the Yuma project and a larger acreage on Wellton Mesa. Grapes produce larger crops on the heavy soils but are earlier and sweeter when grown on the lighter ones. The most extensive plantings are on Superstition sand, with smaller acreages on Mohave loamy coarse sand and Cajon loamy sand.

Dates are also well adapted to the climate, and they bring a very high cash return. The expansion of the acreage in dates is hindered by the scarcity and high price of offshoots and young palms for planting. Only slightly more than 30 acres were in dates in 1928, and most of the trees were too young to produce large crops. The average gross income was approximately $100 an acre, but, judging from experience in other date-growing districts of the Southwest, annual profits of more than $1,000 an acre are possible.

Farming at the present time consists largely of producing cash crops. Greater diversification, together with the raising of livestock and poultry and the development of dairying, would probably lead to greater and more permanent prosperity.

Livestock on the Yuma irrigation project on December 31, 1928, included 2,427 horses, 1,128 mules, 154 beef cattle, 1,119 dairy cattle, 1,727 sheep, 3 goats, 117 brood sows, 1,239 hogs, 45,319 fowls, and 2,254 hives of bees. In addition to these, about 5,000 beef cattle were brought in from the range during the winter to be fattened for the Pacific-coast markets. Several thousand head of sheep were also pastured in the area during the winter and shipped to market or to northern ranges for the summer. In this way a revenue is obtained from cotton, alfalfa, and milo fields which are pastured after removal of the crops. Much alfalfa hay, straw, milo, and cottonseed may be profitably utilized by being fed on the farms. Dairying is carried on to some extent. Most of the whole milk is consumed locally, and a small quantity of butter is manufactured. The poultry industry is not extensive, though it is profitable. A number of cotton gins are maintained in the area, and the baled cotton is shipped to Los Angeles and eastern markets.

SOILS AND CROPS

In its natural state, southwestern Arizona is a desert country. Agriculture, in the small areas where it is carried on, is made possible entirely by irrigation. The rainfall is so scant as to be negligible, and the soils, though rich in mineral plant foods, must have water, artificially applied, to make them productive. Large expanses of potentially fertile soils in this area are without any present supply of water, though proposed irrigation projects may cover much of them.

The soils here, because of their formation and development under a dry climate, have suffered very little loss of the mineral constituents contained in the original geological deposits. They contain high percentages of lime, potash, and phosphorus. In many places an excess of the more soluble salts (alkali) causes an unfavorable condition for the growth of plants. The supply of organic matter and nitrogen is very small, especially in the sandier soils. Some of the recent-alluvial bottom land is richest in this constituent, but even that is poor compared with the soils of the humid and semiarid grasslands. This deficiency may be met by growing alfalfa and other legumes and by plowing under manure, cotton stalks, straw, and other vegetable matter. Owing to the high lime content or alkalinity of the soils, there is, in places, a deficiency of available phosphorus, though the total phosphorus content is comparatively high. Such soils often give marked response to fertilization with superphosphate.

A soil condition, which is peculiar to certain irrigation projects of the Southwest, occurs in this area. It is an artificially laid surface soil or "silt". This is not necessarily silt as technically recognized in textural soil classification but fine material carried in suspension by the river water and deposited on the land by irrigation. It consists largely of clay, some of it very fine or even colloidal, though in periods of high water it includes true silt and a small proportion of very fine sand. Colorado River is a great silt carrier, the waters always being muddy and of a dirty reddish-brown color, even in periods of low water. Every irrigation deposits a layer of fine silty or clayey material on the surface of each irrigated field. A maximum of 3 inches has been laid on a field in a single season. Analysis of this material, made at the Arizona Agricultural Experiment Station, shows it to be well supplied with lime, potash, and phosphorus, and also to contain an appreciable quantity of nitrogen (*3*). Hence all those soils irrigated by Colorado River water are constantly being changed in their surface layers and are becoming yearly more uniform, most of them heavier. A silty clay is apparently the texture toward which these soils are tending. Extensive areas of light-textured sandy and fine sandy soils mapped in the earlier surveys of 1902 and 1904 (*5*, *6*) consist at present of silty clay loam, silty clay, or clay, mainly as the light-textured subsoil phases of the Gila soils. There is little doubt that the textural classification and mapping in the early surveys was essentially correct at that time.

The soils of the area lying in situations where relief makes irrigation possible have been separated into a number of units, or types, and these have been grouped into four groups, or soil series. These are the Gila, Cajon, Superstition, and Mohave series. Other soil areas which are rendered nonagricultural by roughness, presence of outcropping bedrock, or frequent flooding are differentiated only as rough broken land, rough stony land, and undifferentiated alluvial soils, respectively. Dune sand is also mapped.

The Gila and Cajon soils are composed of light pinkish-brown or dull-brown stratified alluvial materials which have been changed but little since they were deposited. The Gila soils are in general of fine texture and comparatively mellow or friable in both surface soils and subsoils, except where the texture is very heavy. The Cajon soils are coarser and very loose and leachy. The Superstition soils, developed from coarse sandy upland and terrace materials, have loose or fairly firm light pinkish-brown surface soils and pinkish-gray subsoils which are slightly compact and very limy. At a depth ranging from 2 to 3 feet a bed of very loose coarse sand or gravelly sand occurs, which makes the water-holding capacity of these soils low. The Mohave soils, as mapped in this area, are also of coarse texture, but the subsoils are more compact, more limy, and redder, and they have a better water-holding capacity than soils of the Cajon and Superstition series.

Considered agriculturally, the soils of the area belong to two large groups: (1) those used for cotton, alfalfa, and general farming, and (2) those used for the production of citrus fruits (grapefruit and oranges), grapes, and other subtropical fruits.

General farming is carried on mainly on the soils of the Gila series, which lie in the river valleys. Citrus fruits and grapes are produced largely on the Superstition soils, with very small acreages on soils of the Mohave and Cajon series. These soils occur on the upland terraces and alluvial fans.

Cotton occupied approximately 60 percent of the total cultivated land in 1928; alfalfa, about 25 percent; and the remaining 15 percent was divided among many crops, the more important of which were tame pasture, milo, lettuce, cantaloups, pecans, citrus fruits, and small grains.

In the following pages of this report the soils of the Yuma-Wellton area are described in detail and their agricultural possibilities and treatment 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 the soils mapped in the Yuma-Wellton area, Arizona-California*

Type of soil	Acres	Percent	Type of soil	Acres	Percent
Gila fine sandy loam	21,824	5.4	Gila clay	13,696	3.4
Gila fine sandy loam, light-textured subsoil phase	3,968	1.0	Gila clay, light-textured subsoil phase	2,240	.6
Gila fine sandy loam, heavy-textured subsoil phase	192	.1	Gila clay, heavy-textured subsoil phase	7,424	1.8
Gila fine sandy loam, humocky phase	768	.2	Gila fine sand	3,648	.9
Gila very fine sandy loam	27,200	6.7	Superstition sand	56,192	13.9
Gila loam	17,088	4.2	Superstition sand, silted phase	1,536	.4
Gila loam, light-textured subsoil phase	1,856	.5	Superstition sand, humocky phase	44,544	11.0
Gila loam, heavy-textured subsoil phase	704	.2	Superstition sandy loam	3,712	.9
Gila silt loam	9,792	2.4	Superstition sandy loam, heavy-textured subsoil phase	448	.1
Gila silt loam, heavy-textured subsoil phase	384	.1	Mohave loamy coarse sand	30,720	7.6
Gila clay loam	4,224	1.1	Mohave fine gravelly sandy loam	7,488	1.9
Gila clay loam, light-textured subsoil phase	3,072	.7	Mohave gravelly sandy loam	2,112	.5
Gila clay loam, heavy-textured subsoil phase	320	.1	Mohave gravelly sandy loam, stony phase	960	.2
Gila silty clay loam	17,088	4.2	Cajon loamy sand	13,760	3.4
Gila silty clay loam, light-textured subsoil phase	1,472	.4	Cajon stony sand	6,528	1.6
Gila silty clay loam, heavy-textured subsoil phase	1,344	.3	Alluvial soils, undifferentiated	46,848	11.6
			Dune sand	4,224	1.1
			Rough broken land	23,104	5.7
			Rough stony land	23,360	5.8
			Total	403,840	------

GENERAL-FARMING SOILS

The Gila soils are by far the most important agricultural soils in the area, both by reason of their location in bottom lands where water may be easily and cheaply applied and because of their good quality, owing to their generally fine texture, good water-holding capacity, and comparative richness in available plant foods. They constitute 95 percent or more of the total irrigated acreage at the present time. Gravity irrigation water is available for a large acreage of these soils on the Yuma irrigation project. They are very well adapted to general farming.

The Gila soils consist of alluvial materials deposited by the Colorado and Gila Rivers in comparatively recent times. They range in texture from fine sand to clay. The lighter-textured soils are light grayish brown or pinkish brown, and the heavier ones (those containing more clay) are darker, being dull brown with a slight red tinge. The subsoils are typically more or less stratified and of variable texture but free from accumulated lime and cementation and compaction due to weathering, although they are in places very tough owing to their heavy texture. They are rich in lime and other minerals and in places are badly affected by alkali, the lime being rather uniformly distributed throughout the soil profile.

The Gila series includes many soil types, or textural members, with phases of these types based on the texture of the subsoil. Eight types and twelve phases of Gila soils are mapped in the Yuma-Wellton area. These soils are very much mixed in occurrence, and only a few large continuous bodies of any one soil type or phase occur, though some of these soils have a large total acreage. Many farms include a number of soils and even some fields include several different soils. This is unfortunate, as each soil needs different irrigation and cultural treatment to produce the best results with crops, and such conditions result in a very spotted condition of the crops in some fields.

As stated heretofore, the Gila soils are, in general, well adapted to general farming and especially to cotton and alfalfa. However, the different soil types and phases within the series have different degrees of adaptation to each of the crops grown.

The typical Gila soils of medium texture include Gila fine sandy loam, Gila very fine sandy loam, Gila loam, Gila silt loam, Gila clay loam, and Gila silty clay loam—all of which are in general granular and friable. They are the most desirable agricultural soils, being friable, easily worked, deep, and productive of all the common crops, where water is applied in sufficient quantities and an excessive salt concentration is not present.

Cotton is by far the most important crop on this group of soils, occupying probably three fourths of the acreage under cultivation. Alfalfa ranks next in acreage, and it yields heavily on these soils. Cotton is the more extensively grown because of its larger average cash return to the acre. Milo, lettuce, cantaloups, pecans, and pasture also are important, and wheat and barley are grown to some extent.

The light-textured subsoil phases of Gila fine sandy loam, loam, clay loam, silty clay loam, and clay have a subsoil of loose clean fine or medium sand, of light pinkish-gray or brownish-gray color, which lies within 20 inches of the surface. Many of these soils represent Gila fine sand which has been artificially altered by the deposition of silt from irrigation water. The thinness of the surface soils and the loose character of the subsoils tend to make these soils poor in moisture-holding capacity. They are also less productive than the soils with medium- or heavy-textured subsoils, and apparently root rot is also more severe. Excessively shallow spots give indication of their presence by the stunted growth of crops on them. Although extensively used for cotton and alfalfa and to less extent for a number of other crops, and giving fair yields, they are not so productive, require more water, and are generally less desirable than the typical Gila soils which have finer-textured subsoils. Pecan trees growing on these soils are doing fairly well, but they make slower growth and will doubtless need more fertilization than those grown on the soils with finer subsoils.

The heavy-textured subsoil phases of Gila fine sandy loam, loam, silt loam, clay loam, silty clay loam, and clay have subsoils in which silty clay or clay predominates, though they may be stratified with lighter-textured materials. Most areas of these soils are not so well drained as are areas of typical Gila soils, and they are more inclined to contain harmful quantities of alkali salts. When present, this excess of salts is harder to remove by leaching than from the more open, better-drained soils. The subsoils probably offer considerable resistance to the development of plant roots as well as to percolation of water, though doubtless, in most places, alfalfa roots penetrate readily. Alfalfa is widely and successfully grown on these soils where drainage is sufficient and alkali concentration not too great. Cotton is also grown and does well where these conditions are favorable. It is locally supposed that the pecan, which has a deep taproot, will find such heavy-textured subsoils especially unfavorable; nevertheless a number of plantings have been made on these soils. All the trees are young, and they vary considerably in thriftiness; some seem to be doing well, whereas in other places many of the trees have died.

It has not yet been clearly demonstrated that this is caused by the toughness of the subsoil. Poor drainage and an excess of alkali are generally conceded to be detrimental to the growth of the pecan (7), and these two conditions more often occur where heavy subsoils are present. It is perhaps safe to say that those soils which have more open subsoils are better adapted to this crop.

On each farm the requirements of farm management make it necessary to grow, generally, all crops on all soils, but the farmer knows he obtains greater yields on some soils than on others and that crops have different periods of growth and ripening on different soils. His experience enables him to vary his treatment somewhat, but rarely can he confine a crop requiring a large proportional acreage to a single soil.

Gila fine sandy loam.—Gila fine sandy loam consists of light pinkish-brown fine sandy loam of variable depth and degree of fineness. In some places it is nearly uniform to a depth of 6 feet, but in most places it is irregularly stratified with materials ranging from fine sand to clay loam but predominately of medium texture and mellow, friable consistence. It has good or fairly good moisture-holding capacity. Much of it contains moderate quantities of alkali salts, and some areas are strongly affected by alkali. Most of the land lies favorably for irrigation.

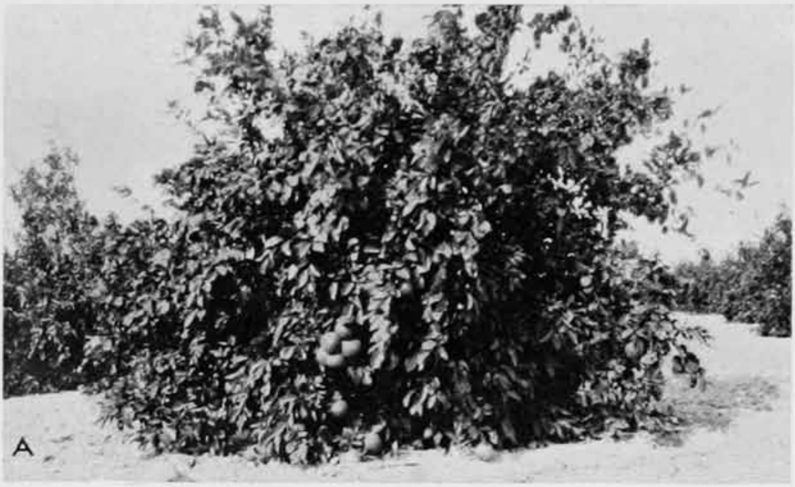
This soil occurs in small areas in all parts of the Colorado and Gila River Valleys. The largest area is in the Gila River Valley at Wellton. In the Gila River Valley the soil occurs mainly in a discontinuous strip along the outer borders of the valley, being bounded on the outer side by the rough belt of the valley bluff, though in places a narrow strip of alluvium may separate it from the bluff. In the Colorado River Valley the areas of this soil are widely scattered and seem to lack systematic distribution.

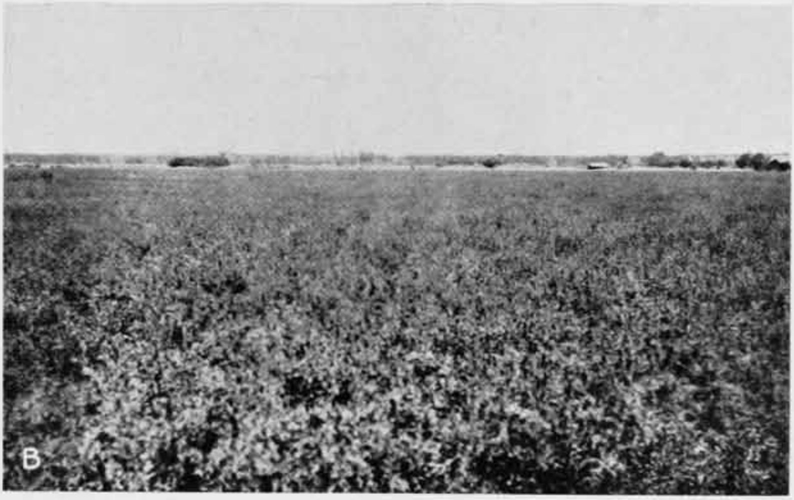
Except in places strongly affected by alkali salts, this is considered a good all-round farming soil. Cotton and alfalfa are the most important crops grown, and pecans may prove well adapted to the soil.

Gila fine sandy loam, light-textured subsoil phase.—Gila fine sandy loam, light-textured subsoil phase, is light pinkish-brown fine sandy loam to a depth ranging from about 8 to about 15 inches. To the latter depth, its characteristics are identical with those of the typical soil. It differs from the typical soil, however, in the presence of gray or pink loose sand or fine sand beneath the surface layer.

The light-textured subsoil phase of Gila fine sandy loam occurs in close association with the typical soil, mainly in the Colorado River Valley. A few small areas are in the Gila River Valley near Wellton. The crop adaptations of this soil are similar to those of typical Gila fine sandy loam. However, more frequent irrigations are necessary than on that soil.

Gila fine sandy loam, heavy-textured subsoil phase.—Gila fine sandy loam, heavy-textured subsoil phase, is identical in general characteristics with the typical soil in its surface soil which is of variable depth. The underlying material is heavier than that beneath the typical surface soil, ranging from clay to silty clay. The heavy texture of the subsoil is in general unfavorable to the productivity of the soil as it renders drainage imperfect, making root





A, Grapefruit tree on Superstition soils on the Yuma Mesa. B, Alfalfa on Gila clay in Yuma Valley.

penetration in many places and for some plants difficult, and through the imperfect drainage tending to cause an accumulation of alkali salts in places.

This soil is so inextensive, the total area being only 192 acres, that it is negligible in the agriculture of the area. It does not occur in the Gila River Valley and occurs in the Colorado River Valley in only two or three very small areas.

Gila fine sandy loam, hummocky phase.—Gila fine sandy loam, hummocky phase, consists of Gila fine sandy loam in which the surface is made slightly uneven by the presence of small hummocks from 2 to 3 feet high. This soil is somewhat lighter in texture and looser than typical Gila fine sandy loam. A rather large amount of work would be required to level the land for irrigation.

Gila very fine sandy loam.—Gila very fine sandy loam is very light brown very fine sandy loam, of variable depth and fineness, having a faint pink shade. The soil material has been laid down layer by layer by the rivers, largely at flood stages, and therefore consists of layers of various textures, ranging from fine sand to clay, but predominantly of medium texture. This soil is, as a rule, mellow and easily penetrated by plant roots. The moisture-holding capacity is good. In places, rather large quantities of alkali are present.

This the dominant soil in the Gila River Valley, with the exception of the undifferentiated alluvial soils. In the Colorada River Valley it occurs in a discontinuous belt along the east bank of the river, from Yuma to a point a few miles above Gadsden, and one area of about 2 square miles is about halfway between Yuma and Laguna Dam. A few small areas are scattered over the alluvial lands.

This soil, like Gila fine sandy loam, is a good all-purpose farming soil, being well adapted to the production of cotton, alfalfa, and truck crops, and it is perhaps one of the best soils for pecan growing.

Gila loam.—Gila loam to a depth ranging from a few inches to a foot or more is light pinkish-brown or brown loam, in which the sand constituent is fine or very fine grained and the percentage of clay is higher than in the surface soils of either Gila sandy loam or Gila very fine sandy loam. The clay constituent is sufficient to accumulate and hold a higher percentage of organic matter than is present in either of the two soils already described, hence the darker color and the masking of the well-defined pink shade present in the sandier soils. This soil is differentiated mainly on the basis of its loam texture and the moderate content of organic matter. The deeper soil material varies in character, being stratified in many places. The soil is permeable and has good moisture-holding capacity.

The total area occupied by this soil is not so large as that occupied by Gila very fine sandy loam, but the soil occurs in all parts of the surveyed area. The largest development is in a somewhat discontinuous belt extending along the Gila River Valley north of the river, in the northeastern part of the area. A few small bodies lie in the vicinity of Wellton, and most of the rest occur as small strips and areas widely scattered over the Colorado River Valley from Laguna south to the Mexican border.

This is a good general-farming soil, similar in value and crop adaptations to Gila very fine sandy loam and Gila fine sandy loam.

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This soil is associated with the heavier members of the Gila series, such as the clay loam and the silty clay loam, rather than with the fine sandy loam.

Gila loam, light-textured subsoil phase.—Gila loam, light-textured subsoil phase, is, like the typical soil, brown loam to a depth ranging from a few inches to a foot or more. The thickness of this layer differs greatly from place to place as it is, in many places, the result of irrigation-deposited silt. This layer is underlain by loose sand or fine sand extending to a depth of 6 feet or more. The presence of the sand causes the soil to be droughty and to require irrigation at more frequent intervals than is necessary on the typical soil. As the soil occurs in small areas on farms containing other soils, it cannot readily be irrigated except when the rest of the farm is irrigated.

All the areas of this light-textured subsoil phase lie in the Colorado River Valley. The total area is only 2.9 square miles.

Gila loam, heavy-textured subsoil phase.—The surface soil of Gila loam, heavy-textured subsoil phase, is like typical Gila loam and the light-textured subsoil phase. The subsoil material, consisting of clay or silty clay, is heavier than in the corresponding layers of typical Gila loam. As in the heavy-textured subsoil phase of Gila fine sandy loam, the presence of this heavy material impedes drainage and presents conditions favorable to the accumulation of alkali. This soil occupies a very small total acreage and is therefore of little agricultural significance in the area.

Gila silt loam.—Gila silt loam, to a depth ranging from a few inches to a foot or more, is grayish brown, with a very faint pink shade, in color, and silt loam in texture. The color is in most places a little less dark than that of Gila loam, indicating a somewhat lower content of organic matter, but this soil probably contains more organic matter than either Gila fine sandy loam or Gila very fine sandy loam.

The surface layer is underlain by material of essentially similar texture but of slightly lighter color, extending to a depth of 6 feet or more. On account of the recent accumulation of the material by deposition from water and the consequent lack of change in soil profile development, practically no structure has developed in any of these alluvial soils. They are generally mellow and easily penetrated by plant roots, but the silty soils become slightly compact.

The character of the material and the succession of layers differs from place to place, but the range of differences is slight, between silt loam and silty very fine sandy loam which may be faintly indurated in thin layers. Layers of material heavy enough seriously to interfere with the downward percolation of moisture or sandy enough to cause excessive loss of water by percolation are not of common occurrence.

Gila silt loam occurs in both the Colorado River and Gila River Valleys, a somewhat larger total area lying in the latter. Like Gila loam it occurs in the lower parts of these valleys but in closer association with the higher parts occupied by the sandy soils.

Like Gila fine sandy loam, very fine sandy loam, and loam, heretofore described, this is a good general-farming soil, except in places where an excessive accumulation of alkali salts exists.

Gila silt loam, heavy-textured subsoil phase.—Gila silt loam, heavy-textured subsoil phase, is brown or grayish-brown silt loam to a depth ranging from a few inches to a foot or more. This material is underlain by clay or silty clay to a depth of more than 6 feet.

The subsoil, being heavier in texture than that of the typical soil, causes this soil to be imperfectly drained and subject to accumulation of alkali where the soil is subjected to the influence of high ground water. Soil of this phase occurs in the Yuma-Wellton area in only two small areas north of Gadsden. Where carefully irrigated and protected from high ground water, alkali should not accumulate. The soil is productive where not charged with alkali.

Gila clay loam.—Gila clay loam consists of dark grayish-brown clay loam to an average depth of about 8 inches from the surface. The dark color is probably caused partly by the presence of organic matter, the amount present being greater than in the sandy and silty members of the Gila series and sufficient to mask the pink color of the materials constituting all these alluvial soils. The content of organic matter is greater also than that present in the normally developed upland soils and greater, therefore, than this soil will have when, and if, in the distant future, it becomes a fully developed desert soil.

The surface soil is underlain by pinkish-gray stratified materials containing less clay than the surface soil. Though variable in texture, this material is friable, permeable, and has a good moisture-holding capacity. It extends to a depth of more than 6 feet.

Gila clay loam is one of the comparatively unimportant soils in the area. Almost all of it occurs in the Colorado River Valley in the southwestern part of the area. A few very small bodies are north of Yuma, and three bodies, two of them very small, are in the Gila River Valley.

The texture of this soil is heavy compared with that of Gila fine sandy loam, Gila very fine sandy loam, and Gila silt loam, and were it not for the usual "slacking", or granulation, of the surface soil on drying it would be a difficult soil to work and to irrigate. On drying it slacks or breaks into a mass of small particles or granules, somewhat adobelike, though the material is not so heavy as most adobe clays. Because of this characteristic, it is one of the productive soils of the area.

Gila clay loam, light-textured subsoil phase.—Gila clay loam, light-textured subsoil phase, consists of rather rich brown clay loam to a depth of a few inches or, in a few places, to a foot or more. It is underlain to a depth of more than 5 feet by clean gray loose fine sand. The surface soil consists largely of silt deposited by irrigation waters and mixed with the original sandy surface soil. Because of the underlying sand, the surface soil is well drained. For the same reason, irrigation water drains through the soil rather rapidly and, unless irrigations are frequent, crops will suffer from lack of moisture.

Most crops do not yield so heavily on this soil as on soils having finer subsoils. Many "burned" spots appear in cotton and alfalfa fields, owing to drying of the soil.

The total acreage of this soil within the area mapped is small, a little less than 5 square miles. It occurs only in the valley of Colorado River in a number of small bodies, and two groups of larger areas, one of which lies in the valley, on the California side, near the northern boundary of the area and the other about 5 miles southwest of Yuma.

Gila clay loam, heavy-textured subsoil phase.—Gila clay loam, heavy-textured subsoil phase, consists of brown or grayish-brown clay loam of variable depth. The material in this layer is somewhat heavier than the surface soil of Gila clay loam, light-textured subsoil phase, but yet within the texture range of the clay loam group. The subsoil to a depth of more than 6 feet consists of silty clay or clay. It is heavier than the surface soil and, because of the lower content of organic matter the structure is tougher and less favorable to crop growing. This soil is imperfectly drained and likely, under conditions of a high water table, to accumulate alkali salts, though the material in its natural condition is not salty. This phase of Gila clay loam is of very small extent in this area. It occurs in only a few small bodies about 8 miles south of Yuma.

Gila silty clay loam.—Gila silty clay loam is similar to Gila clay loam. The very slight differences between the essential characteristics of the two soils signify that they differ very slightly in productive capacity. The silty clay loam contains a somewhat lower percentage of clay and a higher percentage of silt than the clay loam, and the clay loam contains a somewhat higher percentage of fine sand and very fine sand than the silty clay loam.

Gila silty clay loam, to a depth ranging from 5 to 12 or more inches, is brown silty clay loam containing enough organic matter to make it somewhat dark but not enough to warrant calling it dark brown. The subsoil material is similar to that in Gila clay loam. It is silty but contains some very fine sand and enough clay to cause the material to adhere sufficiently to form soft clods. At various depths the texture differs somewhat from place to place but such differences are too slight to cause important differences in the productivity or water-holding capacity of the soil. Its characteristics, like those of the Gila soils already described, are such as to make it a productive soil when well managed.

This soil occurs in both the Gila and Colorado River Valleys. Long narrow strips lie on the north side of the Gila River Valley in the extreme eastern part of the area, a body including more than 1 square mile lies on the south side of the Gila River Valley 4 miles east of Yuma, and a number of small bodies are widely scattered over the Colorado River Valley south of Yuma. The largest area is immediately southwest of Yuma, and a few small areas are in the valley north of Yuma.

Gila silty clay loam, light-textured subsoil phase.—Gila silty clay loam, light-textured subsoil phase, consists of a layer of brown silty clay loam, ranging in thickness from a few inches to more than a foot, underlain by gray loose fine sand which continues to a depth of more than 6 feet. Like the other light-textured subsoil phases already described, this soil is well drained, but crops may suffer at times for moisture if not irrigated frequently.

This soil occurs only in the Colorado River Valley in a number of small areas, the most important of which are about 8 miles southwest of Yuma.

Gila silty clay loam, heavy-textured subsoil phase.—The surface soil of Gila silty clay loam, heavy-textured subsoil phase, is like the surface soil of the light-textured subsoil phase. The subsoil consists of clay or silty clay, thereby rendering drainage imperfect and causing a likelihood of accumulation of alkali salts. This soil is inextensive, and all the small bodies lie in the Colorado River Valley in widely scattered places.

Gila clay.—Gila clay has a heavy surface soil of silty clay or clay and a friable subsoil of medium texture. It is harder to plow, cultivate, and irrigate properly than are the medium-textured Gila soils. It warms up more slowly in the spring, dries out more slowly, and when flooded bakes and cracks badly on drying. Though rich, it does not generally return such high yields as do the medium-textured Gila soils. Alfalfa is the most important crop, giving satisfactory yields of both hay and seed (pl. 1, B). Cotton is grown rather extensively and, under skillful management, produces large yields, though the average is considerably lower than on the medium-textured soils. Lettuce, cantaloups, milo, wheat, and barley are grown to some extent on this soil and give good yields. Doubtless the principal reason for the importance of alfalfa on this soil is that it is more easily and cheaply handled than are crops which require plowing and cultivation of the heavy soil and which do not return such satisfactory yields unless given the most skillful treatment. This soil must be thoroughly pulverized in order to make a favorable seed bed, as it usually breaks up in large clods when plowed.

Gila clay, light-textured subsoil phase.—The light-textured subsoil phase of Gila clay differs from the typical soil only in that the subsoil is loose and light textured. Drainage is good or excessive. This soil, in general, is somewhat less productive than typical Gila clay. It occurs in a few small areas in the Colorado River Valley.

Gila clay, heavy-textured subsoil phase.—Both surface soil and subsoil of Gila clay, heavy-textured subsoil phase, are tough, tight, and comparatively impervious. For these reasons internal drainage through the soil is greatly impeded, and the soil is less desirable for agriculture than typical Gila clay.

Gila fine sand.—Gila fine sand is a soil of minor extent and little agricultural importance. It is loose and leachy from the surface down, has a low moisture-holding capacity, a tendency to blow, and comparatively low productivity. Small areas are under cultivation in Yuma Valley, where water is plentiful and silting gradually builds up fertility. Frequent irrigations are required for crop production. Alfalfa and cotton are the principal crops grown. Alfalfa returns fairly good yields and is better adapted to this soil than cotton, as in such a sandy soil it is very hard to maintain proper moisture conditions for the fruiting of cotton in the extremely hot dry period when the fruit is setting.

FRUIT-GROWING SOILS

The coarse upland soils are used principally for the production of citrus fruits and grapes in the small areas where they are farmed. They are represented most extensively by soils of the Superstition and Mohave series. The Cajon soils are also included in this group on the basis of their crop adaptations. The Cajon soils are not strictly upland soils, as they occur not only on alluvial fans but also along desert washes. They consist of unmodified alluvial deposits of coarse texture.

Of these soils, those belonging to the Superstition series are the most extensive and are the most important agriculturally at the present time. This is owing to the availability of irrigation water rather than to superiority of the soils themselves. In fact, the Mohave soils are doubtless naturally more productive than the Superstition soils and have a higher water-holding capacity. Superstition sand and its hummocky phase comprise most of the Yuma Mesa and much of the Wellton Mesa. Associated with this soil and its hummocky phase are small areas of Superstition sandy loam and its heavy-textured subsoil phase, the silted phase of Superstition sand, dune sand, and rough broken land.

The Mohave soils occupy a great extent of country along the upper edge of the Wellton Mesa, but only a very small acreage is under cultivation. They cover a large stretch of desert country east of Gila Mountains and south of Gila River. Like the Superstition soils, they are of coarse texture, but unlike those soils they have sufficient clay in the subsoil to give them moderately good moisture-holding capacity. They contain, however, a higher percentage of alkali salts, although the concentration in the virgin soil in many places is not sufficient to have a detrimental effect on vegetation.

The agricultural development of the extensive uplands of the Yuma and Wellton Mesas, where the Superstition, Mohave, and Cajon soils occur, is limited to about 2,000 acres, and the land is irrigated only by pumping. These soils are sandy and porous and require rather frequent irrigation for the production of crops (pl. 2, *A*). As a result, irrigation is expensive, and the growing of high-priced crops constitutes the limited agriculture. Grapefruit and oranges are the most important crops grown. Small acreages are in grapes, alfalfa, lemons, dates, figs, and olives. The soils of this group are favored for the production of citrus fruits by a greater degree of freedom from frost than obtains in the lower-lying lands where the Gila soils occur and also by their better drainage and comparative freedom from alkali.

Superstition sand.—Superstition sand, which comprises most of the land on the Yuma Mesa, has a surface soil of light pinkish-brown sand which ranges from loose and clean to somewhat firm and loamy. The subsoil, to an average depth of about 2½ feet, is pinkish-gray loamy sand which contains a high percentage of lime but has only very slight compaction. It contains many small, hard, gray nodules or lime-cemented lumps. The lower subsoil layer, or substratum, consists of a bed of loose sand or gravelly sand. In a few places, more compact, finer-textured layers occur in the deeper part of the subsoil (pl. 2, *B*).

In general it may be said that this soil is coarse, has a low water-holding capacity, is poor in nitrogen, and is not especially rich in other plant-food elements. However, it is comparatively free from harmful accumulation of alkali salts.

The use of silt-laden Colorado River water for irrigation will partly compensate for the inherent lack of fertility in this soil, which may be further supplemented by the application of manure. It may prove profitable to apply small quantities of commercial fertilizers, especially those containing nitrogen and phosphoric acid (*12*). Extensive growing of cover or green-manure crops in the citrus groves or vineyards, although they would doubtless improve the condition of the soil, is probably not economically feasible on account of the greater quantity of water required to grow such crops.

Superstition sand, silted phase.—Superstition sand, which has been irrigated with Colorado River water for a number of years, has been considerably changed by the silt deposit. It is shown on the soil map as the silted phase of Superstition sand. It has a firm surface soil which ranges in texture from loamy sand to clay, depending on the length of time it has been irrigated and the consequent depth of the silt layer. It is much easier to water evenly than is the raw, loose Superstition sand, and it has a higher water-holding capacity. The artificially altered surface soil attains its greatest depth (approximately 16 inches) south of Yuma in the Blaisdell orchard, where the surface soil is silty clay or clay.

This soil is almost entirely devoted to the growing of grapefruit, oranges, and grapes.

Superstition sand, hummocky phase.—Superstition sand, hummocky phase, has a loose surface layer of wind-drifted sand which is hummocky in many places and in some places forms small dunes. Only a very small proportion of this land has been cleared and leveled for cultivation, and attempts to farm it have met with failure. The soil is so extremely loose that it is very hard to irrigate, requires water at frequent intervals, and blows very badly. In fact, the blowing sand often cuts off or buries young vegetation. No silt-bearing irrigation water is available to irrigate this soil at the present time. Well water is used but, as it contributes nothing mechanically to produce a firm surface soil, it would seem that agriculture on this soil is, for the present at least, doomed to failure.

Superstition sandy loam.—Superstition sandy loam has a pale reddish-brown or light pinkish-brown coarse-textured loose sandy loam surface soil and a slightly loamy and slightly compacted subsoil containing irregular-shaped lime nodules, ranging from rather soft to hard. The subsoil rests on very loose light reddish-brown or pinkish-gray sandy materials which are calcareous, though of lower lime accumulation than the subsoil. Subdrainage is excessive, and the soil is of low water-holding capacity, but where irrigated, favorably situated areas are valued highly for the production of citrus fruits.

Superstition sandy loam, heavy-textured subsoil phase.—The surface soil of this phase of Superstition sandy loam is underlain by a heavy compact subsoil which probably represents older sedimentary deposits, over which the surface layer of sand has accumulated. This is an inextensive soil and therefore of very little agricultural importance in the area. In most places the subsoil contains rather large quantities of alkali.

Mohave loamy coarse sand.—Mohave loamy coarse sand consists of rather loose grayish-brown loamy coarse sand, with a faint pink shade, to an average depth of about 10 inches. To a depth of about 20 inches, the surface soil is underlain by reddish-brown or pale-red loamy coarse sand containing a little more fine material than is present in the surface soil and having a compact consistence. Both layers effervesce strongly in hydrochloric acid. Between depths of 20 and 60 inches the material is coarse grained, but the percentage of clay is somewhat higher than in the layers above, and the consistence is rather tough, though the material is not indurated into a hardpan. The percentage of lime carbonate is higher than in the overlying layers, this material occurring both in finely divided form and as concretions, most of which are small. The color, except of the calcium-carbonate lumps and concretions, is redder than in the overlying layers. Below a depth of about 60 inches the material is in most places somewhat looser and coarser, containing less fine-grained material than the material above, and it is grayer in color, but still has a distinct red tinge.

Mohave loamy coarse sand occurs on the uplands in the eastern part of the area. The soil material has been accumulated by deposition, having been washed from the mountain ridges of the region, by the storm waters flowing from the mountains as sheet flood waters and temporary rainy season rills, and spread into broad sloping alluvial fans. Mohave loamy coarse sand is by far the most extensive Mohave soil in the area, covering 48 square miles.

In general this soil has fairly good water-holding capacity, is not seriously affected by alkali, and, where supplied with sufficient water, would doubtless prove to be a good agricultural soil.

Mohave fine gravelly sandy loam.—Mohave fine gravelly sandy loam, to a depth of 4 inches, is grayish-brown or pinkish-brown gravelly sandy loam, in which the gravel are small, most of them less than 2 millimeters in diameter. The content of fine material, clay, silt, and very fine sand reaches a maximum of more than 20 percent. The material in this layer effervesces strongly in acid. Between depths of 4 and 12 inches, the material is reddish-brown gravelly sandy loam, in which the sand is dominantly coarse and a rather large percentage of fine gravel is present but the content of clay is low. The material in this layer contains a fairly large percentage of calcium carbonate occurring as small fragments and nodules. Between depths of 12 and 60 inches the percentage of clay is much higher than in the overlying layer, but the coarser material has essentially the same characteristics as in that layer. It may be described as a gravelly clay loam, in which the percentage of gravel is high and that of clay low. A rather large percentage of calcium carbonate is present. Below a depth of 60 inches is comparatively loose gray gravelly sandy loam which is the original alluvial-fan material still unweathered. A thin surface concentration, or "desert pavement", of gravel is present over much of this soil.

This soil covers a total area of 11.7 square miles, lying in narrow north-south strips or ridges within the large area of Mohave loamy coarse sand in the eastern part of the area surveyed.

This soil is well drained but in spite of this contains moderate or rather large quantities of alkali salts under virgin conditions. This is probably owing to the fact that the extremely low rainfall has been insufficient to remove the salts as it has from the more porous Superstition soils. Under proper irrigation the content of salts would probably gradually be reduced by leaching or washing out.

Only a very small acreage of the land is under cultivation and planted largely to grapefruit, oranges, and grapes, with a small acreage devoted to alfalfa and a few fig, date, and olive trees. Any further extension of agriculture will probably be along the same lines.

Mohave gravelly sandy loam.—Mohave gravelly sandy loam is a coarse-textured soil occupying high-lying rather steep and rough alluvial fans, and it has little present or potential agricultural value. Were water available this soil might be used for growing citrus fruits, but it would not be very desirable on account of its rough relief, coarse texture, and comparatively low fertility. Rather large quantities of alkali salts are present in this soil.

Mohave gravelly sandy loam, stony phase.—Areas of Mohave gravelly sandy loam containing a very large proportion of stone are mapped as a stony phase of that soil. On account of its large stone content, this soil is of little agricultural importance.

Cajon loamy sand.—Loose sandy material consisting of sandy accumulations in the small desert washes and along the bases of the river valley bluffs have been identified in the Yuma-Wellton area as members of the Cajon series.

Cajon loamy sand consists of loose brown sand and fine sand mixed with gray sand or coarse sand to variable depths. Most of the larger particles consist of fragments from granitic rocks. The deeper-lying material consists of gray loose sand, coarse sand, or gravelly sand to a depth of more than 6 feet. The water-holding capacity of the soil is poor, and the soil is low in fertility.

This is not a very extensive soil. It occurs largely on the alluvial fans and along washes south of Wellton and Tacna. Only a few acres (south of Wellton) are under cultivation and planted to grapes and grapefruit, which do not have a very thrifty appearance. Only by frequent irrigation and heavy fertilization can this soil be made to produce good crops.

Cajon stony sand.—Cajon stony sand consists of a mixture of various grades of sand, mainly coarse, mixed with stone to such an extent as to render the land nontillable without removal of the stones. The underlying material is coarse sand and gravelly coarse sand on gravel, cobbles, and boulders. The land is practically valueless for agriculture.

MISCELLANEOUS SOIL MATERIALS

A number of classes of miscellaneous materials are mapped in the Yuma-Wellton area. They are considered as having no agricultural value under existing conditions, though they may have some potential value in the far-distant future. These materials include alluvial soils, undifferentiated, dune sand, rough broken land, and rough stony land.

Alluvial soils, undifferentiated.—Alluvial soils, undifferentiated, consist of those low-lying recent alluvial deposits of the Colorado and Gila Rivers which lie outside of, or without protection of, levees and are therefore subject to rather frequent overflow and to cutting by the shifting river currents. The soil materials represent undifferentiated soils, mainly of the Gila series, and they range in texture from sand to clay.

Very little farming is done on these soils, although small acreages are devoted to cotton, alfalfa, milo, corn, and pumpkins. Part of the land is irrigated and part depends on the overflow of Colorado River for necessary moisture. The stream beds themselves are bare sandy flats which are covered at times of high water. The slightly higher lying areas are covered by backwater at flood time and are in general of somewhat finer material. They support a thick growth of willow, cottonwood, mesquite, arrowweed, and other brush, which forms a practically impenetrable jungle in many places. After the Boulder Dam and other dams in the Colorado River and Gila River watersheds are completed, the river flow will be held in check and floods largely eliminated, and then much of this land may be cleared, leveled, and brought under cultivation. It will differ in agricultural value, according to the texture of the soil and to the position it occupies, ranging from practically worthless to very valuable.

Dune sand.—Dune sand consists of dunes or mounds of loose shifting sand. A few of the small dunes may be leveled and used for the production of crops commonly grown on Gila fine sand and Superstition sand, but the larger ones, especially those covered with mesquite, would probably prove too expensive to level under present or near-future agricultural conditions.

Rough broken land.—Rough broken land comprises rough or steep areas which are comparatively free from stone. Such areas occur in the bluffs or on steep slopes separating the mesas from the river-bottom land and on the steep dissected alluvial fans surrounding the mountains. They are of too rough surface relief to have any agricultural value at present, though it is conceivable that citrus fruits, dates, and grapes might be grown on them if water were available and smoother lands cannot be bought at a reasonable price.

Rough stony land.—Rough stony land includes the bare stony mountain areas and buttes throughout the area surveyed. This class of land has practically no soil covering, and little vegetation grows on it.

IRRIGATION, DRAINAGE, AND ALKALI

As has been stated, irrigation is necessary in growing crops in the Yuma-Wellton area and the supply of irrigation water is limited. As a result the irrigated acreage is confined to a comparatively small area. Most of the cultivated land lies on that part of the Yuma irrigation project in the Yuma Valley which may be watered by gravity flow from Laguna Dam on Colorado River. It is the purpose of the Yuma irrigation project to irrigate approximately 65,000 acres by gravity (on the reservation and valley divisions). In addition to this it is planned to supply water to 45,000 acres on the Yuma Mesa (mesa division) by pumping. A small acreage in the North Gila Valley is also irrigated from Laguna Dam. This area receives an ample supply of irrigation water. Gila River is an intermittent stream and cannot be relied on for irrigation purposes.

A few thousand acres on the Yuma Mesa, on Wellton Mesa, in South Gila Valley, in Antelope Valley, and in Mohawk Valley are irrigated by pumping, but this method of supplying water is rather expensive. The well waters contain a comparatively high percentage of alkali salts,[4] but some of them do not contain a sufficient quantity to damage crops or to cause serious alkali accumulations in the soils, provided proper methods of irrigation are used. On the other hand, the water from some wells is so salty that it is unfit for use either in irrigating or for domestic purposes. Such wells have been abandoned and others put down in order to obtain a better quality of water, but this has increased the expense and retarded the progress of agricultural development. In spite of these obstacles a further extension of the acreage watered by pumping may be expected, especially if the construction of Boulder Dam cheapens the cost of electricity for pumping.

[4] The results of chemical analyses by the University of Arizona show that these waters contain from about 0.1 percent to nearly 1 percent of salts. Those containing much more than 0.2 percent are probably of questionable value, though waters having stronger concentrations may be used under some circumstances for some crops. Water containing 0.35 percent or more has been used successfully in the production of alfalfa hay and seed on well-drained fine sandy loam soils.

The United States Bureau of Reclamation has made surveys of most of the land in this area, as well as in the country to the south and east of the eastern extension of the area, with the idea that it may be brought under irrigation after completion of Boulder Dam. The acre cost of such a project would be high, and it may never be carried out.

The uplands are normally well drained or even excessively drained in this region, but parts of the bottom lands along the rivers are poorly drained. A high water table is the normal condition under much of the land in the Yuma Valley, especially in the summer flood season of Colorado River. After irrigation was started here the level of the water table rose still higher, and parts of the valley became badly water-logged.

A system of open drains has been installed by the Bureau of Reclamation, and pumps lift the water from the lower end of the main drain over the levee into the river. Conditions have been greatly improved, but in some low-lying places the ground water still comes dangerously near the surface in the midsummer flood and irrigation season. In most places the open drains are efficient, as the subsoil is, in general, sufficiently porous to afford fairly good lateral drainage, but in a few places a tough, impervious layer in the subsoil, or substratum, retards percolation and subdrainage. In such places the construction of short lateral drains may prove effective, as the obstructing layer in many places is doubtless narrow and of a dikelike character. High ground water has doubtless been present in the Gila River Valley during flood periods, though at present the water seldom attains a high level.

High ground water, together with a certain amount of seepage and wash from the higher-lying mesas, has caused a concentration of alkali salts in the valley soils. The ground water, as well as the soil material itself, generally contains a considerable percentage of salts. The water is drawn to the surface by capillarity, and when it evaporates it leaves a concentration of salts at or near the surface. On the other hand, where the land is overflowed the salts are largely washed out. Where it is artificially flooded in irrigating, the salts in the soil are dissolved and carried downward by the percolating water to the level of the ground water. If drainage is good and the water table is at a considerable depth below the surface, the percentage of salts in the soil will be lowered or kept low by copious irrigation, unless the water contains a large amount of salts. If the water table is high or the subsoil so heavy and impervious as to retard the movement of water, the leaching process is greatly hindered or it may be entirely unsuccessful.

As previously stated, the soils of this region are normally and universally alkaline in reaction, and they contain a high percentage of soluble mineral salts as compared with soils of more humid sections. None of the soils in this area is alkali-free soil, although most of them do not contain such strong concentrations as to be harmful to vegetation.

Generally speaking, where the concentration of salts in the air-dry soil is less than 0.2 percent to a depth of 1 foot or in the subsoil to a depth of 6 feet, little or no harmful effect is produced on the crops commonly grown in this region. For the purpose of classification and mapping of alkali conditions in this area, such soils are designated as "alkali-free" and are shown on the alkali map, accompanying this report, by the letter F.

Where the salt content of the soil ranges from 0.2 to 0.7 percent, or in some places higher, crops grow, but they are commonly subject to more or less damage at some period of growth and in many places present a somewhat spotted condition. Such areas are designated as slightly affected, or spotted, and are shown by the symbol S. The concentration of alkali salts is seldom uniform over any fairly large area of soil. The vegetal growth is typically variable, or spotted, especially on irrigated land, and the concentration of salts may change greatly in a given spot from year to year, or before and after irrigation. Two soil samples, taken 20 feet apart, may differ from less than 0.2 percent to more than 3 percent in the topmost 12 inches of soil, or from practically alkali-free to strongly affected. In many places this spotted condition of the vegetation is caused by unevenness of the surface and consequent differences in the depth of water applied and in the movement of ground water in different places. When the salts are largely in the subsoil they do comparatively little harm, but when they rise within a foot of the surface they are likely to have a damaging effect on crops. In a few places a concentration of nearly 1 percent was found within 12 inches of the surface in fields where cotton was in good condition. This concentration probably occurred after the crop had become established, as it is difficult to believe that the seed could germinate and the young plants make a good growth with such a concentration of salts. This was probably a much greater concentration than the average in the field.

Areas in which the alkali salts are sufficiently strong to prevent the growth of crops, on areas of sufficient size to be shown on the map, are mapped as strongly affected and are shown by the symbol A. Most of them contain from 1 to 3 percent of alkali in the 12-inch surface layer, and the subsoils in many places are strongly impregnated with salts.

In virgin lands, the salt content of the soil may be very accurately judged by the natural vegetation or by the appearance of the surface soil. Where a concentration of 3 percent or more of alkali is present, the ground in many places is bare of vegetation and is covered with a brown or white alkali crust which has a moist appearance even in the driest weather. In most places the crust is underlain by a granular layer in which the salt crystals are plainly visible. Smaller concentrations of alkali are disclosed by a slight brown stain or a white frostlike efflorescence of salts on the surface. Pickleweed, or California greasewood, is the characteristic vegetation of very strongly affected (from 2 to 3 percent) alkali land. Seepweed is generally found where the concentration ranges from moderate to rather strong (0.2 to 2 percent), and in some places the presence of this weed indicates high alkali content of the subsoil where the surface soil is comparatively free. Saltbush is also an indicator of a moderate salt content. Mesquite and arrowweed are probably not alkali-indicating plants, but they are very tolerant and are found in many places where the salt content is rather high. Desert sage generally indicates a slight concentration of salts (0.1 to 0.7 percent). The native plants which generally indicate the absence of alkali in considerable amounts are creosote bush, locally called "greasewood"; false ragweed; and Mormon tea which grows only on loose, wind-shifted sand. Where a healthy growth of creosote bush occurs, the alkali content of the soil is low, but a few stunted specimens were found on Mohave soils which contained a considerable concentration of salts. In such places the land was largely bare of vegetation.

Alkali determinations of soils in the Yuma-Wellton area were made by use of an electrolytic bridge. In each sample the surface soil, to a depth of 1 foot, and the subsoil, taken in one or two sections, were tested separately. Some of the borings were made to a depth of 6 feet, others to 4½ feet, and a few were shallower where stony or gravelly subsoils prevented taking a deeper boring. The results of the tests are shown on the alkali map accompanying this report, in fractional form, indicating the salt content of the soil at the spot where the sample was taken. The figure above the line represents the salt content in the topmost 12 inches of soil, and the figure below the line shows the average content of a 6-foot or 4½-foot section. Numerous tests were made with phenolpthalein solution for black alkali (sodium carbonate), but no definite indication of this salt was obtained. The salts probably consist largely of the chloride, sulphate, and bicarbonate[5] of sodium, and in some places of calcium chloride.

Most of the Gila soils, in their natural state, are slightly or strongly affected with alkali, although small areas are comparatively free from salts. Under irrigation, many of them become practically alkali free. The Superstition soils are typically free from injurious salt concentrations. The heavy-textured subsoil phase of Superstition sandy loam is an exception to the rule, as it is usually strongly affected. Mohave loamy coarse sand is comparatively free from salts, but it is slightly affected in places. Mohave fine gravelly sandy loam and Mohave gravelly sandy loam are slightly affected in most places, with a few small strongly affected areas. Most areas of the Cajon soils are alkali-free.

SOILS AND THEIR INTERPRETATION

The Yuma-Wellton area does not join with any previously surveyed areas. It does, however, include the area covered by the soil surveys of the Yuma area in 1902 and 1904 (*5*, *6*). In these surveys, which were some of the earliest undertaken in this country, soil mapping was carried on in less detail than at the present time, and systematic soil classification was practically undeveloped when considered in regard to soil development and genetic relationship. Owing to these factors and to actual change in soil textures caused by deposition of fine-textured sediments from irrigation waters, many conflicts in soil classification both in textural classes of soils and in soil series names occur between the present and the older surveys. Changes in soil texture caused by silting, or sedimentation, from turbid irrigation waters from Colorado River are striking and take place in a comparatively short time.

The soils of the arid Southwest, of which the Yuma-Wellton area forms a part, have developed under a dry hot climate. They are distinctly alkaline in reaction, contain a high percentage of the

[5] The cold soil solution when treated with phenolpthalein gives no coloration but on boiling turns bright red.

soluble salts of the alkali and alkaline-earth groups, and, in general, an abundance of the mineral plant foods. They have undergone little leaching; but in the more mature soils much of the lime carbonate and other soluble salts has been removed by solution from the surface soil by rain water percolating downward, and these salts have been deposited in the subsoil to form a compact or slightly cemented layer. It seems that a certain amount of clay and colloidal matter has also been accumulated in the subsoils by downward filtration. The older soils, more particularly in the subsoils, have a distinct red color caused by the large amount of iron oxide present; and they are mottled with gray, due to the accumulated lime.

Although this area lies in the desert where the soils in which the materials have lain in place long enough for development or adjustment to climatic and vegetative conditions to take place assume the characteristics of desert soils, only a small part is underlain by even moderately well developed desert soils. The largest area of soils within the surveyed area having the same stage of development includes soils occupying the alluvial plains of Colorado and Gila Rivers. These soils consist of recently laid alluvium too young to have been influenced by local soil-developing forces. They consist of deposits of sands, silts, and clays, without local soil characteristics, except such as are caused by local accumulation of salts, largely influenced and determined by man through irrigation.

In a typical cross section of either valley, where broad enough for devolopment of a normal cross section, the banks of the river are high and the soils are sandy. From the river bank, the land slopes downward away from the river and attains its lowest level at the valley boundary or near it. The accumulation of material washed from the bluffs and from small streams in the uplands may raise the valley floor level along the bluffs. Such a cross section is characteristic not only of the Gila River Valley and Colorado River Valley but of the valleys of all streams carrying heavy loads of suspended material. In a cross section of the Gila River Valley and Colorado River Valley, the soils along the river banks are sandy, the silt loams occupy a belt lying adjacent to the belt of sandy soils, succeeded in turn by the loams, and finally along the lower part of the valley by the heavy soils. In stretches of the valley where the level is not low enough for the accumulation of clays, the silt loams occupy the lowest part of the valley belt. Such a spot lies immediately east of Yuma and below Wellton. In the valley of Gila River the sandy and silty soils dominate, but in the broader valley of the Colorado these soils are confined to a narrow belt along the river, the dominant soils being heavier.

The soils on the broad terrace, the Yuma Mesa, have been changed slightly by development under the prevailing desert conditions, whereas the upland soils, those designated in this report as members of the Mohave series, have been most thoroughly influenced by prevailing soil-developing forces. The Mohave soils are desert soils, the only true desert soils within the area so far as soil section or soil profile is concerned. Considered agriculturally, however, all the soils of the area are similar. One of the most important characteristics of desert soils is their unleached condition. This also is a characteristic of alluvial soils, though to less extent than of desert soils. In this area both the alluvial soils and the true upland desert soils are unleached, and when water is applied they are productive. The soils of both groups are low in organic-matter content.

The general profile, or section, of desert soils wherever they occur in the western part of the United States shows the following layers:

1. A desert pavement, in most places an inch or two thick, of smooth small stones or pebbles, or, where the desert pavement is absent, a thin surface crust of fine material usually less than one half inch thick. Between the pebbles or stones in the desert pavement and beneath it for about an inch or even less is gray porous or vesicular material.
2. Brown loose material to a depth of 3 or 4 inches.
3. Firm cloddy, in most places slightly heavier, material about 4 inches thick. This is the layer in which grass and shrub roots are most abundant, and, because of its fine-grained material, holds most of the water that sinks into the soil after desert showers. It usually does not effervesce in acid unless it contains fragments of limestone.
4. The material in this layer is loose, much of it is lighter in texture than that above it, and it contains calcium-carbonate spots and concretions, though these may not be present at the top of the layer.
5. The underlying material. In the Great Basin region this usually consists of sand and gravel washed from the mountains, but on the gentler slopes it contains clay and may be somewhat compacted, as in the Mohave soils.

In the southwestern part of the United States, layer 3 and those below are usually red.

The layers in the alluvial soils represent the strata formed in the water when the material was being deposited. In many places, however, a thin surface crust and a loose ½-inch layer beneath it occur on the alluvial land.

All the soil materials from which the soils of the area have developed have been deposited by running water. The alluvial-fan parent materials of the Mohave and Cajon soils have been carried only a short distance from the nearby mountains. They are predominantly granitic. The materials from which the Superstition soils are derived occupy old terraces of stream origin and possibly in part of lacustrine or marine origin. They have been transported from considerable distances and are of mixed lithologic character but of comparatively coarse texture. The soils or soil materials of the Gila series represent recent alluvial deposits of the Colorado and Gila Rivers.

The Gila soils of the present survey were mapped and classified in the older soil surveys covering the Yuma area mainly under the Imperial series. The recent unmodified river-bottom soils which are extensive in this area are now recognized as Gila, though in many respects they resemble the soils of the Imperial series to which they are closely related. The Imperial soils are now recognized as representing a slightly weathered and modified development of the Gila materials.

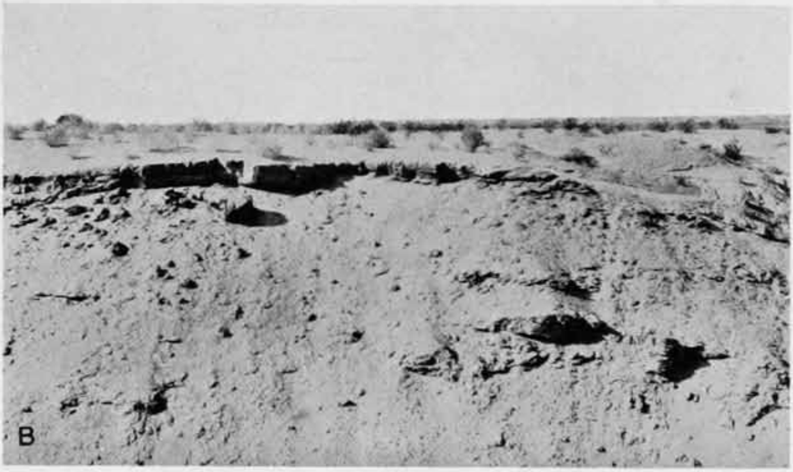
The Gila soils are in general comparatively fine in texture and have been but little modified since deposition. Such variations as occur in the soil profile, from the surface down, are due to differences in texture of the stratified materials resulting from differences in the velocity of the water from which they settled and its transporting power. These soils represent a practically unmodified parent soil material. Their characteristics are comparative friability, rather high content of lime carbonate, and a color ranging from light grayish brown or pinkish brown in the lighter-textured materials to dark brown or dull brown with a slight red tinge in the heavier ones. Alkali salts have, in some places, slightly modified these soils. The apparent change produced by a heavy surface concentration of alkali occurs, in most places, within a few inches of the surface. In such places the soil material is generally moist, appears dark brown, and commonly has a crust about one fourth inch thick, in places coated with a white layer of crystallized salts. Underneath this is a loose granular mulchlike layer, from 1 to 4 inches thick, in which salt crystals are plainly visible. Beneath this, in turn, is a thin, rather tough layer grading with depth into more friable material. In most places, these modified layers do not extend to average plow depth, and where the land is reclaimed and cultivated they disappear entirely. In places where the subsoil has a heavy texture, alkali accumulates in the heavy subsoil layers and, perhaps, renders them somewhat tougher than they would otherwise be.

Gila fine sand, an unimportant soil which occurs close to the river channels, is loose light pinkish-brown or pinkish-gray fine sand or medium sand in both the surface soil and subsoil. It has a lower water-holding capacity and is less productive than other typical Gila soils.

Gila very fine sandy loam is an extensive soil in this area, and it represents well the general characteristics of the typical Gila soils. A pit was dug in this soil in South Gila Valley, on the smooth, nearly level, flood plain of Gila River, and a study made of the soil. Drainage is good in this locality. The soil material is calcareous throughout and contains a small amount of alkali salts. The material to a depth of 22 inches consists of friable light grayish-brown or pinkish-brown very fine sandy loam which has a platy structure and breaks up in soft platelike clods. This structure is doubtless due to the gradual building up by sedimentation, layer by layer. Between depths of 22 and 28 inches is a rather compact layer of stratified platy materials of rather heavy texture, ranging from silt loam to silty clay loam or possibly silty clay. The compactness is doubtless caused by the heavy texture of the material rather than by weathering. Between depths of 28 and 60 inches is friable stratified material, ranging in texture from silt loam to fine sandy loam, and between depths of 60 and 72 inches is rather loose loamy fine sand. The color varies but little from the surface down, though the heavier strata are a l ttle darker than the lighter-textured ones. This soil has a good moisture-holding capacity, is pervious, and has great potential fertility.

The other typical soils of the Gila series are much like Gila very fine sandy loam, the chief difference being in the texture of the surface soils. The subsoils are typically considerably stratified but are of medium texture, fairly friable, and lack thick layers of compact heavy material (silty clay or clay). Gila clay has a rather tough surface soil ranging in texture from silty clay to clay, but the subsoil is friable and predominantly of medium texture. Gila fine sandy loam has a hummocky phase which occupies small scattered areas in the Gila Valley. It consists of small mounds or dunes of granular soil material nearly everywhere strongly impregnated with alkali salts.

The light-textured subsoil phases of the Gila soils have surface soils typical of the Gila soils, but the subsoils are loose leachy fine sand or medium sand, like the material described in connection with Gila fine sand. In many places these soils consisted originally of



A, Uncultivated desert area of sandy soils of the Superstition series, showing pipe sections distributed for installation of irrigation. B, Exposed profile in sandy soils of the Superstition series, showing slightly compacted subsoil.

Gila fine sand which has been artificially altered by the deposition of silt from irrigation water. They have lower water-holding capacity and are less productive than the typical Gila soils.

The heavy-textured subsoil phases of the Gila soils are similar to the typical Gila soils except that the subsoils are heavier in texture and consequently tougher. They contain thick layers of compact silty clay or clay within 6 feet of the surface. Such layers are doubtless sufficiently compact to make the soils drain slowly and to hinder the development and penetration of plant roots to some extent.

The Cajon soils also represent comparatively recent unmodified alluvial deposits. They are coarser in texture than the Gila soils and in general less retentive of moisture. The soil material, which occupies alluvial fans and flats along desert washes, is derived mainly from granite and the particles are angular.

The soil materials from which the Superstition soils have developed are apparently similar to those which compose the coarser Gila soils and the Cajon soils.

They have been considerably modified since deposition but probably are still comparatively immature, and they apparently represent a younger stage in soil profile than the Mohave soils which will be described later. Lime has accumulated in the upper part of the subsoils, much of it in the form of small hard nodules, but little compaction has developed. The lower part of the subsoils, or substrata, is generally loose and unmodified.

The Superstition soils of the present survey were designated in the earlier soil survey of 1904 as the Yuma soils. In the present survey they were judged to depart so little from the Superstition soils, as mapped in recent surveys in the Imperial Valley in California, that they are now correlated as Superstition.

The Superstition series is typified by Superstition sand, the most extensive member of the series in the Yuma-Wellton area. A study of this soil, made in an open pit on a smooth gently sloping area on the Yuma Mesa, shows the typical profile development. The surface soil to a depth of 6 inches is fairly firm light pinkish-brown sand or loamy sand, breaking up in soft easily crumbled clods. It is rather highly calcareous and somewhat mottled with lime. A small amount of gravel and a few lime-carbonate nodules are scattered over the surface. Between depths of 6 and 30 inches is a slightly compacted layer of light grayish-brown or slightly pinkish brown loamy sand or sand, which is very limy and contains many hard white lime nodules. Beneath this lies very loose light brownish-gray or pinkish-gray fine sand or medium sand, which is distinctly calcareous and contains a few small lime nodules.

The surface relief of Superstition sand is rather variable. Typically it is that of alternating firm and somewhat crusted flat areas of slightly loamy sand and areas of loose somewhat hummocky sand which forms a veneer over the firmer limier material. The loose sand in many places is heaped about desert shrubs, but the firmer areas are comparatively bare of vegetation and in many places have a desert pavement, or thin layer of gravel, concentrated on the surface.

The silted phase of Superstition sand is an artificially modified soil. It was originally Superstition sand, but now, after irrigation, it has a surface texture which ranges from loamy sand to silty clay. The hummocky phase has a loose and generally hummocky surface layer of sand ranging from a few inches to nearly 6 feet in thickness. The subsoil, like that of typical Superstition sand, is slightly compact and limy and contains hard lime nodules. In places the sand forms into small dunes. In a few places the subsoil is redder and more compact, like that of the Mohave soils. This is a shifting soil of poor water-holding capacity, and it is in general poorly suited to agricultural development.

Superstition sandy loam is similar to Superstition sand, but it has a firmer and loamier surface soil and in most places a somewhat better water-holding capacity. It has a surface concentration of gravel, or desert pavement, in many places.

The heavy-textured subsoil phase of Superstition sandy loam has a coarse surface soil similar to that of typical Superstition sandy loam, but it has a slightly redder color. A heavy-textured subsoil lies at a depth ranging from a few inches to 3 feet or, in a very few places, deeper. It consists of dull-red or reddish-brown compact clay, somewhat mottled and flecked with gray lime accumulations. In most places both the surface soil and subsoil contain a large amount of alkali salts. The clay subsoil apparently represents an older alluvial deposit which is known to underlie the Yuma Mesa in a number of places and is generally at considerable depth below the surface. This soil is distinct from the typical Superstition soils, but on account of its very small total extent it was shown on the soil map as a phase of Superstition sandy loam rather than as a distinct soil type in another series.

The Mohave soils have reached the most mature stage of weathering of any soils in this area. They have friable light pinkish-brown or pale reddish-brown surface soils and dull-red or reddish-brown more compact and heavier-textured subsoils containing a considerable amount of lime accumulation in the form of gray mottlings and nodules. In the Mohave soils of this area, most of the soil material is rather coarse and angular and is derived largely from granite and granitic gneiss.

Mohave loamy coarse sand is the most extensive soil representing the Mohave series in this area. The study made of this soil brings out the characteristics of the series. In a pit dug on a smooth gently sloping alluvial fan a few miles south of Tacna, the surface soil to a depth of 10 inches is light grayish-brown or pinkish-brown slightly loamy coarse sand which is rather loose but lightly crusted over. It is distinctly calcareous, though in typical Mohave soils occurring under slightly higher rainfall the surface horizon is leached of lime. Between depths of 10 and 20 inches is rust-brown or reddish-brown coarse sandy loam of compact and cloddy structure. The material in this layer is rather highly calcareous and contains gray flecks of accumulated lime. Between depths of 20 and 55 inches is very compact reddish-brown or dull-red coarse sandy loam or loamy sand, containing many gray lime nodules and mottles. At a depth of 55 inches and continuing to a depth of more than 6 feet is somewhat less compact and less red loamy coarse sand. The subsoil in this place shows somewhat more pronounced compaction than in most of the other areas mapped. In some places the soil is less maturely developed and approaches in character the soils of the Superstition and Cajon series, and in surface appearance it is difficult to distinguish from those soils. A small amount of alkali salts (about 0.1 percent) was found in the subsoil here.

Mohave fine gravelly sandy loam is similar to Mohave loamy coarse sand, but it contains a higher percentage of fine gravel which is concentrated on the surface in many places. The surface soil is somewhat redder and firmer than in Mohave loamy coarse sand, and both surface soil and subsoil normally contain a considerable quantity of alkali salts (0.1 to 2 percent).

Mohave gravelly sandy loam and its stony phase are similar to the Mohave soils as described, but they contain a higher percentage of gravel and stone. They occur mainly on the higher and steeper fans near the mountains. They normally contain considerable quantities of alkali salts.

In the Mohave soils, a filtration or downward movement of clay and colloidal material from the surface soil into the subsoil has apparently taken place, in addition to the translocation of the lime carbonate and other soluble alkali and alkaline-earth salts. Leaching of these soils has been less in this area than in the Mohave soils of the Salt River Valley, Ariz. (*4, 13*), where the rainfall is higher. In that region the undisturbed surface soil in few places contains enough lime carbonate to produce effervescence when treated with hydrochloric acid. Also, in that region, as much as 0.2 percent of alkali salts in the surface soil or subsoil of Mohave soils was extremely rare, except in a few localities where poor drainage had caused an abnormal accumulation.

The presence of rather large quantities of alkali salts in much of the Mohave soils of this area is a striking fact. It is due not to poor drainage (at the present time at least) but rather to a lack of leaching. The strongest salt concentrations are almost invariably found on ridges or steeply sloping fans, which are unusually well drained. In such places the penetration of moisture is often superficial, the rain water draining off to spread out as sheet wash and finally to be absorbed by the smoother-lying land.

SUMMARY

The Yuma-Wellton area lies mainly along the Colorado and Gila Rivers in Yuma County, Ariz., with a small part extending into Imperial County, Calif. It occupies a total area of 631 square miles, or 403,840 acres. It consists largely of fairly smooth valley lands or plains, but a number of small mountain masses or ranges are included in, or ajacent to, the area surveyed. The two main physiographic divisions are the river valley or bottom lands, and the upland terraces or mesas, together with the alluvial fans.

The climate of the region is characterized by extremely low rainfall, low relative humidity, a very large percentage of sunny days, long very hot summers, and short mild winters with infrequent frost. Irrigation is necessary for the production of crops. Many crops which thrive in a cooler and more humid climate are not well adapted here, but a number of important crops do very well. Among these are cotton, alfalfa, milo, dates, olives, figs, and European varieties of grapes. In rather limited areas of comparatively frost-free land,

grapefruit and oranges do well. Lettuce, cantaloups, peas, and other truck crops are successfully grown in the fall, winter, and spring. The pecan tree is successfully grown in the Yuma Valley.

Cotton is the most important crop in acreage and in total value, and alfalfa, grown for hay and seed, ranks second. Milo, a grain sorghum, and pasture occupy fairly large areas. Other crops which bring a good cash return are lettuce, cantaloups, grapefruit, oranges, and pecans. Wheat and barley occupy small acreages and do not yield heavily. Double cropping, or the growing of two crops on the same land in a single season, is practiced by many farmers in this area.

The river valley, or bottom land, is composed largely of the Gila soils, most of which are of fine texture and may be fairly easily watered. They are extensively farmed and are well adapted to general farming, including the growing of cotton, alfalfa, milo, lettuce, cantaloups, and other truck crops. Pecans also do well on the more pervious and alkali-free Gila soils. The mesa and alluvial-fan soils, included in the Superstition, Mohave, and Cajon series, are of coarse texture. They are more expensive to irrigate, and farming on them is confined largely to the growing of such crops as grapefruit, oranges, and grapes, which give a high cash return.

The culture of citrus fruits, pecans, dates, grapes, and other subtropical fruits is in its infancy but has great promise in this area.

The soils are normally high in lime carbonate and alkali salts, but only rather small areas contain enough alkali to prevent or seriously hamper the production of crops. Reclamation of alkali-affected lands, in most places, is feasible, though it may be costly.

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A. G. McCALL, CHIEF, SOIL INVESTIGATIONS
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP
YUMA-WELLTON AREA
ARIZONA AND CALIFORNIA

UNIVERSITY OF ARIZONA
AGRICULTURAL EXPERIMENT STATION
E. D. BALL, DIRECTOR
P. S. BURGESS, HEAD, DEPARTMENT OF AGRICULTURAL CHEMISTRY AND SOILS

Macy H. Lapham, Inspector, District 5.
Soils surveyed by F. O. Youngs, in charge, W. G. Harper, and James Thorp, U. S. Department of Agriculture, and M. R. Isaacson, University of Arizona.

BASE MAP IN PART FROM
U. S. GEOLOGICAL SURVEY SHEETS

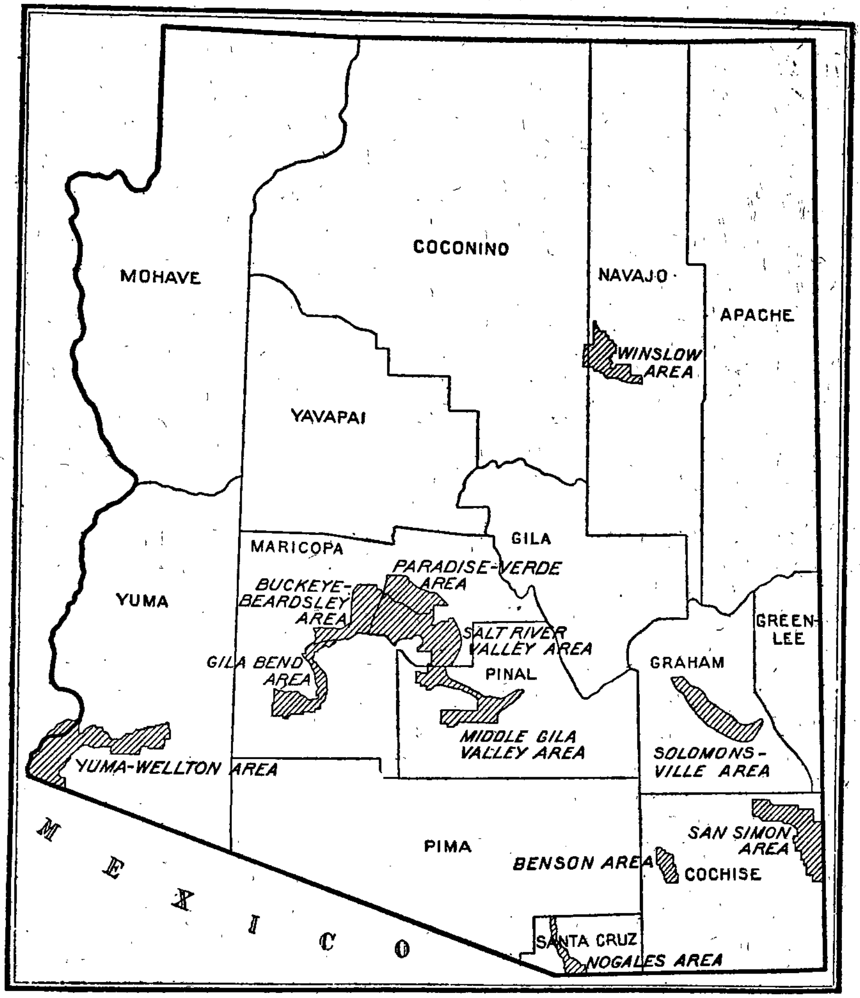
Scale 1/62500
Contour interval 25 feet.
Datum is mean sea level.

WILLIAMS & HEINTZ CO., WASH., D.C.

Field Operations
Bureau of Chemistry and Soils
1929

Authority for printing soil-survey reports in this form is carried in Public Act No. 269, Seventy-second Congress, second session, making appropriations for the Department of Agriculture, as follows:

There shall be printed, as soon as the manuscript can be prepared with the necessary maps and illustrations to accompany it, a report on each soil area surveyed by the Bureau of Chemistry and Soils, Department of Agriculture, in the form of advance sheets bound in paper covers, of which not more than two hundred and fifty copies shall be for the use of each Senator from the State and not more than one thousand copies for the use of each Representative for the congressional district or districts in which a survey is made, the actual number to be determined on inquiry by the Secretary of Agriculture made to the aforesaid Senators and Representatives, and as many copies for the use of the Department of Agriculture as in the judgment of the Secretary of Agriculture are deemed necessary.



Areas surveyed in Arizona, shown by shading.

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