

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey
of
The Longmont Area, Colorado

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In cooperation with the Colorado Agricultural Experiment Station

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SOIL SURVEY OF THE LONGMONT AREA, COLORADO

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AREA SURVEYED

The Longmont area lies in north-central Colorado a short distance north of Denver (fig 1). It extends 18 miles from north to south, approximately 42 miles from east to west, and includes an area of 752 square miles, or 481,280 acres, about two-thirds of which is in Weld County and the other third in Boulder County.

It occupies a small portion of the extreme western and higher part of the Great Plains area. As a whole it is an eastward gradually sloping plain which has been rather completely but not deeply dissected by broad shallow stream valleys.

Near the foothills of the Rocky Mountains, which rise abruptly immediately to the west, there are within the area surveyed a number of high mesas, or tablelands. One of these lies a short distance north of Boulder, and a smaller one is south of Boulder Lake. Table Mesa lies east of Altona, and Table Mountain is 2 miles southwest of Terry Lake. Haystack Mountain, 3 miles west of Niwot, is the remnant of a mesa.

Table Mesa, the largest of these tablelands, has a nearly smooth but gradually eastward sloping surface with a maximum elevation of 5,600 feet above sea level.¹ Along its eastern edge is a very steep slope, the drop being 100 feet or more within a distance of about one-fourth mile. The smaller mesas are not so high, but their edges are sharply defined, especially along the east side. Gunbarrel Hill, a high irregular area south of Niwot, has a maximum elevation nearly as great as that of the higher mesas. It is capped with gravelly material, but the slopes are gradual. A few small hills of the same character, but not so high, are scattered throughout the area.

Along the western edge of the area several streams enter from the mountains and foothills, flowing eastward through broad but comparatively shallow valleys which unite before the streams enter South Platte River. This river flows nearly due north through the center of the area in a shallow valley approximately 1 mile wide. The valley of South Platte River and in places the valleys of the smaller streams are bordered by low-lying broad poorly defined terraces which are best developed near the junctions of the streams.

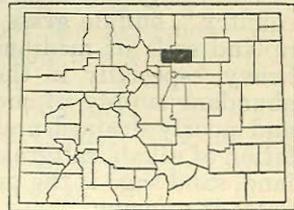


FIGURE 1.—Sketch map showing location of the Longmont area, Colo.

¹ UNITED STATES GEOLOGICAL SURVEY. NIWOT QUADRANGLE. U.S. Geol. Survey Sheet Ed. ——— 1904.

———— GREELEY QUADRANGLE. U.S. Geol. Survey Sheet Ed. ——— 1910.

East of the valley of the South Platte are two low belts extending north and south. One is known as Beebe Draw and the other is followed by Boxelder Creek. Separating these low belts and extending in the same direction are broader and higher undulating areas.

The more nearly level agricultural lands in the northwestern part of the area range from 5,000 feet above sea level near Mead to 5,100 feet at Hygiene. In the southwestern part, south of Boulder Creek, they range from 5,100 feet near the edge of the valley to 5,300 feet along the Base Line Road on the south. South Platte River Valley at Fort Lupton has an elevation of 4,900 feet, and at Platteville, 9 miles farther north, the elevation is 4,800 feet. The higher uplands between Fort Lupton and Hudson range in elevation from 5,000 to slightly more than 5,100 feet, and those southeast of Hudson have about the same elevation. The general slope is toward the east and northeast.

The Longmont area lies in the region known as the "short-grass country", buffalo grass and grama predominating, especially on the upland soils of medium or heavy texture. Where the soil is very heavy, especially in the small valleys, where there is also a more abundant supply of moisture, wheatgrass predominates. In seepy and poorly drained areas and where there is even a slight accumulation of alkali, saltgrass is the principal vegetation. On very sandy land, sand sage is the predominant growth, and in places a tall sand grass is common.

Activity in the settlement of this region began soon after the discovery of gold in 1859. The city of Boulder was started in the winter of 1858-59, and two villages, Aurora and Denver, were united in one municipality in April 1860 by act of the legislature of Jefferson Territory, as this region was then called. The estimated population then was 1,100, and the miners of that time believed the country entirely unsuited for agriculture. Denver, in 1930, only 70 years later, had a population of 287,861. The legislature which met in 1871 divided the territory into 17 counties, of which Weld and Boulder were two.

Interest in agricultural lands began through the efforts of the officials of land-grant railroads—the Denver Pacific and Kansas Pacific—the owners of which were anxious to dispose of their lands and to get settlers along their lines.² The agricultural lands in this part of eastern Colorado were settled largely by colonists. Such settlement offered a number of advantages, but perhaps the greatest was unity of action and cooperation in the development of irrigation, without which large projects like those of this region could never have been carried out.

The Union Colony which settled Greeley, the present county seat of Weld County, was founded in 1869, the people coming from New England and the North Central States. Evans, also in Weld County, was selected in 1871 as the site of the St. Louis-Western Colony. Longmont was founded in 1870 by the Chicago-Colorado Colony, and by July 1871 it had several hundred inhabitants.

In 1930 Boulder County had a population of 32,456, of which 27,792 were native white, 2,702 foreign-born white, 1,675 Mexican, 133 Japanese, 128 Negro, 7 Chinese, and 7 Indian. Weld County in

² HISTORY OF COLORADO, v. 2, p. 441.

the same year had 65,097 inhabitants, of which 49,221 were native white, 6,204 foreign-born white, 8,792 Mexican, 712 Japanese, 111 Negro, 19 Indian, and 1 Chinese.

Boulder, the county seat of Boulder County and the seat of Colorado University, had in 1930 a population of 11,223; Longmont had 6,029; and Fort Lupton, in Weld County, 1,578. All these towns are connected with each other and with Denver by hard-surfaced highways. Lyons, in the northwestern part of the area, is one of the principal entrances to Estes Park. Erie, Frederick, Dacono, and Firestone are important coal-mining towns. Platteville, in the valley of South Platte River, and Hudson and Keenesburg, in the southeastern part of the area, are surrounded by thickly settled and highly developed farm communities. As indicated by the number and distribution of the houses shown on the soil map, population is fairly dense.

In Boulder County only one-sixth of the land is under irrigation and in Weld County about one-seventh. Of the Longmont area, which is confined largely to the irrigated and better agricultural lands, nearly three-fourths is under irrigation.

The area is well supplied with railroad facilities. The Union Pacific Railroad, the Chicago, Burlington & Quincy Railroad, the Colorado & Southern Railway, and lines owned and operated by the Great Western Sugar Co. extend into all parts of it.

United States Highway No. 85 extends northward from Denver along the South Platte Valley, across the east-central part of the area, and United States Highway No. 285 extends from Denver northwest through the west-central part. A branch road from United States Highway No. 285 extends to Boulder. A State highway connects Boulder and Lyons, and another State highway extends through Keenesburg and Hudson to Denver. Over much of the area public roads follow nearly every section line. Several of the more important roads have a hard surface of gravel, and practically all are well graded and maintained. Several lines of passenger stages run on regular schedules on the main highways, and a very large part of the farm products reaches market by means of trucks.

In the south-central part of the area is a large coal-mining section, several of the smaller towns in this section being dependent almost entirely on the mining industry. The larger mines have railroad connections, but much of the coal is hauled by truck. Weld County ranks second and Boulder County seventh in the State in the production of coal.

The area is well supplied with rural and graded schools and has a number of consolidated high schools. City and village churches are numerous, and there are a few rural churches. Modern conveniences of all kinds are available in most sections.

The manufacture of agricultural products is important. One of the large sugar companies operates a factory at Longmont, one at Fort Lupton, and one at Brighton. The last-named is outside the area surveyed, but it receives a large proportion of the beets grown here. Molasses from all these factories is further refined at Johnstown, Weld County. Large canning plants are operated at Longmont, Brighton, and Fort Lupton. A condensed-milk company operates a large plant at Fort Lupton, receiving milk from all parts of the area. Alfalfa mills are operated at Niwot, Mead, and Keenes-

burg. A large part of the wheat grown in the Longmont district is ground into flour at Longmont. There is a large tile factory at Longmont, and other manufacturing industries are carried on within the area.

CLIMATE

The part of Colorado included in the Longmont area has an equable continental climate well suited for the type of agriculture carried on. The mean annual precipitation at Longmont is 14.66 inches. It is well distributed. Approximately three-fifths of the rainfall occurs during the 7-month period, from April to October, inclusive. Irrigation water is depended on for the growing of sugar beets, alfalfa, truck crops, and a large part of the other crops. Rainfall also supplies a considerable part of the moisture where irrigation is used. Large acreages of wheat, corn, and pinto beans are grown without irrigation. In this region of comparatively low temperature and correspondingly lower evaporation, dry farming is carried on more successfully than farther south and at lower elevations where the rainfall is as great but the temperature and evaporation are higher. A few hundred miles in latitude make an important difference in dry-farming possibilities, even where the annual rainfall is the same.

The mean annual temperature at Longmont is 47.8° F. The average date of the last killing frost is May 7 and of the first is September 30, giving a frost-free season of 146 days. The average length of the frost-free season at Boulder is 165 days; at Greeley in Weld County, but outside the area, 149 days; and at Denver 158 days. The latest killing frost at Longmont occurred on June 2 and the earliest on September 8.

Table 1, compiled from records of the United States Weather Bureau station at Longmont, gives the more important climatic data for the area.

Although the length of the frost-free season, compared with that of some other important agricultural sections, seems short, at this high altitude, with clear air and bright sunshine, plants grow more rapidly and mature more quickly than at lower altitudes. Flowers of all kinds are highly colored and produce large crops of seed. The sugar content of beets is high, and all grains are heavy in weight. In the midsummer season at this latitude daylight extends from before 5 a.m. to later than 7 p.m. Twilight begins at 5 p.m. and does not end until 9:30 p.m., which also increases the efficiency of the growing season. Atmospheric pressure at Denver is only 12.2 pounds a square inch, 83 percent of that at sea level. Humidity averages 53 percent, as compared with 74 percent at Chicago and 80 percent at San Francisco, Calif., or Jacksonville, Fla.

Dry weather in the spring results in low germination of seed and poor stands of sugar beets and other crops. Dry windy weather also causes shifting and drifting of sandy soils in the cultivated fields, at times resulting in serious damage. Injury from hail is also sometimes heavy. Early killing frosts and freezing weather accompanied by rain and snow in the fall sometimes interfere with the harvesting of sugar beets and other late crops. Normal fall weather, however, is characterized by bright, fair days which continue until late November.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Longmont, Boulder County, Colo.

[Elevation, 4,950 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1932)	Total amount for the wettest year (1915)	Snow, average depth
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December.....	26.1	74	-30	0.55	0.38	0.49	7.1
January.....	26.2	71	-31	.36	.19	.35	3.6
February.....	29.9	76	-29	.53	.73	1.39	9.4
Winter.....	27.4	76	-31	1.44	1.30	2.23	20.1
March.....	37.5	82	-15	.88	.65	1.16	6.2
April.....	46.8	86	1	1.90	1.04	4.20	6.9
May.....	56.2	95	18	2.61	1.08	2.97	1.8
Spring.....	46.8	95	-15	5.39	2.77	8.33	14.9
June.....	65.6	103	30	1.66	1.76	1.40	(¹)
July.....	70.2	100	40	1.91	.76	4.02	.0
August.....	69.0	100	39	1.35	.60	2.16	.0
Summer.....	68.3	103	30	4.92	3.12	7.58	.0
September.....	60.0	98	26	1.00	.02	2.20	.2
October.....	48.2	91	-5	1.32	.80	2.05	1.7
November.....	37.0	82	-13	.59	.28	.28	5.6
Fall.....	48.4	98	-13	2.91	1.10	4.53	7.5
Year.....	47.8	103	-31	14.66	8.29	22.67	42.5

¹ Trace.

AGRICULTURE

The first white man who made a serious effort to raise livestock and grow crops along South Platte River in the territory now embraced in Colorado was Lancaster P. Lupton. In 1836 he established himself near the site of the present town of Fort Lupton to engage in the fur trade. He seems also to have been much interested in farming, as, when Fremont visited his place in 1843, he observed that Mr. Lupton's post was "beginning to assume the appearance of a comfortable farm." Hogs and cattle were ranging the prairies. There were different kinds of poultry, and he had planted a garden in which a number of different vegetables were in a flourishing condition.

In 1868 the following crops were grown along the South Platte in the vicinity of Denver: Wheat, oats, corn, barley, rye, and potatoes. There were also several patches of beans, and more than 200 acres were devoted to gardens and miscellaneous crops.³

Agriculture in this part of Colorado has from its beginning been closely associated with irrigation. Early irrigation was carried on by means of small private ditches used in supplying water for low-lying lands near the river channel. These were gradually enlarged, and since about 1870 irrigation has been by means of much larger canals supplied with dams and head gates and later supplemented

³ STEINEL, A. T. HISTORY OF AGRICULTURE IN COLORADO * * * p. 18. Fort Collins, 1926.

by numerous large storage reservoirs. The earlier systems depended on direct flow from the streams, but, by use of storage reservoirs, the supply of irrigation water has been greatly increased, and irrigation farming has become stabilized.

Boulder County in 1919 had 159,781 acres irrigated, 1,467 miles of ditches and laterals, and an investment in these of \$1,774,922. Weld County at the same time had 382,701 acres irrigated, 1,990 miles of ditches and laterals, and an investment in these irrigation projects of \$16,417,224.⁴ The United States Census report for 1930 shows 159,428 acres under irrigation in Boulder County in 1929, and 443,915 acres in Weld County. About 75 percent of the land within the Longmont area is irrigated. The larger part of the remainder is not irrigated because water is not available or because the land lies at too great a height above the ditches. Some parts, on account of rough and broken surface relief or a high concentration of alkali, are not suited for irrigation. Some pumping, where water is available at slight depths, is carried on, and where water is not available for irrigation much of the land is dry-farmed, the remainder being used for range land.

In table 2 the value of farm crops in Boulder and Weld Counties for the year 1930 is shown.

TABLE 2.—*Value of crops in Boulder and Weld Counties, Colo., in 1930*¹

County	Corn	Wheat	Oats	Barley	Rye	Potatoes	Dry beans
Boulder.....	\$250,790	\$284,530	\$76,290	\$158,370	\$710	\$5,400	\$5,940
Weld.....	1,239,950	1,638,890	227,550	1,172,950	38,630	2,262,560	1,278,890
Total.....	1,490,740	1,923,420	303,840	1,331,320	39,340	2,267,960	1,284,830

County	Sorghums	Sugar beets	All hay	Fruits	Miscellaneous crops	Total
Boulder.....		\$874,500	\$557,820	\$16,480	\$211,210	\$2,442,040
Weld.....	\$114,500	9,451,460	2,615,020	6,200	1,139,270	21,185,870
Total.....	114,500	10,325,960	3,172,840	22,680	1,350,480	23,627,910

¹ COLORADO STATE BOARD OF IMMIGRATION. YEAR BOOK OF THE STATE OF COLORADO, 1931, pp. 64-65.

These values change from year to year, depending on seasonal conditions, which affect crop yields, and on crop prices. Crop prices not only determine the value of the current crop but in many cases influence the acreage planted to a given crop the following year. This change in acreage is most pronounced in potatoes, sugar beets, and the miscellaneous crops. The more important miscellaneous crops in these counties are tomatoes, garden peas, red beets, snap beans, cabbage, pumpkins, onions, and sweet corn. Only a small quantity of fruit, principally cherries, is grown.

The average acre value of cultivated crops in 1930 was \$29.37 in Boulder County and \$28.99 in Weld County.

The values given in table 2, with the exception of that for potatoes, indicate the relative values of crops in the Longmont area.

⁴ COLORADO STATE BOARD OF IMMIGRATION. YEAR BOOKS OF THE STATE OF COLORADO—Compiled and edited by T. R. Ingram. 1928-29 yearbook, p. 37.

In this area potatoes are not so important as in other parts of Weld County. Sugar beets had a value nearly three times that of any other crop.

Interest in the beet-sugar industry in this section began about 1893, when a small acreage was planted to sugar beets, and three carloads were shipped to a factory at Lehi, Utah. In 1899 a factory at Grand Junction, Colo., began slicing beets and manufactured 6,600 sacks of sugar. A factory at Loveland, only a few miles north of Longmont, began operations in 1901. At present Colorado has 17 beet-sugar factories, representing 29.7 percent of the total number in the United States. Of these, the one at Longmont has a slicing capacity of 2,750 tons every 24 hours, the one at Fort Lupton a daily capacity of 975 tons, and the one at Brighton, outside the surveyed area but using a large part of the beets grown within the area, a daily capacity of 1,650 tons.

The growing of sugar beets has been an important factor in stabilizing the agriculture of this section. Although returns, as compared with those of other specialized crops, are not high, this is one of the most dependable crops grown. The beets are grown under contract, by which the grower knows approximately the price per ton he will receive for his crop before the seed is planted. They require fertile soil and intensive cultivation for profitable returns. They are grown under the supervision of competent field men, and the methods learned in growing sugar beets are followed in the production of other crops.

The production of sugar beets (pl. 1, *A*) has led to better crop rotations; to building up the soil by use of manure and commercial fertilizers; to a more careful use of irrigation water; and to a more prosperous and stable agriculture, for which the soil of much of this area is well suited.

Hay, the second crop of importance, consists largely of alfalfa. This crop is grown, both for hay and for pasture, on the irrigated lands in all parts of the area. It, also, is important in building up the soil. Much of the alfalfa is fed to work animals, sheep, and cattle, but large quantities are ground into meal and shipped. Three alfalfa mills in the Longmont area grind about 204 carloads each a season. Alfalfa not only has an important place in the crop rotation on the better soils but is also used on soils of lower productivity.

The small grains, wheat, barley, and oats, are important crops. Wheat (pl. 1, *B*) and barley are grown extensively both on the irrigated and unirrigated lands. Oats are grown in the higher parts of the area near the mountains.

Corn is a crop of increasing importance in Colorado. Production for the State has increased from 255,207 bushels in 1880 to 37,142,000 bushels in 1930. It is grown in all parts of the Longmont area on both irrigated and unirrigated land, but most extensively on the sandy lands in the eastern part, a large proportion of it without irrigation. Yields on such land are variable, depending on seasonal conditions. This dry-land corn makes a low growth, but when there is sufficient moisture it produces large, heavy ears abundantly (pl. 2, *A*). The average yield of corn on nonirrigated land in 1930 in Weld County was 20 bushels an acre, and in Boulder County 22 bushels.⁵ On irrigated land it was 42 bushels in Weld County and 45 in Boulder County.

⁵COLORADO STATE BOARD OF IMMIGRATION. YEAR BOOK OF THE STATE OF COLORADO. 1931.

Dry beans are an important crop, especially on nonirrigated sandy land. In 1930 Weld County produced 421,400 bushels of beans on irrigated land, the average being 20 bushels an acre, and 525,960 bushels on nonirrigated land, the average yield being 10.8 bushels.⁵ The acreage in Boulder County was not so large.

A considerable acreage is devoted to crops grown for canning, the most important of which are garden peas and tomatoes. Other important crops are green beans, pumpkins, red beets, cucumbers, and cabbage. Some lettuce (pl. 2, *B*), onions, celery, and other crops are grown, largely for the Denver market.

Car-lot shipments from Longmont and Fort Lupton, the two most important shipping points in the Longmont area, during the year 1929 are as follows:⁶ Sugar, 1,469 cars; livestock, 268; canned milk, 264; grain, 242; canned goods, 227; cabbage, 80; flour, 78; molasses, 62; vegetables, 38; beet pulp, 36; miscellaneous crops, 34; building tile, 31; bran, 8; show livestock, 6; straw, 3; beans, 2, and cucumbers for pickling, 1 car. In addition to the car-lot shipments there were many part-car-lot shipments. Very large quantities of many farm products, including livestock, poultry, poultry products, garden truck, grain, and other commodities are shipped to market by truck.

Agriculture in this region has undergone important transitions. Prior to 1900, cash crops were the principal ones grown, but little attention was paid to livestock feeding, the use of manure, and the maintenance of soil fertility. Attention later became centered on alfalfa as a means of keeping the soil in a high state of productiveness, but this crop did not offer an entirely satisfactory solution. Since sugar-beet growing, sheep and cattle feeding, and dairying have become general, the profits have not only been surer through crop diversification, but the soils have also been kept in a higher state of productiveness through the rotation of crops and the use of manure.

Disease of alfalfa and the dying out of the older stands has in the last few years caused many fields to be plowed up. It is now becoming generally recognized that alfalfa cannot be grown successfully as a permanent crop but must be used in a rotation, one seeding being allowed to stand for a period ranging from 3 to 5 years.

Another important development of recent years has been that of dairying. Both Weld and Boulder Counties are classed among the principal dairy counties of the State. In 1929 there were milked in Weld County 22,428 cows and in Boulder County 6,386 cows. The average annual production of milk in the State per cow was about 500 gallons in that year.

The most rapid agricultural development has been in the nonirrigated districts of eastern Colorado, owing largely to a change in farming methods. Forage crops are now being grown extensively and silos for storing winter feed are in general use. In 1930, a con-

⁵ Data supplied by the agent of the Union Pacific R.R., Fort Lupton; by J. F. Valley, assistant general freight agent of the Chicago, Burlington & Quincy R.R., Denver; and by S. Gilmer, agent of the Colorado & Southern Ry., Longmont.



A, Sugar beets on Weld soil near Mead, in July. *B*, Wheat on Berthoud soils near Boulder.



A, 50-bushel per acre corn on Valentine loamy fine sand, heavy-subsoil phase, without irrigation, east of Fort Lupton. *B*, Head lettuce on Gilcrest sandy loam near Fort Lupton.

densed milk company was receiving at their Fort Lupton plant the milk from 19,000 cows.

In the early days of agriculture in Colorado the soils were believed to be so rich as to need no fertilizers. Continuous cropping and removal of crops from the land, however, resulted in decreased yields, and alfalfa was used to restore the soil to its original state of productiveness. With the introduction of sugar beets and more intensive farming practices, manure came into demand. This was supplied through the feeding of livestock, and for many years all available manure has been carefully used in building up the soil.

Soon after sugar beets became an important crop in this section, commercial fertilizers were tried in an experimental way but apparently without results justifying their use. During the last several years, however, experiments have been carried on by the Division of Soil Fertility of the Bureau of Chemistry and Soils in other parts of Colorado. Results of these experiments indicate that certain fertilizers under the right soil conditions might be used with profit.

More recent experiments have been carried on by the sugar company at Longmont and by the State Agricultural College of Colorado at Fort Collins. Results obtained indicate that where the soils have been impoverished by continuous cropping, commercial fertilizers high in phosphates are sufficiently beneficial to be used with profit. A further discovery was made that where sugar beets have black heart, one of the serious physiological diseases of sugar beets, this is practically overcome by the use of phosphate fertilizer.

The general tendency of agriculture in the Longmont area is as follows: (1) Crop diversification and rotation, a seeding of alfalfa being allowed to stand from 3 to 5 years only, and not more than two crops of sugar beets being grown in succession; (2) a combination of livestock feeding and dairying, use of all available manure, and a much more general use of commercial fertilizers, especially phosphate; and (3) a smaller acreage but higher production to the acre of all crops through improved soil conditions.

When the beet-sugar industry was started in Colorado, German-Russian beet laborers were recruited from older beet-growing sections, largely from Nebraska. These early workers induced others to come from Europe, and their numbers increased until the time of the World War. Many of this class were thrifty and industrious, and in time became tenant farmers or bought farms of their own. Some of these and their families have continued to do much of the hand labor in the beet fields, but others have become employers of cheaper labor.

Spanish-American and Mexican labor have been used in southern Colorado on the farms and ranches since the earliest settlements, and this class of laborers began coming into northern Colorado as early as 1905. Since 1915 such labor has been depended on to a very large degree. Considerable labor, especially in the truck-growing and gardening sections, is done by Japanese, and some by Chinese. These people also are thrifty and soon become tenant farmers or farm owners and hire Mexican or other labor.

Beets are grown under contract, by which all hand labor, including blocking and thinning, hoeing, weeding, pulling, and topping, is done for a basic price of \$23 an acre (1930), with a bonus of 50

cents a ton for beets yielding more than 12 tons an acre.⁷ In 1930 day laborers in the Longmont area received from \$2 to \$2.50 with board or \$2.50 to \$3 without board. When hired by the month, men are paid from \$65 to \$75, and they board themselves and have a house and garden furnished.

Rentals vary somewhat in different parts of the area and also according to the crops grown. The farm owner usually receives on the farm one-half of the alfalfa grown. He receives one-third, one-fourth, and in some cases seven twenty-fourths of the sugar beets grown, delivered at the beet dump. The landowner receives one-third of the small grain delivered, except oats and barley, when these are to be used for feed, which are not delivered. The landowner receives one-third of the potatoes and furnishes one-third of the sacks.

In 1930 Boulder County had 1,473 farms, with an average acreage per farm of 138 acres. Owners operated 802 farms, renters 479, managers 15, and part owners 177. Weld County had 5,457 farms, averaging 362.4 acres in size. Of these, 1,668 were operated by owners, 2,837 by renters, 920 by part owners, and 32 by managers. In Boulder County the majority of the farms range in size from 50 to 500 acres. In Weld County 956 farms range in size from 50 to 100 acres, 1,681 from 100 to 175 acres, 478 from 175 to 260 acres, and 1,000 from 260 to 500 acres. In both counties there are a few farms smaller than 50 acres and a few larger than 500 acres.

As a rule the smaller farms are on the irrigated lands, and the larger farms and ranches include land that is dry-farmed or is wholly or partly used for range land.

There has been a gradual decrease in size of farms in Boulder County since 1880. In Weld County there has been considerable fluctuation in size of farms, probably due to early homesteading of lands and unsuccessful attempts at dry farming.

Farms of the Longmont area are well equipped with fences and buildings. Many farm implements and labor-saving machinery are used. Farmhouses, barns, and other outbuildings, especially in the irrigated sections, are well built and painted. Most farms have one or more neat, well-built tenant houses. Many have silos.

On irrigated farms, horses are used to a large extent, but on the dry lands tractors and heavy machinery are in more general use. Combines are used largely in harvesting wheat on the dry lands, and dry beans are shocked and threshed with separators.

Farming in the area is diversified. A one-crop system is practically unknown. In the irrigated part, which embraces about three-fourths of the area, including a very important part of both Weld and Boulder Counties, agriculture centers around the three major crops—sugar beets, alfalfa, and small grains—supplemented by numerous crops of less importance. The growing of these crops is closely connected with dairying and the feeding of cattle and sheep. Very few raw products are shipped. Beets are manufactured into sugar, and the byproducts—tops, pulp, and molasses—are used in the feed lots. Cattle and sheep for feeding are bought on the markets, and a good many hogs are raised and fattened. Much

⁷ Statement of L. A. Moorhouse, professor of rural economics and sociology, State Agricultural College of Colorado.

of the wheat is ground into flour, and most of the alfalfa, barley, and corn is fed to livestock within the area. Some feed is shipped in.

Truck crops are sold on the Denver markets or in the pack from the canneries. Beans for seed are grown extensively. Even the byproducts of peas and beans are utilized for feed for livestock. Poultry raising and beekeeping are carried on throughout the area. The growing of certified seed and of flowers and bulbs is receiving attention.

DRAINAGE AND ALKALI

In parts of the Longmont area are sections which contain alkali in harmful amounts. The most extensive of these are in the western part on heavy types of the Terry soils, especially on the valley phase of Terry clay. Along the southeast side of the valley of Boulder Creek, midway between Longmont and Firestone, is an area of Cass clay, in much of which there is a heavy accumulation of alkali.

In the valley of South Platte River there are numerous seepy and alkali areas, due to a high water table which is maintained at river level.

An analysis⁸ of alkali crust from the South Platte Valley near Fort Lupton, made in the soils laboratory of the State Agricultural College of Colorado, gave the following results: Total water-soluble salts 35.42 percent, of which 0.8 percent is Ca, 0.46 percent Mg, 19 percent SO_4 , 3.35 percent Cl, 0.02 percent CO_3 , and 0.2 percent HCO_3 .

An analysis of a sample of alkali crust from the Platte Valley near Fort Lupton showed the predominating anion to be sulphate. The chloride anion was fairly abundant, and the amount of carbonate and bicarbonate anions were very low. The amount of water-soluble calcium was approximately twice that of magnesium, although both were present in very small amounts. This indicates that either sodium or potassium is the predominating cation. It is highly probable that sodium exists in much greater quantities than potassium. This analysis indicates that the predominating salt is probably sodium sulphate, and sodium chloride is present to less extent.

Under present agricultural conditions it seems doubtful that any considerable parts of those areas in which there is a heavy accumulation of alkali can be profitably reclaimed. There are also numerous smaller areas which, on account of lack of drainage, have become seepy, and alkali has accumulated in the surface soil until crops cannot be grown with profit. A number of alkali determinations were made in such areas, and the principal accumulation was found to be in the surface soil, where it is most harmful. The total amount of soluble salts is not high. Results of a determination in the worst part of the seepy area along United States Highway No. 285, 3 miles south of Longmont, is representative, showing a concentration of 1.3 percent in the surface foot of soil and of only 0.34 percent in the fifth foot.⁹ These are as follows: From 0 to 12 inches, loam, 1.3 percent alkali; from 12 to 24 inches, clay loam, 0.65 percent; from

⁸ Analysis by R. D. Hockensmith, associate professor of agronomy. State Agricultural College of Colorado.

⁹ Determination by the electrolytic bridge.

24 to 36 inches, clay loam, 0.57 percent; from 36 to 48 inches, clay loam, 0.39 percent; and from 48 to 60 inches, clay loam, 0.34 percent.

In this soil, sodium sulphate predominates and sodium carbonate is not present in sufficient amounts to be toxic. The more tolerant crops—sweetclover, alfalfa, and sugar beets—in a soil as heavy as this, can withstand considerable concentration of salts. Under favorable conditions a stand can be obtained under a concentration of nearly 0.5 percent, and after being well started these crops can grow where the concentration is twice as great.¹⁰

It is believed that many of the smaller seepy and alkali areas might be profitably reclaimed by drainage. In Beebe Draw there are a number of larger areas affected by alkali. A good deep outlet through the lower part of this land has long been in use but has not proved effective in reclaiming the land. In addition, deep open ditches to cut off the underflow from the slopes are needed. It is believed that the construction of such ditches, the cultivation of the soil, and seeding to sweetclover in a few years would reclaim much of this land.

Areas in which harmful amounts of alkali are present are indicated on the soil map by the symbol "A" in red.

SOILS AND CROPS

Agriculture in the Longmont area, as already noted, is widely diversified. All the more important crops are grown on practically all kinds of irrigated land regardless of the soil type, and some are grown on the unirrigated or dry land. There are, however, certain soil and crop adaptations which are generally recognized, as the use of deep well-drained soils of medium or heavy texture for sugar beets, of warm sandy and gravelly well-drained soils for early truck crops, and of sandy soils with heavy subsoils for dry beans and corn.

Based on their natural, or inherent, characteristics which bear a close relation to their supply of plant nutrients, moisture conservation, and drainage, soils of the area may be divided into seven broad groups as follows: (1) Soils of the Weld group, including the Weld soils which have developed on the uplands, partly from wind-blown material, and the Fort Collins soils developed on old high stream terraces, largely from old alluvial material, consisting of well-weathered soils with deep, friable well-drained subsoils, the dominant types being of medium texture and well supplied with plant nutrients and lime; (2) soils of the Terry group, which are somewhat similar to those of the Weld group but have sandstone, shale, or sandy shale in the subsoil at widely different depths and include the medium and heavier types of the Terry series; (3) soils of the Gilcrest group, consisting of sandy and gravelly soils underlain, in many places at slight depths, by clean sharp stream gravel, belonging to the Gilcrest series, soils, having the same arrangement of layers but darker in color and with deeper, heavier subsoils, of the Nunn series, and the Greeley soils of more recent formation; (4) soils of the Larimer group, consisting of gravelly soils with shallow subsoils more or less cemented with lime carbonate; (5) soils of the Valentine group, consisting mainly of wind-blown sands of the Valentine series but

¹⁰ SWEET, A. T. SOIL FACTORS INFLUENCING CROP PRODUCTION IN THE ARKANSAS VALLEY, COLORADO. U.S. Dept. Agr. Circ. 53, 25 pp., illus. 1928.

including some areas of deep, sandy soils of the Terry series; (6) soils of the Berthoud group, developed on the slopes largely from alluvial and outwash material but including shallow soils, weathered from shaly limestone, of the Laporte series, soils, weathered from red sandstone and shale, of the Neville series, and rough mountainous land; and (7) soils of the Cass group, consisting of soils in the stream valleys composed of recently deposited alluvium, and for the most part being dark colored, having gravelly subsoils, and with the ground water lying at a slight depth.

In soil classification and mapping, the soils of an area are divided into groups, all the members of which are alike in all characteristics except the texture, or coarseness or fineness, of the surface soil. These groups, or series, are given a name, usually that of some place in which the soils are typically developed. Thus we have in the Longmont area the Weld series which includes upland soils having three distinctly developed layers with a well-drained deep subsoil of lighter texture. Each series includes two or more soil types which have the common characteristics of the series but differ in texture, or the proportion of sand, silt, and clay contained in the surface soil.

On the accompanying soil map the different soil types are indicated by colors and symbols, the meaning of these being shown in the legend on the margin. In places variations of importance occur within the areas of typical soil and are indicated as phases.

On the accompanying map soils of 13 series, represented by 27 soil types and 10 phases of types, in addition to river wash and rough mountainous land are shown. Table 3 shows the acreage and proportionate extent of each soil mapped.

TABLE 3.—Acreage and proportionate extent of the soils mapped in the Longmont area, Colo.

Type of soil	Acres	Per- cent	Type of soil	Acres	Per- cent
Weld loam.....	73, 088	15. 2	Valentine loamy fine sand.....	73, 408	15. 3
Weld loam, valley phase.....	3, 456	. 7	Valentine loamy fine sand, heavy- subsoil phase.....	54, 016	11. 2
Weld fine sandy loam.....	21, 248	4. 4	Terry fine sandy loam.....	18, 432	3. 8
Weld fine sandy loam, valley phase.....	1, 024	. 2	Terry fine sandy loam, deep phase.....	10, 240	2. 1
Weld clay loam.....	30, 592	6. 4	Berthoud clay loam.....	8, 256	1. 7
Fort Collins loam.....	11, 648	2. 4	Berthoud loam.....	11, 136	2. 3
Fort Collins clay loam.....	6, 912	1. 4	Neville fine sandy loam.....	384	. 1
Fort Collins clay.....	1, 792	. 4	Laporte gravelly loam.....	1, 536	. 3
Terry clay.....	6, 144	1. 3	Rough mountainous land.....	8, 832	1. 8
Terry clay, valley phase.....	5, 568	1. 2	Cass fine sandy loam.....	15, 680	3. 3
Terry clay loam.....	31, 872	6. 6	Cass fine sandy loam, deep phase.....	2, 240	. 5
Terry loam.....	12, 736	2. 6	Cass fine sandy loam, shallow phase.....	768	. 2
Terry loam, deep phase.....	896	. 2	Cass clay loam.....	10, 496	2. 2
Gilcrest gravelly sandy loam.....	3, 008	. 6	Cass clay loam, deep phase.....	2, 880	. 6
Gilcrest sandy loam.....	7, 872	1. 6	Cass clay.....	3, 136	. 7
Nunn gravelly sandy loam.....	3, 264	. 7	Kuner fine sandy loam.....	11, 456	2. 4
Nunn clay loam.....	3, 072	. 6	Kuner clay loam.....	1, 728	. 4
Greeley fine sandy loam.....	7, 488	1. 5	River wash.....	4, 288	. 9
Larimer gravelly loam.....	1, 152	. 2			
Larimer clay loam.....	2, 752	. 6			
Larimer clay loam, stony phase.....	6, 784	1. 4	Total.....	481, 280

SOILS OF THE WELD GROUP

Soils of the Weld group have a 12-inch brown, dark-brown, or slightly reddish brown surface soil; a lighter brown heavier subsoil, with an accumulation of carbonate of lime occurring as light-gray spots, which extends to an average depth of about 30 inches; and a third layer of soil lighter in texture and without lime spots.

The upland soils of this group, which belong to the Weld series, have developed largely from weathered wind-blown or loess material of local origin. When cut into by roads or ditches, this material stands up in nearly perpendicular banks several feet high, in which the prismatic structure characteristic of wind-blown material is seen. Good exposures of soil material of this kind may be seen at the old brickyard in the northwest part of Longmont (pl. 3, A), in the railroad cut east of the sugar factory at Longmont, a short distance north of the junction of the Boulder Highway with United States Highway No. 285, along the outlet to Baller Lake, in the railroad cut a mile west of Keenesburg, and in other places.

In places the Weld soils have water-worn gravel on the surface and through the soil. These gravel have been carried down the slopes from gravel-capped hills. Many of the natural basins, as Terry Lake, are believed to be partly of wind-blown origin, the soft sandstone and shale material having been scooped out by the wind and deposited on the uplands.

In many places in this area and in other parts of eastern Colorado, where the deep material underlying mature soils is exposed in excavations or gully banks, two or more zones of lime accumulation occur. These are most numerous in old high stream terraces and in deep deposits of wind-blown material and seem to represent former cycles of soil development.

The Weld are the dominant upland soils in a broad belt extending from the limits of the area north of Mead south and west to the Base Line Road between Lafayette and Boulder. A large body extends from Hudson and Keenesburg east and south beyond the limits of the area, and a third occupies the larger part of the uplands between Dacono and Wattenberg.

Weld loam, Weld clay loam, and Weld fine sandy loam are the most important sugar-beet soils of the area (pl. 1, A).

The Fort Collins soils of this group occur on old high stream terraces and broad valleys no longer occupied by the streams which formed them. The surface relief is smooth and nearly level, sloping uniformly down the valleys. These soils also have formed three layers much like those of the upland soils. They are slightly more reddish brown and contain small quantities of water-worn gravel on the surface and through the surface soil and subsoil. The parent material is of alluvial origin but in places has been modified by wind-blown material.

Soils of this kind are extensively developed southwest of Longmont on the low but not very clearly defined terraces which separate the valleys of St. Vrain Creek, Lefthand Creek, and Dry Creek. A belt occupies a valleylike strip which extends from the vicinity of the sugar factory at Longmont northwest beyond the limits of the area.

Although the parent materials of the Weld and Fort Collins soils differ rather widely, the soils have, through a long process of development, become much alike. This group embraces the most productive sugar-beet, alfalfa, and small-grain soils of the area.

Following is an estimate¹¹ of the percentage of the total acreage devoted to the several crops grown on soils of the Weld group:

¹¹ These figures were obtained from estimates of A. C. Maxon, agriculturist, Great Western Sugar Co., Longmont; T. G. Stewart, extension agronomist, Agricultural College of Colorado; and R. E. Kiely, extension agent, Boulder County.

Small grains, 33 percent; sugar beets, 24; alfalfa, 24; corn, 9; beans, 4; peas, 2; pasture, 1; sweetclover, 1; cabbage, 1; and garden and truck crops, including tomatoes, pumpkins, cucumbers for pickles, and onions, 1 percent.

In 1929 sugar-beet receiving stations along the Burlington Railroad southeast of Longmont showed an average production, principally on soils of this group, ranging from 13 to 15.9 tons of sugar beets an acre.¹² Some sugar beets came from the highlands directly south of the Longmont sugar factory. The station receiving these sugar beets had the highest average in the district.

The crops grown and acre yields obtained, largely on soils of this group, in 1930 by the Kuner-Empson Canning Co., at Longmont, were as follows:¹³ Lima beans on 160 acres yielded 1,800 pounds, green beans on 216 acres yielded 4,800 pounds, red beets on 118 acres yielded 13,300 pounds, peas on 1,240 acres yielded 1,800 pounds of shelled peas, pumpkins on 320 acres yielded 7½ tons, and tomatoes on 175 acres yielded 12,000 pounds.

Estimates of the percentage of the total acreage and average acre yields of crops, both irrigated and nonirrigated, on soils of this group in the Hudson-Keenesburg section are as follows:¹⁴ On irrigated soils, principally Weld loam, alfalfa, 30 percent, average yield 2 or 2½ tons, large yield of 4 tons; sugar beets, 25 percent, average yield 15 tons, large yield ranging from 16 to 25 tons; wheat, 20 percent, average yield 20 to 30 bushels; dry beans, 15 percent, average yield 1,500 to 2,000 pounds; and oats and barley, 10 percent, average yield 60 to 90 bushels. On nonirrigated soils of the same type, winter wheat, 60 percent, average yield, from 15 to 25 bushels; pinto beans, 25 percent, average yield, from 1,000 to 1,200 pounds; corn, 10 percent, average yield, from 10 to 40 bushels; and millet, 5 percent.

Weld loam.—Weld loam consists of dark-brown or dark grayish-brown loam to a depth of about 12 inches, at which depth it is underlain by distinctly lighter brown, grayish-brown, or olive-brown loam of slightly heavier texture, which contains well-defined nearly white lime spots from one-half to 1 inch in diameter. At a depth ranging from about 30 to 36 inches the material grades into a more friable lower subsoil layer which contains very few lime spots. The subsoil extends to a depth of 60 or more inches.

Uncultivated areas of this soil have a thin surface mulch of finely granular and rather sandy material moderately crusted at the surface. Below the mulch the surface soil when dry breaks into hard somewhat regular clods with smooth surfaces. The upper part of the lighter colored layer also breaks into fairly hard somewhat regular clods which in places have a thin coating of limy material over their surfaces.

The third layer has a rather distinctly prismatic structure characteristic of many wind-blown materials, the vertical cleavage planes of which allow free movement of moisture, air, and plant roots (pl. 3, B). In places fine rootlets are present, nearly covering the face of the cleavage planes at a depth of several feet below the surface.

¹² From records of the Great Western Sugar Co., Longmont.

¹³ From records of the Kuner-Empson Canning Co., Longmont.

¹⁴ Estimates by P. R. Culverwell, secretary, Henrylyn Irrigation District, Hudson, Colo.

Readings made of the resistance of this soil at various depths indicate a slight concentration of soluble salts in the middle layer.

This soil has developed largely from material believed to have been blown from the soft shale and sandstones of nearby regions and to some extent from the river flood plains. Owing to differences in the materials from which the soil has developed, depth of soil material, and relief, this soil includes rather wide variations. Near outcrops of sandstone it tends to be lighter in texture than in areas in which the parent material is entirely from shale. Where the loess deposit is shallow the soil is, as a rule, heavier than where the loess is deep. Where the land is nearly level, the subsoil is more completely developed and heavier than where the soil occupies slopes. Although classed as a loam, this soil contains a very high percentage of very fine sand and silt, and in places the texture is clay. In the Longmont area the olive-brown tint is less pronounced than in the Fort Collins area.

In table 4 the results of mechanical analyses of samples of several layers of Weld loam, taken 5 miles north of Lafayette in sec. 10, T. 1 N., R. 69 W., show the proportion of fine sand and very fine sand to be large, whereas that of silt is comparatively small.

TABLE 4.—*Mechanical analyses of Weld loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay ¹
		Percent	Percent	Percent	Percent	Percent	Percent	Percent
491015	Surface soil, 0 to 1½ inches.....	0.2	0.8	1.6	16.3	29.0	17.5	34.6
491016	Subsurface soil, 1½ to 12 inches.....	.2	1.7	2.4	20.1	26.3	11.5	37.8
491017	Subsoil, 12 to 30 inches.....	.3	1.2	1.2	11.2	21.9	25.4	38.8
491018	Subsoil, 30 to 60 inches.....	.3	1.3	1.5	11.7	23.4	29.1	32.7

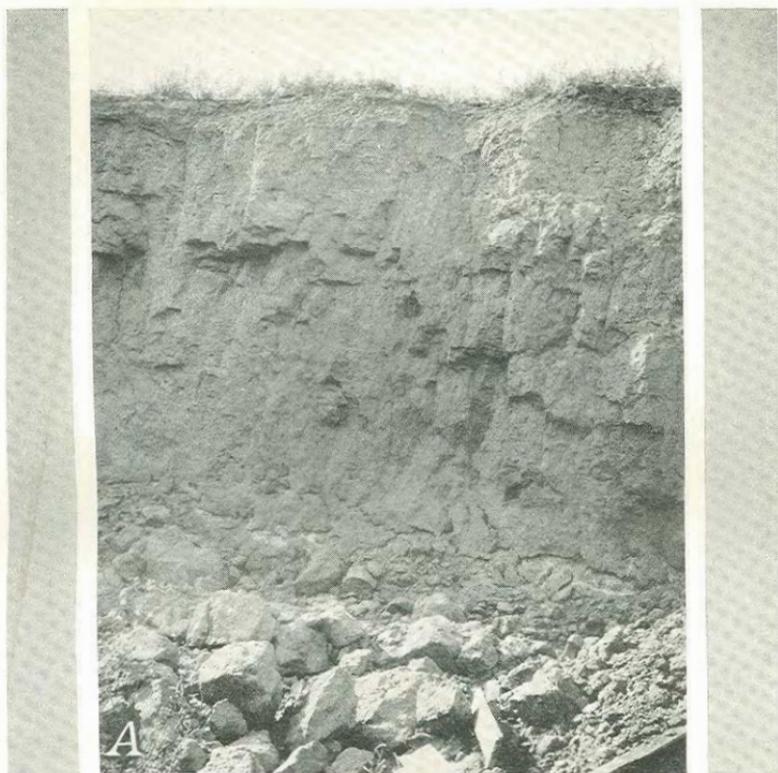
¹Under methods of mechanical analysis used at the present time, the silts and sands of some soils are broken down, giving a much higher percentage of clay than would be indicated by a field examination, on which the soil classification is largely based.

A sample of the same soil taken 3 miles east of Hudson, in sec. 8, T. 1 N., R. 64 W., shows only about one-fifth as much fine sand, four-fifths as much very fine sand, more than twice as much silt, and nearly as much clay as in the sample taken nearer the mountains, thus showing an increase in the finer material toward the plains. The results of the analyses of this sample are given in table 5.

TABLE 5.—*Mechanical analyses of Weld loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Percent	Percent	Percent	Percent	Percent	Percent	Percent
491086	Surface soil, 0 to 1 inch.....	0.2	0.7	1.6	7.8	32.2	41.1	16.4
491087	Subsurface soil, 1 to 12 inches.....	.0	.2	.8	3.1	17.7	28.3	49.8
491088	Subsoil, 12 to 30 inches.....	.1	.1	.1	1.0	15.1	48.5	35.2
491089	Subsoil, 30 to 60 inches.....	.0	.1	.1	.6	15.1	55.0	29.1

If cultivated when too wet this soil puddles easily and for this reason should be handled with care. It also responds freely to manure and to good care, and by such means it may be kept in a high state of productivity. The lower part of the surface soil is



A, Profile of wind-blown soil material (Weld), 10 feet thick in pit at old brickyards in Longmont, showing structure of deep subsoil. *B*, Profile of Weld loam, along highway east of Hudson, showing deep cracks and columnar structure of subsoil.

more reddish brown and more plastic than the surface layer. Too much of this material should not be brought to the surface at one time. The subsoil is deep and in general well drained. Where in a high state of tilth and fertility this is probably the most productive and durable soil in the Longmont area.

In a few places soft sandstone or soft sandy shale occurs at a depth of less than 5 feet. Plant roots readily penetrate this underlying material, but it seems to check underdrainage, especially where there is a heavy accumulation of lime above it. Where drainage is good, this deep subsoil material has little if any effect on the productivity of the soil, but in basinlike areas or on slopes it checks deep moisture penetration and decreases production.

Weld loam, valley phase.—Occupying the entire valley of several of the smaller streams is a soil very similar to Weld loam. The soil material seems to have been blown, and to some extent washed, from the adjacent slopes. As a whole it is slightly darker than the typical soil, the three layers are not quite so sharply developed, and in places, especially in the lower part of the subsoil, there are thin stratified layers.

Rather important areas of this soil lie along Big Dry Creek, extending into the valley of South Platte River northwest of Wattenberg, along the valley of the small stream which enters the river valley north of Traceyville, and in a number of other places.

Four miles south of Longmont southeast of Gaynor Lakes, and in a few other places, basins of this kind are not well drained, and alkali in harmful amounts has accumulated. Such seepy areas are indicated on the map by alkali symbols. In places seepy and alkali areas have been reclaimed by proper drainage. Much more work of this kind might be done with profit.

Weld fine sandy loam.—Weld fine sandy loam consists of dark-brown fine sandy loam to a depth of about 15 inches. Where cultivated too wet or packed by trampling of livestock, the material breaks up into large hard clods, but under favorable moisture conditions it crumbles and pulverizes easily.

The dark-colored surface layer is thicker and the transition between this and the lighter colored subsoil is not so sharp as in the heavier Weld soils or as in areas of this soil in the Eaton district of Weld County where it was first identified.

Below an average depth of about 15 inches is lighter brown heavy fine sandy loam or light loam with some accumulation of lime, which extends to a depth ranging from 30 to 36 inches and is underlain by light-brown light-textured fine sandy loam or loamy fine sand, free from spots of lime.

This soil approaches the very sandy soils in ease of handling and crop adaptation, but as a whole it is more productive, does not blow so badly, and does not require so much water. It is used for alfalfa, sugar beets, corn, beans, and the other main crops of the area. It is not predominant over any large area but is associated in small bodies with Weld loam on one side and with Valentine loamy fine sand on the other.

The surface soil to a depth of 15 or more inches does not effervesce with acid but has a pH value of 7 or more. The material in the subsoil effervesces freely, indicating an abundance of lime. In places

soft sandstone is reached at a depth of 5 feet or less, but crop production here differs little from that of the deeper soil areas.

Table 6 shows the results of mechanical analyses of samples of the surface soil, the subsurface soil, and the subsoil of Weld fine sandy loam.

TABLE 6.—*Mechanical analyses of Weld fine sandy loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		<i>Percent</i>						
490805	Surface soil, 0 to 1½ inches.....	0.0	0.5	0.7	29.9	33.9	17.2	17.6
490806	Subsurface soil, 1½ to 10 inches.....	.0	.2	.4	28.3	30.6	17.6	22.5
490807	Subsoil, 10 to 30 inches.....	.0	.1	.2	16.1	34.4	28.9	20.1
490808	Subsoil, 30 to 60 inches.....	.0	.1	.2	17.2	39.0	24.2	19.2

Weld fine sandy loam, valley phase.—The valley phase of Weld fine sandy loam bears the same relation to the typical fine sandy loam as the valley phase of Weld loam bears to its typical soil. It is slightly darker, is a little heavier in texture, requires the application of less water, has in places small areas in which alkali accumulates, and is, as a whole, slightly more productive than the typical soil.

Weld clay loam.—Weld clay loam has the dark-brown surface layer, the lighter brown heavier upper subsoil layer containing light-gray spots of lime accumulation, and the lower subsoil layer of slightly lighter texture characteristic of the Weld soils. In texture the surface soil material ranges from heavy clay loam to clay. Under cultivation it breaks up into large hard clods which are difficult to pulverize except when in very favorable moisture condition. When dry the subsoil cracks deeply, and when wet it is very sticky and plastic.

In the northern part of the area between Mead and Highland this soil is very heavy, has an olive-brown tint in both surface soil and subsoil, and, although apparently of wind-blown origin, has much the appearance of the soil around Terry Lake which seems to have been derived directly from weathered shale.

This soil is well developed south of Big Dry Creek and south and east of Gaynor Lakes, and is here naturally somewhat lighter in texture than the areas west of Mead, and it has also become much more friable through good farm practices and the use of large quantities of manure.

In places disintegrated sandstone or sandy shale is reached at a depth of less than 5 feet, but in such places the growth and production of crops differ little from those on the deeper soil.

There are no sharp lines of separation between Weld loam and Weld clay loam and but little difference in crop yields, but there is a rather marked difference in the ease with which the two soils may be cultivated. The pH value of the surface soil and the abundance of lime in the subsoil are about the same in both soils.

In a large area extending from Big Dry Creek to Dacono this soil is closely associated with a deeply weathered area of Terry clay loam which it here closely resembles. East and southeast of Hudson an area of very heavy soil occupies a long valleylike area, probably an old high valley of Boxelder Creek. A few small bodies, in which

the soil is not so heavy but is darker brown, occupy some small valleys east and northeast of Prospect Reservoir. These represent a valley phase of Weld clay loam, but on account of their small extent have not been separately mapped.

Fort Collins loam.—In the soils of the Fort Collins series in the Longmont area the line of demarcation between the dark-colored surface soil and the lighter colored subsoil lies at a greater depth and is not so sharp as in soils of the same series along Cache la Poudre River in Larimer County, where the series was first established.

Fort Collins loam is the most extensively developed and most important soil of the Fort Collins series in this area. It consists of brown, dark-brown, or slightly reddish brown rather light textured loam to a depth of about 10 or 12 inches. Under cultivation it forms large clods, but these, when in the proper moisture condition, pulverize easily. The subsoil is lighter brown slightly heavier material containing an abundance of small white spots of lime accumulation, especially in the upper part. Below a depth of about 30 inches the texture is lighter, and in the lower part of the subsoil, at a depth ranging from 4 to 5 feet, lime-coated gravel is present. Below this, in places, is a heavy layer of stream gravel and lime.

This soil is well developed at Burlington School, where a good exposure may be seen along the highway or at the old gravel pit 40 rods to the west. It is well developed along the valley of St. Vrain Creek, a mile south of Hygiene, at Nelson School, and around Niwot. The town of Longmont is situated largely on this soil, which is light in texture in places, especially near the edge of the terrace, where it is fine sandy loam.

This soil is used for sugar beets, alfalfa, and intensively cultivated truck and garden crops, and some small grains are grown. Yields, where the fertility of the soil has been well maintained through the use of manure and the rotation of crops, are about the same as on Weld loam, but much of the Fort Collins soil has been under cultivation longer than the Weld soil, and some has not received good care. For this reason crop yields on such areas are lower than on the corresponding Weld soil.

In the vicinity of Boulder, a valley phase of this soil is included in mapping. This soil consists of dark reddish-brown sandy loam or light loam, which has been carried down from the mountain valleys and deposited as small deltas at the upper edge of the plain and along the outer edge of Boulder Creek Valley. The greater part of this valley soil is well drained, free from alkali, and productive. Some is used for growing tree fruits, small fruits, nursery stock, and flowers, for which it seems well suited. This is owing in part to its favorable situation in areas protected from winds by the mountains, and the soil also has good air drainage.

Fort Collins clay loam.—Fort Collins clay loam is redder, heavier in texture, and more difficult to cultivate than Fort Collins loam. In a few places, as south of Terry Lake, it lacks good underdrainage and has become seepy.

Under cultivation this soil is rather hard and cloddy when dry and is sticky when wet. The percentage of silt and clay is high, but the soil can be greatly improved by the use of manure. It occupies the larger part of the low belt extending northwest from Long-

mont and, between Hygiene and Niwot, the higher part of the terraces. South of Hygiene it grades into the Larimer soils, which have a highly developed lime layer at a comparatively slight depth. As a whole, Fort Collins clay loam returns lower yields of sugar beets than Weld loam and Weld clay loam.

In table 7 are given the results of mechanical analyses of samples of the surface soil, subsurface soil, and subsoil of Fort Collins clay loam, taken one-half mile south of Terry Lake, in sec. 16, T. 3 N., R. 69 W.

TABLE 7.—Mechanical analyses of Fort Collins clay loam

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Percent	Percent	Percent	Percent	Percent	Percent	Percent
491052	Surface soil, 0 to 1 inch.....	3.2	5.5	3.3	8.6	17.0	33.1	29.2
491053	Subsurface soil, 1 to 14 inches..	3.7	3.5	2.2	5.1	12.3	31.0	42.3
491054	Subsoil, 14 to 36 inches.....	.7	1.1	.7	2.7	9.2	36.1	49.5
491055	Subsoil, 36 to 60 inches.....	4.3	3.8	2.2	5.1	10.8	28.4	45.3

Fort Collins clay.—Fort Collins clay consists of deep reddish-brown clay to a depth of about 10 inches, where it grades into slightly lighter reddish-brown clay. Below a depth ranging from 24 to 30 inches the material is lighter in texture and contains a good quality of sand and gravel. Large water-worn gravel are thickly scattered over the surface and gravel in various quantities are distributed through the surface soil and subsoil.

The largest body of this soil occupies a long, gradual slope between Lefthand Creek and Dry Creek, southwest of Niwot. Southwest of Longmont are a few small included areas of dark-brown or reddish-brown silty clay which continues to a depth of 4 feet and is underlain by slightly micaceous clay loam. In places this soil has somewhat the appearance of soils of the Larimer series.

Fort Collins clay is very heavy and refractory, difficult to cultivate, and rather low in productivity. It is used for small grain, alfalfa, and pasture.

SOILS OF THE TERRY GROUP

The Terry group includes the medium and heavier textured soils of the Terry series. In the western part of the area these soils are underlain at different depths by olive-gray or olive-brown clay shale. The heavier textured soils are very heavy and difficult to handle. They do not respond to drainage and in many places contain alkali in harmful quantities. The lighter textured and better drained soils are irrigated to some extent and are used to a greater extent without irrigation for small grains. In the south-central part of the area these soils are deeper, more highly developed, and have in the lower part of the subsoil a sandy shale in which are thin layers and lenses of very hard sandstone. Where deep the soil in this part of the area has much the appearance of soils of the Weld group. An unirrigated area of this kind east of Erie is used for small grain.

Terry clay.—The surface soil of Terry clay is dark olive-brown clay which is very stiff and plastic when wet and hard and cloddy when dry. Cultivation is difficult and good stands of crops are

difficult to obtain. The subsoil, extending from a depth of 12 inches to an average depth of about 30 inches, is slightly lighter olive-brown clay containing fragments of partly disintegrated shale. In many places this layer contains white spots of lime or gypsum and a white coating of soluble salts along the cleavage planes. The lower subsoil layer is soft clay shale, in places carrying rather large quantities of soluble salts, especially sodium sulphate, the rather predominant "white alkali" of this region.

Areas of this soil occurring on the slopes support a native vegetation, largely wheatgrass. The land under cultivation is used without irrigation for small grains and where irrigated, largely for alfalfa.

Terry clay, valley phase.—Terry clay, valley phase, represents areas of Terry clay occupying the small valleys and basinlike depressions in which the soil is darker and contains rather large quantities of alkali. In places small areas have a white surface deposit of salts. This soil supports a growth of wheatgrass and saltgrass and is used almost entirely for range land.

In the northwestern part of the area near Lykins Gulch are a few small poorly drained areas in which the surface soil consists of black shiny clay high in organic matter. Beneath this is dark-gray stiff plastic clay which rests on the soft clay shale underlying Terry clay. Efforts to drain one of these areas near the St. Vrain Creek Valley has proved entirely ineffective. On account of its heavy plastic texture and the nearly impervious character of the subsoil, attempts to reclaim such land by drainage, under present agricultural conditions, does not seem advisable.

Areas of Terry clay and its valley phase extend in a broken belt from Terry Lake southwest to the valley of Boulder Creek south of Beasley Reservoir.

Terry clay loam.—Closely associated with Terry clay in the western part of the area and covering a broad upland area extending from Erie eastward beyond St. Vrain are bodies of soils classed as Terry clay loam. This soil is lighter in texture, deeper, better drained, and as a whole more productive than Terry clay.

The surface soil consists of light-brown or slightly yellowish brown loam to a depth of 6 inches, where it grades into brown heavy clay loam continuing to a depth of about 12 inches. Below this is lighter brown clay loam. In the western part of the area the material in this layer is streaked with rust brown and, at a depth of about 30 inches, grades into soft partly disintegrated shale. In the Erie-St. Vrain section, however, the soil has developed more deeply, spots of lime accumulation occur in the lighter brown subsoil, and the parent shale material has a soil covering more than 3 feet thick. Here, in stage of development and in crop value, the soil approaches closely Weld clay loam with which it is associated.

Northwest of Union Reservoir is an area of this soil, which is deeper than the average. This has a surface soil ranging from loam to clay loam, a heavy sticky clay loam subsoil, especially in the lower lying less well drained parts, and a sandy shale lower subsoil layer which, over most of the area, has a soil covering 3 feet thick or thicker. Alkali in harmful quantities has accumulated in the less well drained areas.

Terry loam.—Terry loam has a brown or dark-brown fine sandy loam surface layer grading, below a depth of 3 or 4 inches, into light-

textured loam continuing to a depth of about 10 inches. Below this is lighter brown or olive-brown loam containing some light-colored spots of lime accumulation in the lower part. At an average depth between 24 and 30 inches the subsoil is underlain by yellowish-brown soft fine-grained sandstone, the parent material, which varies considerably, including layers of massive sandstone and beds of thin clay shale. In many places the sandstone beds contain thin layers of dark reddish-brown iron sandstone and nodular masses of the same material which break down very slowly, and fragments of it on the surface and around ant hills may be used in identifying the Terry soils in the Erie-St. Vrain section.

On the south slope of Gunbarrel Hill a body of this soil has been eroded until the underlying massive sandstone has been uncovered in places. Along the east side of Gunbarrel Hill the soil occupies the steeper slope but merges into Weld loam toward the east, where the surface is more nearly level and conditions are more favorable for deep weathering.

Terry loam, deep phase.—South of Mead is a small area of Terry loam having a deeper surface soil and subsoil. This is indicated on the soil map as Terry loam, deep phase. Alkali has accumulated to considerable extent. The land is of low agricultural value, and little of it is used for cultivated crops.

SOILS OF THE GILCREST GROUP

Soils of the third, or Gilcrest, group are distinctly different from those of the first two groups.

Extending entirely across the area along South Platte River, principally along its east side, is a nearly level bench, or terrace, approximately a mile wide, lying at an elevation ranging from 15 to more than 20 feet above the level of the river channel. Small parts of a similar terrace extend along the west side of the valley, and lower terraces are along the south side of St. Vrain Creek near its junction with South Platte River. Here the surface soil is brown, dark brown, or slightly reddish brown, and it contains an abundance of small sharp stream gravel and coarse sand on the surface and throughout the surface soil and subsoil. The upper subsoil layer is lighter in color and heavier in texture, but the lower subsoil layer, ranging in depth from 12 inches to 3 feet below the surface, is composed of small sharp granitic gravel and sand with practically no binding material. These soils belong to the Gilcrest series. They are used to considerable extent for general farm crops and for truck crops. Until recently they have also been used rather extensively, especially north of Platteville, for early potatoes.

Included in this group are soils of the Nunn series, which are darker and have a deeper and heavier subsoil than the soils of the Gilcrest series and the Greeley soils. The Greeley soils are sandy, of more recent formation, and the second layer is not so strongly developed as in the Gilcrest soils.

An estimate of the percentage of the combined area of the soils of this group devoted to the different crops grown is as follows:¹⁵

¹⁵ Estimate by T. G. Stewart, extension agronomist, State Agricultural College of Colorado.

Sugar beets, 25; small grain, 30; alfalfa, 15; corn, 12; dry beans, 4; cabbage, 4; cucumbers for pickles, 3; potatoes, 2; and truck crops, including green beans, lima beans, pumpkins, onions, horse-radish, and lettuce, 5 percent.

The acreage and yields of crops grown on soils of this group, principally on Gilcrest gravelly sandy loam, in 1930, by the Fort Lupton Canning Co. of Fort Lupton¹⁶ is as follows: String beans on 290 acres produced an average yield of 3 tons an acre, tomatoes on 140 acres produced an average yield of 11 or 12 tons, peas on 300 acres produced an average yield of 1½ tons, cabbage on 300 acres produced an average yield of 15 tons, and cucumbers for pickles were grown on 70 acres, but data on the yields of cucumbers are not available.

The acreage and yields of crops grown on these soils at Fort Lupton and at Platteville in 1930 by the Kuner-Empson Canning Co., of Fort Lupton,¹⁷ are as follows: At Fort Lupton, peas on 176 acres, with an average yield of 1,984 pounds of shelled peas an acre; string beans on 212 acres, with an average yield of 4.3 tons; tomatoes on 235 acres, with an average yield of 10.8 tons; pumpkins on 146 acres, with an average yield of 9 tons, and cucumbers for pickles on 100 acres, with an average yield of 135 bushels. At Platteville, peas on 310 acres, with an average yield of 1,696 pounds of shelled peas an acre; string beans on 22 acres, with an average yield of 3½ tons; and tomatoes on 78 acres, with an average yield of 7.8 tons. Differences in yields at Fort Lupton and at Platteville are believed to be due to differences in preparation and cultivation of the soil rather than in the soil itself.

Gilcrest gravelly sandy loam.—Gilcrest gravelly sandy loam has a brown gravelly sandy loam surface soil containing some coarse sharp sand. Where exposed, the soil material is strongly crushed at the surface. The upper subsoil layer is slightly heavier than the surface soil, and the gravelly lower subsoil layer is reached at a depth of about 30 inches. This consists of coarse sharp sand and small sharp quartz and granitic gravel, with very little finer material. The gravel from this deep subsoil is used in many places for building purposes. In places small patches of gravel have no soil covering.

This soil is used in the production of sugar beets, early potatoes, small grains, beans, and a number of other crops. Its water requirement is high, and as a whole the soil is less productive than soils having heavier subsoils.

Gilcrest sandy loam.—The surface soil of Gilcrest sandy loam is brown or grayish-brown sandy loam to a depth of 6 or 8 inches. The upper soil layer is slightly heavier than the surface soil and in places has a distinctly columnar structure. Areas of this soil differ considerably in thickness of soil material. Along United States Highway No. 85, 2 miles north of Fort Lupton a clean gravel lower subsoil layer is reached at a depth of 20 inches, 2½ miles south of Platteville at a depth of 36 inches, at a road intersection south of Independence School at a depth of 20 inches, and on the north side of Platteville at a depth of 24 inches. This gravelly ma-

¹⁶ Data supplied by O. A. Carlson, superintendent.

¹⁷ Data supplied by C. P. Howe, superintendent.

terial is similar in composition to that of the Gilcrest gravelly sandy loam subsoil, and the water requirements under irrigation are not very different. The crops grown are those suited to lighter textured soils—sugar beets, early potatoes, beans, and other truck crops. Yields are very slightly higher than on Gilcrest gravelly sandy loam but lower than on the heavier textured soils.

Nunn gravelly sandy loam.—Nunn gravelly sandy loam differs from the Gilcrest soils in that it is darker, slightly thicker, a little heavier in texture, and has, in most places, at a depth between 20 and 30 inches, a layer of distinctly heavier soil—loam or clay loam. In some places in the subsoil are layers in which there has been a heavy accumulation of lime or of limy material.

This soil and Gilcrest sandy loam extend as an almost continuous belt along the east side of South Platte River, from Platteville southward across the area, and smaller bodies are on the west side. A large part of the early garden and truck crops grown in the South Platte Valley is on soils of this kind.

Nunn clay loam.—The surface soil of Nunn clay loam is dark-brown heavy clay loam, the topmost 4 or 5 inches in cultivated fields being fairly friable. Below this the material is stiff and plastic when wet, and when dry it breaks into large hard clods that can be pulverized only when in proper moisture condition. At a depth of about 12 inches it is underlain by lighter brown clay loam which is lighter in texture and grades, at a depth of about 24 inches, into thin layers of sand, gravel, and heavier material and, below a depth ranging from 30 to 36 inches, into clean sand and sharp fine gravel.

Along the outer side of the valley at Platteville and south of Ione the soil material is thicker than typical and has been modified by clay washed from the slopes above the terrace floor to the east. In places the gravel layer in the lower part of the subsoil is very thin or may be entirely lacking, the subsoil here consisting of shale or sandstone. In the valley of St. Vrain Creek a rather large body, extending from north of Gowanda to near the mouth of Idaho Creek, is included with this soil in mapping. This area is low lying, dark brown, and heavy textured, and parts of it are poorly drained. The soil here is intermediate between the Nunn and Cass soils.

Greeley fine sandy loam.—Included with the soils of this group are areas of sandy soil which occupy low terraces and outwash fans, principally along the south side of Boulder Creek. These differ from the Gilcrest soils in that they have little coarse sand in the surface soil and have a fine sandy lower subsoil layer instead of one composed of coarse sand and clean gravel. They have, however, much the same crop adaptation as the Gilcrest soils. This soil is Greeley fine sandy loam. It corresponds rather closely to the low-lying phase of Greeley fine sandy loam mapped in the Greeley area.

To a depth of about 15 inches the soil consists of brown or light-brown fine sandy loam containing some stream gravel but less than in the Greeley area, where the Greeley series was first established. Below this is slightly heavier brown fine sandy loam extending to a depth of about 30 inches and underlain by light-brown fine sand. In places the lower subsoil layer is more or less stratified and is underlain by stream gravel.

This soil is used for sugar beets, alfalfa, small grains, and to a considerable extent for truck crops.

SOILS OF THE LARIMER GROUP

The fourth group of soils includes soils belonging to the Larimer series. They are brown or reddish brown and have a shallow gravelly subsoil. In the upper part of the subsoil is a heavy accumulation of white material, much of which is carbonate of lime. This material, in places, is cemented into a hardpan. Small areas of these soils are under cultivation, but production is low. The greater part of the land is used as range land.

These soils occupy parts of the high mesas in the western part of the area, and isolated small hills and ridges in other parts.

Larimer gravelly loam.—The surface soil of Larimer gravelly loam is brown, dark-brown, or slightly reddish brown fine sandy loam or light loam, having sharp quartz, granitic, and water-worn gravel over the surface and through the soil. At a depth of 8 or 10 inches it is underlain by gray, pinkish-gray, or reddish brown slightly heavier gravelly loam, the gravel ranging widely in kind, size, and amount, much of it being heavily coated with lime. Below an average depth of about 30 inches are beds of very gravelly material consisting largely of water-worn gravel which are less heavily coated with lime. As shown in roadside cuts this gravelly material overlies beds of shale, a white deposit of lime marking the line of contact.

This soil occurs in small areas capping isolated hills and ridges, and along the edge of the uplands bordering the larger valleys. A few bodies are in all parts of the area, but they are most numerous adjacent to the valleys. The land furnishes some forage but otherwise is of little agricultural value.

Larimer clay loam.—Larimer clay loam consists of dark reddish-brown heavy clay loam to a depth of about 10 inches. The material is heavy and refractory under cultivation. Below this is much lighter brown friable loam extending to a depth of 30 inches and containing spots of lime and water-worn gravel in the lower part. Below this is a heavy layer, rather strongly cemented in the upper part, of water-worn gravel embedded in lime. Areas of this kind lie to the northeast and south of Table Mesa but at much lower elevations. They grade into, and are not markedly different from, the heavy soils of the Weld group immediately east of them. This soil is also developed on a small high mesa northwest of Table Mountain, where it is dry-farmed to small grain.

Larimer clay loam, stony phase.—The 10-inch surface soil of Larimer clay loam, stony phase, is dark reddish-brown clay loam. It is underlain by lighter reddish brown very gravelly loam which, in turn, is underlain at a depth of about 18 inches by stream gravel embedded in lime. The surface is covered with water-worn gravel and boulders, rendering the land almost nonagricultural.

In small areas, most of them occupying slight depressions, the soil is deeper, lighter in texture, and contains less gravel. Some of these included areas are under cultivation. Near the base of the foothills, where small streams flow out on the plain, the gravel and boulder deposit is deep, and the lime layer is not so well developed.

SOILS OF THE VALENTINE GROUP

The soils of the Valentine group are characterized by their light sandy texture, loose open structure, and slight subsoil development.

They are brown or slightly reddish brown at the surface and lighter brown in the lower part of the subsoil. The surface soil does not effervesce on application of hydrochloric acid, but the subsoil effervesces from slightly to freely.

Soils of the Valentine series have a deep subsoil of loamy sand or sand, but those of the Terry series included in this group are underlain by soft sandstone or sandy shale.

Under irrigation these soils are productive. Where dry farmed they produce well when there is sufficient moisture, but they tend to blow and drift badly.

In the section immediately west of Beebe Draw, a rather large proportion of this soil is under cultivation, much of it is irrigated, and, where the water supply is sufficient, it is productive. The most serious difficulty is that after the land has once been cultivated it is likely to blow badly.

Estimates of the percentages of the irrigated area occupied by these soils and of average yields of crops grown near Hudson are as follows:¹⁸ Corn on 40 percent of the irrigated land produced an average yield of 25 bushels an acre, alfalfa on 40 or 45 percent produced an average yield of 2½ or 3 tons, and dry beans on 15 or 20 percent produced yields ranging from 600 to 1,000 pounds.

In many places the irrigated soils of this group are used for sugar beets, alfalfa, and other crops, and good yields are obtained. South and east of Fort Lupton large areas are used in the production of truck crops, such as tomatoes, peas, pumpkins, beans, and melons. A part of the acreage and yields reported by the canning companies of Fort Lupton are for crops grown on such soils as these.

A rather large area of the unirrigated land is dry farmed, the principal crops being corn and dry beans, with a small acreage in sorghum, millet, and Sudan grass. The average yields are not high, but under favorable moisture conditions good yields are sometimes obtained. Yields of corn under favorable conditions of late summer rain, such as that of 1930, ranged from 25 to 50 bushels an acre (pl. 2, A).

Much of this land is used as range land, and, although the acreage necessary to maintain each animal is larger than on the "hard lands", the sandy land furnishes considerable forage, and the grass can be pastured earlier in the spring than on the heavier soils.

Valentine loamy fine sand.—Valentine loamy fine sand consists of brown loose incoherent fine sand varying but little in color or texture to a depth ranging from 30 to 36 inches. Below this depth the material is lighter in color but has the same texture and loose consistence. This soil covers extensive undulating and slightly hilly upland areas and in places has been blown into dunes by comparatively recent wind action. Except in a few places where wind erosion has been very recent, the soil is stable and is covered with a growth of grass and sand sage. It is used as range land.

Valentine loamy fine sand, heavy-subsoil phase.—Over much of the area covered by Valentine loamy fine sand, a heavy layer has developed in the subsoil. This for the most part occurs in nearly level and valleylike areas, but it is also present in the hilly and higher lying areas. This layer, in much of the soil, is reached at a depth

¹⁸ Estimates made by R. P. Culverwell, Hudson, Colo.

ranging from 24 to 36 inches below the surface. In places it ranges in thickness from only 6 to 10 inches and consists of rather sticky sandy loam or loam. Whether this layer has developed through the gradual carrying downward of finer soil material and the more soluble minerals by percolating soil moisture, or is an old surface soil which has been covered, is not definitely known.

Terry fine sandy loam.—Terry fine sandy loam consists of brown or dark, slightly reddish, brown light fine sandy loam or loamy fine sand, extending to a depth of about 10 inches. Below this is lighter brown fine sandy loam of slightly heavier texture. In places, especially on nearly level areas, are light-gray spots of lime accumulation like those in the Weld soils. At widely different depths soft, partly disintegrated, sandstone is reached, and on steep slopes the sandstone has but a shallow soil covering.

The most extensive area covered by Terry fine sandy loam extends as a nearly continuous belt along the slope bordering the valley of South Platte River on the east. Smaller bodies border the drainage-ways east of Mead and the north slope of the St. Vrain Valley. Small areas are associated with the sandy soils northwest and northeast of Firestone.

Terry fine sandy loam, deep phase.—In much of the area occupied by Terry fine sandy loam, soft sandstone is reached at a depth ranging from 3 to more than 5 feet. In many places the sandstone has a deep covering of wind-blown sand and differs little from the heavy-subsoil phase of Valentine loamy fine sand. Such areas are mapped as Terry fine sandy loam, deep phase.

A rather large body of this deep soil extends north and west from Davis. The crops grown and yields obtained are similar to those on the heavy-subsoil phase of Valentine loamy fine sand.

SOILS OF THE BERTHOUD GROUP

Soils of the Berthoud group are in general gravelly and more or less stony, are shallow, being underlain at widely different depths by rock beds, and they include areas in which the soils are highly productive. Included with this group are soils of the Berthoud series, which have developed from colluvial and outwash material from widely different sources; soils of the Laporte series, developed from shaly limestone; soils of the Neville series, developed from red sandstones and shale; and rough mountainous land.

Berthoud clay loam.—The surface soil of Berthoud clay loam is dark slightly reddish brown material containing considerable water-worn gravel and some sharp gravel on the surface and throughout the soil. When dry this material breaks into large clods which, on account of the sand and gravel contained, pulverize easily, especially if in good moisture condition. The subsoil is slightly lighter reddish brown heavy clay loam which is underlain at various depths by rock material. Under much of the soil, the rock material is shale, and in places there is an accumulation of lime over the shale.

Near the lower edge of areas of Berthoud clay loam, the soil has developed much like Fort Collins clay loam, with white spots of lime in the upper part of the subsoil. The surface soil effervesces freely with acid, whereas that of the Weld and Fort Collins soils does not. The pH value of samples tested is about 7.7.

The land is used largely for small grains, alfalfa, and some other crops.

Berthoud loam.—Berthoud loam consists of dark reddish-brown light-textured loam to a depth of about 15 inches, below which is slightly lighter reddish brown loam, somewhat heavier in texture, containing a few spots of lime accumulation, especially along the lower slopes where the soil has weathered most completely. A large quantity of gravel fragments occurs on the surface and in the surface soil and subsoil.

In the lower part of the subsoil, rock material is reached, the character of this differing widely in different places. In places it is shale, in other places it is thin-bedded limestone, and in others, particularly in the vicinity of Boulder, granite or other metamorphic rocks are abundant.

Berthoud loam, as mapped in the Longmont area, differs from that lying west of Berthoud in the Fort Collins area, in that it contains more gravel, stones, and boulders in both surface soil and subsoil and less of the white and pink limy material in the lower part of the subsoil.

In the northwestern part of the area are bodies occupying steep slopes. Here the soil material is rather shallow and very gravelly. It is used principally as dry-farming land for small grain.

In places, areas of Berthoud loam occur in which the soil material is slightly lighter in color than typical. It is not so deep and in many places contains more gravel and rock material. A rather large area of this included soil occupies the lower more gradual slopes of Rabbit Mountain, and a larger body lies east of the highway between Boulder and Lyons, north of Table Mesa. Part of the land is dry-farmed and part is used for pasture land.

Neville fine sandy loam.—Neville fine sandy loam consists of reddish-brown, dull-red, or red fine sandy loam underlain at a depth of about 15 inches by lighter red soil of heavier texture, which at widely different depths grades into partly disintegrated red sandstone or red sandstone and shale. The upper dark layer has a thin mulch at the surface and below this breaks into clods with somewhat regular faces. Where deep, the second layer in places contains well-defined white spots of lime. Sharp sand and small gravel in varying quantities occur on the surface and scattered through the surface soil and subsoil.

This soil shows rather wide variations. The parent material from which it developed includes a wide range of sandstones and shales, which in places have been modified by material from limestone, granite, quartz, and rhyolite. The soil ranges from very shallow and stony on the upper parts of the slopes and around included stony areas and rock outcrops to deep, and in many places heavier, soil in the lower parts of the glades and valleys. It has been modified by colluvial material moved down the slopes, by material washed into the lower parts, and in places by an accumulation of wind-blown material.

A small area in the vicinity of Lyons includes soils on the lower slopes and in the valley of St. Vrain Creek, which are darker and deeper than those of the upper slopes, being partly alluvial. These soils are well suited for the growing of small fruits.

Laporte gravelly loam.—Areas of Laporte gravelly loam occur near the northwestern corner of the area in a small high valley, in which the soils are largely the product of weathering of light-gray thin-bedded limestone much like that extending northward from Laporte in Larimer County and like that at Penrose in the section west of Pueblo. A few small areas lie near the foothills in the Longmont area.

This soil is light-gray loam well filled with small irregular fragments of shaly limestone and underlain at a depth ranging from only a few inches to 3 feet by the unweathered parent material. In this area the land is used entirely for dry farming to small grains or as range land.

Rough mountainous land.—The Longmont area includes strips of mountain slopes on its borders and a number of hills and ridges within the main body of smoother land. The term "rough mountainous land" is applied to these areas of rough land, where the soil is not tillable, either on account of the steepness of the slopes or because of the large quantity of rock strewn over the surface or embedded in the soil. The slopes in many places rise abruptly from the smooth flat areas to mountainous peaks and ridges having a gradient of 1,000 or more feet to the mile. Bare rocky slopes and rock ledges and cliffs are common. In all the rough mountainous land areas the soil covering, if any has formed, is very shallow, and the land supports only a scant growth of grass and in places small hardy shrubs, which provide some pasture for livestock, but aside from this the land has no agricultural value.

SOILS OF THE CASS GROUP

Soils of the Cass group are characterized by their gray, dark-gray, or dark-brown surface soil, by a heavier subsoil, the lower part of which is mottled with light gray and rust brown, and by a poorly drained lower subsoil layer. This group includes soils of the Cass and Kuner series, in addition to river wash. The Cass soils have deep subsoils of stream gravel, and the Kuner soils have deep subsoils of soft sandy shale.

Soils of the Cass series differ greatly. In the valley of St. Vrain Creek much of the soil is dark brown, reddish brown, or nearly black and contains a high percentage of fine highly micaceous sand. In the valleys of Boulder Creek and Lefthand Creek the soils contain a larger percentage of brown medium and coarse sand, and in the lower part of Boulder Creek much gray clay. Soils in the valley of the South Platte are characterized by their dark-brown, nearly black, color, by the presence of much coarse sharp sand and fine granitic gravel in the surface soil, and by a deep subsoil of similar gravel.

Near the mountains some of the soils of this group give a slightly acid reaction, the pH value ranging as low as 6. Most of them, however, especially where they have received some wash from the slopes, are basic, the pH values being as high as 7.8.

Cass fine sandy loam.—The surface soil of Cass fine sandy loam where typically developed consists of grayish-brown, dark-brown, or nearly black, highly micaceous fine sandy loam, becoming heavier with increasing depth. Below a depth of about 15 inches, this mate-

rial grades into loam which, at widely different depths, becomes mottled with rust brown, contains sand and water-worn gravel, and is underlain by stream gravel at a depth ranging from 18 to 30 inches. This soil is not only variable in depth but also in texture, and it includes many areas of sandy loam and, in the Platte Valley, of coarse sandy loam and gravelly loam. In the lower part of the city of Boulder and in Boulder Creek Valley as far east as Valmont, soil of this kind is rather shallow and gravelly, and large areas are poorly drained. These are used principally as pasture lands.

Cass fine sandy loam, deep phase.—A deep phase of Cass fine sandy loam, in which the soil extends to a depth of 30 or more inches, has been outlined, the largest continuous area being in the valley of Lefthand Creek. Areas of this deep soil, where well drained, are suited to the production of sugar beets, alfalfa, corn, truck crops, and, to some extent, small grains, especially oats. Much of this soil, on account of poor drainage, is used as pasture land, and some is used as native-hay land. Many areas of this kind, which have not been shown on the soil map, occur in all the stream valleys.

Cass fine sandy loam, shallow phase.—A shallow phase of Cass fine sandy loam is mapped in a few small areas, in which the surface soil is sandy and gravelly, with stream gravel occurring at a depth of less than 12 inches. Many areas of this kind are included with the typical soil. Such areas furnish considerable grass for pasturage but are of but little use for cultivated crops.

Cass clay loam.—The surface soil of Cass clay loam consists of dark grayish-brown or nearly black clay loam grading at a depth of a few inches into heavy clay loam or clay. If cultivated when wet the soil shows a sticky shiny surface, and when dry it breaks up into large hard clods which, on weathering, crumble into small hard sharp clods. The subsoil is nearly black clay loam or clay, which becomes slightly lighter in color with depth. White specks and small spots of alkali are common in the less well-drained areas. At a depth ranging from 3 to 5 feet, the subsoil becomes lighter in texture, shows mottling of rust brown, and is underlain by stream gravel. This soil as a whole is deeper and more uniform than is the typical fine sandy loam. Much of the land is in need of drainage, and in places alkali has accumulated in harmful quantities.

Cass clay loam, deep phase.—In the deep phase of Cass clay loam the stream gravel of the deep subsoil lies at a depth of more than 3 feet. Much of the soil is very heavy in texture, ranging from heavy clay loam to clay, and a large proportion of it lies high enough to be fairly well drained. The most extensive areas of this kind are on the west side of South Platte Valley between Wattenberg and Vollmar. This soil is used for alfalfa, sugar beets, corn, and small grains. Much of the land, on account of poor drainage, is used only as pasture land.

Cass clay.—The surface soil of Cass clay is brown, yellowish-brown, or grayish-brown heavy silty clay loam or clay, which when wet is extremely slick and plastic. When dry it breaks up into large hard clods which on weathering crumble into smaller hard angular clods. The subsoil is slightly lighter brown or grayish-brown tenacious clay containing numerous white specks and larger spots of alkali accumulation. In the lower part of this layer the

clay grades into fine micaceous sandy loam which is underlain at an average depth of about 36 inches by stream gravel.

The larger part of this soil carries alkali in sufficient quantities to render the growing of crops difficult or impossible. Much of the land supports a dense growth of saltgrass and has an accumulation of alkali on the surface. In some parts, where the soil has been modified by surface deposits of lighter soil or has better drainage, the land is used for alfalfa and seems to produce well. Attempts at drainage have been made but have been only partly successful, probably owing to the heavy plastic character of the soil and possibly to impervious clay deposits within the underlying gravel, thus interfering with free underground movement of water.

Kuner fine sandy loam.—Extending across the eastern part of the area are two low belts of Kuner soils, one occupying the lower part of Beebe Draw and the other the valley of Boxelder Creek. These soils are partly alluvial, having been carried into the lower areas and deposited by water, principally during periods of heavy rainfall. They rest on beds of soft sandstone or sandy shale, this material in many places being within 5 feet of the surface. They have also been modified by wind-blown fine sand.

Kuner fine sandy loam is much more extensive than Kuner clay loam. Along the west side of Beebe Draw it consists of light-brown or grayish-brown light fine sandy loam or fine sand, grading below a depth of 15 inches into rather sticky light-brown fine sandy loam. The soil material gradually becomes heavier with depth and, at a depth ranging from 3 to 5 feet, is underlain by light-brown or grayish-brown soft micaceous sandstone which differs but little in appearance from the subsoil above it, rust-brown spots being one of the principal means of identification of the shaly sandstone. The sandstone, however, restricts underdrainage.

Much of this soil, which for a short time was very productive, within a few years after it was first irrigated became seepy, excessive quantities of alkali accumulated at the surface, and the land was abandoned for cultivated crops. It quickly grew up to saltgrass and is now used for pasture land only.

The bodies in the valley of Boxelder Creek have better drainage. There has been less surface accumulation of alkali, and some crops, principally corn and dry beans, are grown.

Kuner clay loam.—The surface soil of Kuner clay loam is dark-brown heavy clay loam, the upper 6 inches of which are fairly friable. This layer contains considerable sand and under favorable moisture conditions pulverizes readily. The subsoil is heavier and, at a depth ranging from 30 inches to 5 feet, is underlain by shaly sandstone. The heavy texture and dark color in places may be due to the weathering of heavy shale like that of the heavy substratum. Only a few small bodies of this soil occur. Most of them carry alkali in rather large quantities. A small body, 2 miles west of Roy, however, is practically free from alkali and is fairly productive.

In the lower valley of Boxelder Creek in the Greeley area, much drainage of the Kuner soils has been done, and soil and alkali conditions are greatly improved.

River wash.—Scattered areas of river wash lie near the channel of South Platte River. These consist of fine sharp granitic gravel, to-

gether with some rounded water-worn gravel. They occupy low-lying uneven ridges. Many are too small to be outlined on the soil map and have been included with adjacent Cass soils. Some extend as long strips near the outer edge of the valley, marking old overflow channels.

River wash supports a forest growth, principally of cottonwoods, and a small quantity of grass which is used for pasturage.

In the valley of St. Vrain Creek, below the mouth of Idaho Creek, considerable areas of river wash have nearly level surface relief and a sandy and gravelly soil covering from 2 to 6 inches thick. Such bodies support a grass growth, principally saltgrass.

SOILS AND THEIR INTERPRETATION

The Longmont area lies in the region of brown soils. Where dry in cultivated fields or at bare roadsides the soils have a gray or light-brown appearance, but where moist or in recently made cuts the virgin soil is distinctly brown or slightly reddish brown. The soils have developed under a short-grass vegetation and a normal annual rainfall of about 15 inches, at an altitude of 5,000 feet. The normal frost-free season extends over a period of 146 days, and the mean annual temperature is 47.8° F.

These agencies have resulted in mature soils having three clearly defined layers, as follows:

- A. A dark-brown surface soil, extending to an average depth of 12 inches, which is composed of three layers: A_0 , a fine-granular mulch 1 inch or less thick, which is somewhat crusted in the lighter soils and strongly crusted in the heavier soils; A_1 , a brown somewhat loamy layer, extending to a depth of about 6 inches, completely filled with grass roots and showing a slight tendency to regular fracture and columnar structure; and A_2 , a deep-brown or slightly reddish brown layer which has a well-defined prismatic breakage into rather regular hard clods from one-half to 1 inch in diameter, this structure being most pronounced in the heavier soils.
- B. A second main layer, or upper subsoil layer, is lighter brown, slightly heavier, has a tendency to break into smaller rather irregular clods from one-fourth to one-half inch in diameter, and in the upper part contains small light-gray spots of lime accumulation.
- C. A third layer of the same color as the second, but in which the vertical cleavage is less pronounced and the spots of lime accumulation are lacking, this deep subsoil normally extending to a depth of about 5 feet and in many places to a greater depth.

Soils of two series in the Longmont area belong to this group of completely developed soils. They are the Weld soils, developed largely from wind-blown material of local origin and from deeply weathered soft sandstone, and the Fort Collins soils, developed on old stream terraces, largely from alluvial material.

The soils of the Fort Collins series have developed on old higher terraces of streams smaller than Cache la Poudre River, on the terraces of which soils of this series were first established. As a whole the horizons are not so sharply marked, and the lower subsoil layer is not so thick or so well drained as on the Cache la Poudre River terraces.

Fort Collins loam is well developed in sec. 1, T. 2 N., R. 70 W., 1 mile south of Hygiene, where in a roadside cut the following profile is exposed:

- 0 to 1 inch, brown slightly crusted fine sandy loam.
- 1 to 12 inches, dark slightly reddish brown loam which, in the lower part, breaks into hard, somewhat regular clods from one-fourth to one-half inch in diameter and has small lime-coated gravel on the surface and through the soil, also contains abundant plant roots, many of which follow cleavage planes.
- 12 to 30 inches, light-brown, fine-textured loam containing a few well-defined light-colored spots of lime accumulation and some lime-coated gravel.
- 30 to 52 inches, light-brown light loam without lime spots, underlain below a depth of 52 inches by reddish-brown loam grading into a very limy and gravelly lower subsoil layer. Toward the west, the Fort Collins soils lie at higher elevations, are older, and grade into soils of the Larimer series which have a subsoil very high in lime.

The second group of soils includes those which have developed directly from underlying shale and sandstone. Weathering, however, has not been deep, and the parent material is the dominant factor. The loam, clay loam, and clay types of the Terry soils are very closely related to the kind of material from which they have developed. In general, a mixture of sandstone and shale has produced loams and clay loams. Where the underlying rock has been heavy clay shale, weathering has resulted in the formation of a parent material of clay. Terry fine sandy loam, in which soil formation has reached a more advanced stage than in any soil in this group, is included with the group of sandy soils.

There is also a direct relation between the depth of the soil and surface relief, the more shallow and younger soils occurring on the steeper slopes. The deeper soils and those in a more advanced stage of development occupy the valleys and more gradual slopes. On nearly level areas, such as that south of Dacono, the clay loam of the Terry series differs very little from Weld clay loam.

In a deep roadside cut 2 miles southeast of Dacono, Terry clay loam is typically developed, and the following layers are exposed:

- 0 to 2 inches, a dark-brown finely granular mulch, well crusted, on the surface of which is an abundance of small fragments of reddish-brown ferruginous sandstone.
- 2 to 10 inches, darker, slightly yellowish, brown heavy clay loam or clay, having a slight tendency to show a prismatic structure and breaking into hard, somewhat regular clods from 1 to 2½ inches in diameter.
- 10 to 30 inches, lighter brown heavy clay loam containing no lime spots, which breaks into sharp, angular clods.
- 30 to 48 inches, yellowish-brown heavy clay.
- Below a depth of 48 inches, soft partly disintegrated shale mottled light brown and rust brown.

The surface soil does not effervesce with acid, but below a depth of 40 inches the soil effervesces freely.

Soils of the third main group, the Gilcrest group, also have three rather well developed layers. These soils are developed from somewhat different material from that giving rise to the Fort Collins soils, and the stage of development is less advanced. The Gilcrest soils have developed from weathered water-laid sharp granitic material and are underlain at comparatively slight depths by nearly clean sharp granitic gravel. They have developed principally on a broad nearly smooth terrace of South Platte River. Excellent exposures of the soils of this group, principally the sandy loam member, may be seen in many places along United States Highway No. 85 between Platteville and the southern boundary of the area.

In the northwest corner of sec. 29, T. 2 N., R. 66 W., 2 miles north of Fort Lupton, a profile of the virgin soil of Gilcrest sandy loam, as exposed in a recently made roadside cut shows the following layers:

- 0 to 1½ inches, a dark grayish-brown moderately crusted sandy loam mulch.
- 1½ to 10 inches, dark-brown or slightly reddish dark-brown sandy loam which becomes heavier and slightly redder with depth. This material shows slight vertical cleavage and breaks into large clods from 1 to 3 inches in diameter, which can be crumbled in the hands. It contains much fine sand but enough coarse sand and small sharp gravel to give it a distinctly coarse or rough feel. The gravel are largely granitic and from one-eighth to one-fourth inch in diameter, but mixed with the material are some larger water-worn gravel.
- 10 to 20 inches, lighter reddish-brown sandy loam containing more sand and gravel than the layer above, the quantity of sand and gravel increasing with depth.
- 20 to 30 inches, thinly stratified layers of coarse sand and fine gravel.
- Below a depth of 30 inches and extending to a depth ranging from 8 to 10 feet, clean sharp fine granitic gravel.

This soil to a depth of 10 or 12 inches in most places does not effervesce with acid.

The fourth group includes soils that have a heavy accumulation of lime at a slight depth. This condition is owing largely to the location of the soils near the edge of old high mesas, on isolated hills, and at the top of steep slopes bordering the larger valleys. In such places the ground water is brought to or near the surface, on reaching the heavy layers underneath at a slight depth. Evaporation is rapid, and lime accumulations are formed in large quantities.

These soils, which belong to the Larimer series, are characterized by dark-brown or dark reddish-brown surface soils and a comparatively thin subsoil with a high accumulation of lime. This layer is light-gray or nearly white material which extends to a depth ranging from 1 to 3 feet and contains much water-worn gravel. Below the heavy gravelly lime layer is stream gravel resting on shale or sandstone.

A small area of Larimer gravelly loam occurs along United States Highway No. 285, 2 miles north of Longmont, where it is well exposed in a gravel pit and shows the following profile:

- 0 to 1 inch, dark, slightly reddish brown finely granular slightly crusted fine sandy loam.
- 1 to 10 inches, dark, slightly reddish brown gravelly sandy loam which breaks into irregular clods which are easily crumbled.
- 10 to 20 inches, lighter brown loam containing streaks and abundant white spots of lime accumulation.
- 20 to 60 inches, nearly white lime and water-worn gravel, the gravel heavily coated with lime, especially on the lower side, and in the upper part cemented with a lime hardpan or caliche. The quantity of lime decreases downward, and below 60 inches the gravel and sand are not cemented.

SUMMARY

The Longmont area covers an important agricultural section in north-central Colorado, a short distance north of Denver.

About three-fourths of the area is under irrigation and is used in the production of sugar beets, alfalfa, small grains, corn, beans, truck, and other crops. Much of the unirrigated land is also farmed, the principal crops on such land being wheat, dry beans, and corn.

A large acreage of truck and garden crops are grown for the Denver markets and to supply local canneries. The more important of these are peas, green beans, tomatoes, pumpkins, and cabbage.

The feeding of sheep and cattle is carried on extensively, and dairying is one of the important industries.

The general tendency in farming seems to be toward upbuilding of the soil through the conservation and careful use of manure; the following of a systematic rotation; diversification of crops; and the production of good yields rather than the farming of a large acreage. The use of commercial fertilizers, high in phosphates, on sugar beets and to less extent on alfalfa, seems to be coming into general use.

The most productive soils for sugar beets, alfalfa, and small grains have developed largely from wind-blown material of local origin and belong to the Weld series. These soils are extensively developed in a broad belt extending across the central part of the area, and they also cover a considerable section in the southeastern part. In the section between Longmont and Niwot are soils much like those of the Weld series but developed partly from old alluvial material on high, poorly defined stream terraces—the Fort Collins soils.

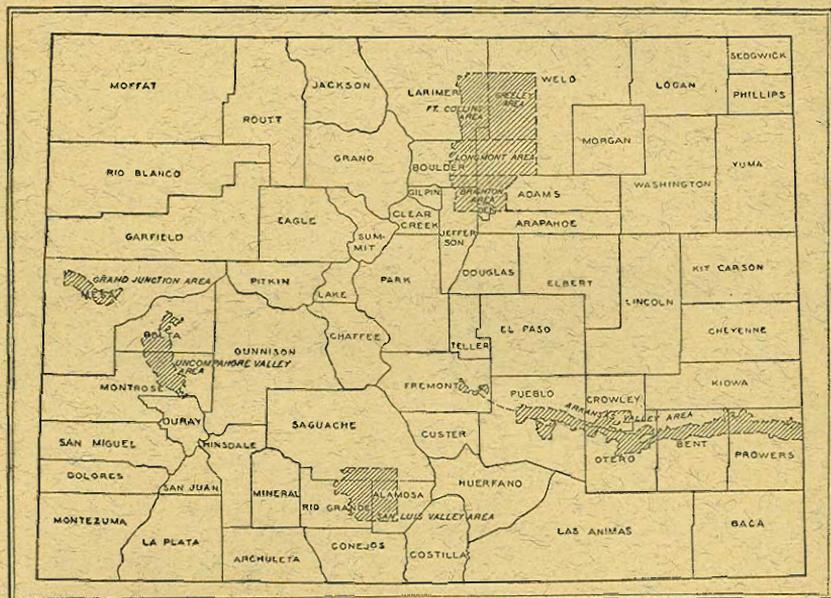
Occupying broad, high terraces in the Platte River Valley are sandy and gravelly soils having subsoils of sharp clean water-laid gravel at slight depths. These soils, which belong to the Gilcrest series, are used extensively for truck crops, but are also used for all farm crops commonly grown in this section. Associated with these soils are sandy soils of more recent origin belonging to the Greeley series.

Within the area are extensive tracts of very sandy soils. Some of these lie west of Platte River Valley, but east of the valley they are the predominant soils. Where they have a heavy subsoil and are irrigated, they are productive but on account of their tendency to blow are difficult to handle. Large bodies of sand soils are used for range land only.

Soils of the main stream valleys are dark colored, have weathered but little, and are underlain by stream gravel. They include areas of highly productive soils but as a whole are uneven, include many shallow and gravelly bodies, and have a high water table. Other alluvial soils are the Kuner soils which are partly alluvial but are underlain by sandstone and shale.

Less extensive and less important agricultural soils are the Berthoud, Neville, and Laporte soils, occurring on slopes and having slightly developed soil profiles, and the Larimer soils, occupying old high terraces and outwash fans, having strongly developed profiles.

The Terry soils have developed from sandstone and shale, the parent material being reached at slight depths in the heavier soils and on slopes, but at considerably greater depths in the lighter soils and on level and gently rolling areas.



Areas surveyed in Colorado shown by shading. Detailed surveys shown by northeast-southwest hatching.

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