Series 1929 Number 5

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Survey
of
The Greeley Area, Colorado

By

A. T. SWEET
United States Department of Agriculture, in Charge
and
L. A. BROWN and W. E. HAINES
Colorado Agricultural Experiment Station

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

For sale by the Superintendent of Documents, Washington, D. C.

BUREAU OF CHEMISTRY AND SOILS

HENRY G. KNIGHT, *Chief*
A. G. McCALL, *Chief, Soil Investigations*
SYDNEY FRISSELL, *Editor in Chief*

SOIL SURVEY

CURTIS F. MARBUT, *in Charge*
T. D. RICE, *Inspector, District 3*

COOPERATION

COLORADO AGRICULTURAL EXPERIMENT STATION
C. P. GILLETTE, *Director*

CONTENTS

	Page
Area surveyed	1
Climate	4
Agriculture	5
Drainage, alkali, and irrigation	8
Soils and crops	9
Soils of the Weld group	11
Weld fine sandy loam	12
Weld fine sandy loam, valley phase	12
Weld loam	13
Weld loam, heavy phase	13
Soils of the Terry group	13
Terry fine sandy loam	14
Terry fine sandy loam, steep phase	15
Terry loam	15
Terry silty clay loam	16
Soils of the Gilcrest group	16
Greeley fine sandy loam	18
Greeley fine sandy loam, sandy phase	18
Greeley fine sandy loam, low-lying phase	18
Greeley clay loam	19
Fort Collins loam	19
Gilcrest sand	19
Gilcrest gravelly sandy loam	19
Gilcrest gravelly sandy loam, heavy-subsoil phase	20
Gilcrest gravelly sandy loam, heavy phase	20
Gilcrest loam	20
Gilcrest fine sandy loam	21
Gilcrest fine sandy loam, heavy phase	21
Nunn clay loam	21
Nunn clay loam, heavy phase	22
Nunn clay loam, silty phase	22
Soils of the Larimer group	22
Larimer fine sandy loam	22
Larimer fine sandy loam, shallow phase	23
Larimer gravelly loam	23
Soils of the Valentine group	23
Valentine loamy fine sand	24
Valentine loamy fine sand, heavy-subsoil phase	24
Soils of the Cass group	25
Cass fine sandy loam	25
Cass fine sandy loam, shallow phase	25
Cass fine sandy loam, deep phase	26
Cass clay loam	26
Kuner silty clay loam	26
Kuner fine sandy loam	26
River wash	26
Utilization of the Greeley area soils	27
Soils and their interpretation	27
Summary	29
Literature cited	30

SOIL SURVEY OF THE GREELEY AREA, COLORADO

By A. T. SWEET, United States Department of Agriculture, in Charge, and L. A. BROWN and W. E. HAINES, Colorado Agricultural Experiment Station

AREA SURVEYED

The Greeley area lies in the western part of Weld County in northern Colorado, midway between Denver, Colo., and Cheyenne, Wyo. (Fig. 1.) The area is 34 miles long and 24 miles wide. It includes 803 square miles, or 513,920 acres, about one-fifth of the total area of the county.

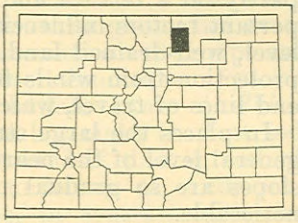


FIGURE 1.—Sketch map showing location of the Greeley area, Colorado

The entire region is an eastward and southeastward sloping plain extending from the foot of the Rocky Mountains to Missouri River. The Greeley area lies near the western edge of the region in the higher part of the plain.

The highest elevation in the area, 5,500 feet above sea level, is in the extreme northwestern part near the county line west of Nunn. The lowest part of the uplands, in the southeast corner, 8 miles south of Kuner, is about 4,700 feet above sea level (*7*, *8*).[1] The river flood plain north of Kersey has an elevation of less than 4,600 feet. The maximum range in elevation within the area is more than 900 feet.

Broad shallow valleys have been cut into this slightly tilted plain. Cache la Poudre River enters the area from the west, joining the South Platte east of Greeley. The valley of these streams forms an east and west low belt across the area dividing it into two unequal parts, the upper or northern part including about two-thirds of the total area. This part of the area has no large streams or stream valleys but has long gentle slopes to the south and southeast. The southern, especially the southwestern, part of the area, west of South Platte River, is much more completely dissected and hilly.

Each of the large streams is bordered by a flood plain from one-fourth to three-fourths of a mile wide and by wider old flood plains or terraces lying from 20 to 40 or more feet higher, and in general having greater width. The terraces are not continuous, in most places being present on one side of the stream only. The terrace along Cache la Poudre River ranges in width from 1½ to nearly 3 miles. It follows the north side of the river from the county line west of Windsor to a point within about 3 miles of Greeley. Below Greeley it lies on the south side of the river. The principal terrace of Thompson River lies along the south side of the stream and is a mile or more in width. The South Platte flood plain is bordered

[1] Italic numbers in parentheses refer to Literature Cited, p. 30.

110779—32——1

on the southeast by a terrace ranging from 3 to 4 miles in width. Well-defined terraces are developed at the apex of the uplands which separate Thompson and Little Thompson Rivers, Thompson and South Platte Rivers, and Cache la Poudre and South Platte Rivers.

The stream side of the terraces is in most places steep and sharply defined, and in many places it is marked by outcrops of gravel and by gravel pits. In some places there are narrow lower terraces intermediate between the high terrace and the stream flood plain, but the soils have more nearly the characteristics of the higher terrace than of the stream flood plain. The outer edges of the terraces are less well defined and extend to the upland with a gradual slope. In many places the terraces are partly covered by wind-blown sand.

Many of the larger towns of the area and of this region as a whole are located on stream terraces. This is true of Greeley, Windsor, Evans, La Salle, Milliken, Gilcrest, and Kersey. Johnstown is partly on a terrace and partly on the adjacent uplands. The important factors influencing the selection of these sites were probably level, well-drained land, ease of irrigation, abundant water supply, protection from winds for man and livestock, and nearness to trails and lines of travel, which in many places followed the valleys.

In places the large stream valleys lie 100 or more feet below the general level of the near-by uplands, but in most places the adjacent slopes are so gradual that the limits of the valleys are scarcely noticeable.

In addition to the broad east and west valleys are broad shallow valleys and intervening low ridges and divides which have a general north and south or northwest-southeast trend. One of these enters the area northwest of Nunn and extends south and east to the valley of South Platte River east of Greeley. It is occupied by Lone Tree Creek, Owl Creek, and other small intermittent streams, at present much too small to have eroded so wide and deep a valley. West of this old valley the slope is fairly steep, rising within a distance of a mile or two to a height of about 200 feet. Along its east side the slope is less pronounced and is more or less eroded by small streams. The difference in elevation between valley and upland is also slightly less on the east than on the west side.

In the southeastern part of the area are two of these broad, shallow north and south valleys, one occupied by a small stream, Boxelder Creek, and the other known as Beebe Draw, which is without a natural stream channel. These north and south valleys are believed to be due partly to the underlying rock formation which consists of alternating soft and slightly harder beds of sandstones and shales tilted to the east and northeast. The small streams, Lone Tree and Owl Creeks, possibly carried at one time a much greater volume of water than at present, and erosion was doubtless much more active. Evidence of this is found in the high benches underlain by stream gravel.

Numerous short drainage ways lead into all the large valleys so that the surface relief of the entire upland ranges from gently undulating to slightly hilly, the general slope of the uplands ranging from about 40 to 80 feet a mile and of the upland valleys and stream terraces from 10 to 20 feet. The gradient of the large stream flood plains is approximately 10 feet or less a mile.

In addition to the valleys, hills, and ridges due to water erosion there are numerous shallow basins and sand dunes, which have been caused by wind erosion. The basins are round or elliptical, many of them occurring in chains with a general northwest-southeast trend.

A very definite relation exists between all these flood plains, terraces, uplands, and upland valleys and the development of the soils of the area.

On the soil map numerous short intermittent streams are indicated in small valleys where no stream channels exist, this means being used to indicate the presence of slight valleylike depressions, in which the soil is darker and slightly heavier than on the adjacent slopes.

The Greeley area lies in the region known as the "short-grass country," the predominant grasses of the uplands being the short grama and buffalo grasses in contrast with the taller bluestem, bunch grass, and other grasses of the prairies farther east. These short grasses and many other native plants grow throughout the area. Some of these as individuals and others in associations or groups are suggestive indicators of surface soil and subsoil conditions (*5*).

Grama (*Bouteloua oligostachya*) and buffalo grass (*bulbilis dactyloides* Nutt.) grow throughout the area but make the best sod and furnish the better range on the "hard lands," that is, soil of somewhat heavy texture, especially where underlain at a comparatively slight depth by sandstone or shale, in contrast with the "sandy lands" where the sand is deep and has been blown into dunes by the wind. Wheatgrass (*Agropyron smithii* Rydb.) grows on very heavy soils especially in valleys where moisture is abundant. A low-growing shrub of this region, shadscale (*Atriplex confertifolia* Torr.), grows almost exclusively on a heavy soil, on a soil with heavy subsoil, or one in which there is restriction to downward movement of moisture. (Pl. 1, A.) Sand sage (*Artemisia filifolia* Torr.) grows exclusively on deep sandy land, making its best growth in the sand hills. Soapweed (*Yucca glauca* Nutt.) is also found principally on sandy or very gravelly droughty soil. Small rabbitbrush (*Chrysothamnus graveolens*), umbrella plant (*Eriognum corymbosum*), mountain sage (*Artemisia frigida* Willd.) a small plantain (*Plantago purshii*), wild alfalfa (*Psoralea tenuiflora* Pursh.), wire grass (*Arstida longiseta* Steud.), and several other plants have a rather broad adaptation between the most sandy soil and that which is heaviest. Bunch grass (*Andropogon scoparius* Michx.), bluestem (*Andropogon hallii* Hack.), and sand grass (*Calamovilfa longifolia* Hook.) are tall grasses which grow on the very sandy soils of the southeastern part of the area. Squirrel-tail grass (*Hordeum jubatum*), locally known as bearded foxtail (pl. 1, B), grows on seepy and alkali land and its presence in alfalfa fields and other places is an almost sure indicator of such conditions.[2]

A large part of the Greeley area was settled soon after the founding of the Greeley colony in 1870. Nearly three-fourths of the area surveyed is at present under cultivation, and this part is rather thickly settled and intensively farmed. Density of settlement is

[2] Identification of these plants has been made for the soil survey by Ernest C. Smith, curator of the herbarium, Colorado Agricultural College.

indicated on the soil map by the abundance of roads and number of home sites. Farm improvements are good, consisting of attractive well-built houses (including tenant houses), barns, and other buildings.

The unirrigated parts of the area are much less densely settled. A large part of this land is dry farmed, and some is used for livestock range only.

Weld County has a total area of 4,022 square miles. Of this area about 356,112 acres, or approximately 15 per cent, is irrigated. The Greeley area embraces a large part of the irrigated land of the county and some dry-farmed areas. Much of the irrigated land has been under cultivation since about 1870, and some of the remainder for 30 years or longer.

The approximate land area of Weld County is 2,574,080 acres, of which about 85 per cent in 1930 was classed as agricultural land, that is, crop land and pasture.[3]

The population of Greeley, the county seat, was 12,203 in 1930. Here is situated the State Teachers College, a factory of the Great Western Sugar Co., a large canning plant, a large flour mill, and other manufacturing industries. Other important towns are Windsor, Eaton, Ault, Johnstown, La Salle, Milliken, Kersey, Pierce, Gilcrest, and Nunn.

Sugar beets are grown in all irrigated parts of the area under contract with the Great Western Sugar Co., which in addition to the factory at Greeley also has factories at Eaton, Windsor, and Johnstown, all of which are within the surveyed area, and at many other towns in this region but outside the limits of the area. A milk condensary at Johnstown furnishes a market for large quantities of milk. Denver furnishes a market for many products of the area. Livestock, potatoes, and some other products are shipped to markets outside the State.

United States Highway No. 85 extends north and south through Greeley and the central part of the area connecting with Denver, Colo., and Cheyenne, Wyo. United States Highway No. 38 extends from Greeley eastward to Fort Morgan and points east. State Highway No. 14 crosses the area from east to west extending from Fort Collins through Ault to Sterling. Many of the numerous other good highways are hard surfaced with stream gravel. As shown on the soil map, public roads extend throughout the irrigated regions along nearly every section line.

The Union Pacific Railroad, the Colorado & Southern Railway, and private lines of the Great Western Sugar Co. furnish transportation and shipping facilities for all parts of the area. Through passenger bus lines furnish transportation facilities north, south, east, and west. Trucks are used throughout the area in transporting farm products of all kinds to the markets.

CLIMATE

The mean annual precipitation at Greeley, which is representative of the area as a whole, is 12.65 inches. Of this amount 7.44 inches,

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

much more than one-half, falls during the four months of April, May, June, and July. The heaviest precipitation normally occurs in May and the lowest in January.

The mean annual temperature at Greeley is 48.1° F. July is the warmest month and December and January the coldest. The average length of the frost-free season, from May 4 to September 29, is 148 days. The relative humidity is low. The air movement is good, the prevailing winds being from the west, north, and northwest.

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

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Greeley, Weld County, Colo.*

[Elevation, 4,649 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1893)	Total amount for the wettest year (1915)	Snow, average depth
	° F.	° F.	° F.	*Inches*	*Inches*	*Inches*	*Inches*
December	26.0	60	−37	0.41	0.24	0.33	5.3
January	26.0	59	−29	.32	(1)	.20	3.5
February	27.8	63	−45	.41	.42	.70	6.0
Winter	26.6	63	−45	1.14	.66	1.23	14.8
March	38.0	70	−19	.73	.18	1.49	5.6
April	47.4	78	−1	1.71	.57	3.87	4.6
May	56.8	80	18	2.47	1.27	2.45	.7
Spring	47.4	80	−19	4.91	2.02	7.81	10.9
June	66.6	91	28	1.41	.71	2.03	.0
July	70.9	93	34	1.85	.07	1.69	.0
August	70.0	90	35	1.13	1.04	3.89	.0
Summer	69.2	93	28	4.39	1.82	7.61	.0
September	61.2	83	24	.96	.48	1.17	.3
October	49.1	86	−8	.92	.11	2.81	2.2
November	36.6	68	−18	.33	.21	.26	3.2
Fall	49.0	86	−18	2.21	.90	4.24	5.7
Year	48.1	93	−45	12.65	5.40	20.89	31.4

[1] Trace.

AGRICULTURE

The principal industries in the Greeley area are general farming, livestock feeding, and dairying. Much attention is given to crops requiring special cultivation and handling, as sugar beets, potatoes, seed beans, and miscellaneous crops for canning and for local markets.

The various crops in Weld County, most of the irrigated part of which is included in the Greeley area, had in 1925 and 1930 a value as shown in Table 2.

TABLE 2.—*Value of crops in Weld County, Colo., in 1925 and 1930* [1]

Crop	1925	1930	Crop	1925	1930
	Dollars	*Dollars*		*Dollars*	*Dollars*
Sugar beets	2,195,146	9,451,460	Barley	917,938	1,172,950
Potatoes	5,254,468	2,262,560	Beans	1,409,922	1,278,890
Hay	3,960,477	2,615,020	Oats	423,461	227,550
Wheat	2,201,408	1,638,890	Sorghum	117,017	114,500
Corn	1,186,172	1,239,950	Miscellaneous crops	1,759,384	1,139,270

[1] Colorado State Board of Immigration. Year Books of the State of Colorado. Compiled and edited by T. R. Ingram (*1, 1926, p. 57; 1931, p. 65*).

The greatest fluctuations in crop values in these two years, it will be noted, are in sugar beets and potatoes. This is due partly to prices of the year and of the preceding year and partly to seasonal conditions.

Of these more important crops, potatoes, alfalfa, sugar beets, and much of the corn, beans, and small grains are grown under irrigation. Corn, beans, small grains, wild hay, and sorghums are grown also on unirrigated land. The 1930 census report shows that 94,437 acres were planted to corn, 22,767 acres to potatoes, 101,012 acres to alfalfa, and 82,453 acres to sugar beets, in 1929.

In 1929, Weld County reported 353 acres in cucumbers, 1,388 acres in cabbage, 499 acres in tomatoes, 1,292 acres in snap beans, and 425 acres in dry onions. Other miscellaneous crops include root crops for livestock feed, alfalfa seed, sweet corn, cantaloupes, Honeydew melons, watermelons, pumpkins, and squash.

The same census reports the number of animals on farms in Weld County, on April 1, 1930, as follows: Horses, 30,124; mules, 2,623; cattle, 86,477; and swine, 30,604.

The average acre yields of the various crops for a 5-year period ended with 1925 was as follows: Winter wheat, irrigated, 28.11 bushels, nonirrigated, 12.49 bushels; spring wheat, irrigated, 24.89 bushels, nonirrigated, 8.60 bushels; corn, irrigated, 31.58 bushels, nonirrigated 12.72 bushels; barley, irrigated, 39.93 bushels, nonirrigated, 17.25 bushels; and potatoes, irrigated, 139.04 bushels, nonirrigated, 40.81 bushels.

A fairly well defined relationship seems to exist between soils, the crops grown, and the yields. Sugar beets and alfalfa return the best yields on soils with well-defined profiles and deep well-drained subsoils, largely because of the amount and control of the moisture supply but also because the soil texture is favorable to deep rooting. Late potatoes are grown more extensively on Weld fine sandy loam than on any other soil, but they are also successfully grown on Nunn clay loam and other soils. Early potatoes are grown most extensively on Gilcrest gravelly sandy loam, the heavy-subsoil phase being more productive than the typical soil. Cabbage are grown extensively on heavy soils, such as the heavier low-lying valley phase of Weld fine sandy loam, and miscellaneous truck crops are grown on the low-lying phase of Greeley fine sandy loam.

The average size of farms in Weld County is 362.4 acres. The range in size is from 20 to 5,000 acres. On the average farm about 15 per cent of the cultivated land is devoted to corn, 15 per cent to

wheat, 5 per cent to oats, 8 per cent to barley, 20 per cent to alfalfa, and 5 per cent to sugar beets.

The following estimates (Table 3) of crop yields have been supplied by the county extension agent of Weld County and are believed to be fairly accurate and conservative. In these estimates, average yields are distinguished from good yields which are usually much higher but are not extreme yields on the medium and better soils.

TABLE 3.—*Estimated crop yields in the Greeley area, Colorado*

Crop	Average yield	Good yields	Crop	Average yield	Good yields
	Tons	*Tons*	Winter wheat:	*Bushels*	*Bushels*
Alfalfa	2 25	3. 5–4	Irrigated	40	48
Sugar beets	13	15–16	Nonirrigated	20	15–35
	Bushels	*Bushels*	Spring wheat:		
Potatoes	175	300–350	Irrigated	35	42
Corn	40	60–65	Nonirrigated	20	15–35
Pinto beans:					
Irrigated	20	30–40			
Nonirrigated	3. 5–8	5–15			

Agricultural methods in the Greeley area are as a whole good. This is due (1) to the character of intelligent, well-informed farmers; (2) to the use of productive, high-priced lands which can be made to produce an income on the investment only by skillful handling; (3) to the grade of high-priced crops grown, as sugar beets, potatoes, and several miscellaneous crops; (4) to the assistance given the growers by the sugar-beet companies through publications and their field men; and (5) to the assistance given the farmers through the county extension agents, the Colorado College of Agriculture, the Colorado Agricultural Experiment Station, and other agencies.

In 1929, 82,445 acres of sugar beets, valued at more than $8,000,000 were grown in Weld County, a large part of which were produced in the Greeley area. All were grown under the direct supervision of experienced field men. In beet production rotation of crops is stressed. Fields infested by nematode are condemned until nonhost crops have been grown for a period ranging from three to five years. Fall plowing, thorough early preparation of the seed bed, and early planting are recommended. Tests are made to determine the need for commercial fertilizers. Early thinning, leaving the larger plants, and uniform spacing are insisted on. Frequent light irrigations and careful and thorough cultivation are recommended.

Hand labor in beet growing is done principally by contract, Mexican laborers doing the greater part of this work. The contract price at present (1929) ranges from $22.50 to $24 an acre. This provides for thinning, hand cultivation, and topping. The average yield is less than 15 tons to the acre, but yields of 20 or more tons are common. The price at present (1929) is $7 a ton.

Other crops, such as potatoes, beans, and alfalfa, require much less labor both for cultivation and harvesting. Potatoes are planted, cultivated, harvested, and sorted by machinery. Beans are cut by machinery, piled, and stacked like hay and later threshed by bean threshers. Binders, headers, and combines are all used in harvesting small grains. Tractors and trucks are in use on practically all farms.

Large numbers of livestock, both sheep and cattle, are fed in the area. Alfalfa, corn largely as silage, beet pulp and tops, barley, and concentrates are used as feed for livestock. The manure produced is applied to the soil.

DRAINAGE, ALKALI, AND IRRIGATION

Natural drainage of the uplands and river terraces as a whole is good, small tributary streams reaching into practically every part of the area and the slopes being favorable for rapid surface run-off. Through the extensive use of irrigation water without necessary provisions for taking care of the natural seepage through the subsoil, however, numerous small seepy areas have developed. These are most extensive in the small valleys where ground water has accumulated until the water table is near or at the surface. Smaller seepy areas have also developed on slopes, especially below irrigation ditches, where the downward movement of water is checked by impervious layers of sandstone, shale, or accumulated lime.

The large amount of seepage water in this region is due to a rather abundant water supply, to heavy applications of irrigation water, to open, porous upper subsoil layers, and to impervious deep subsoils. This is brought out in the following statement from a State Bulletin (*4*):

"The return flow to the South Platte River is phenomenal. The diversions from the river after the spring floods have subsided are practically all from seepage or return water."

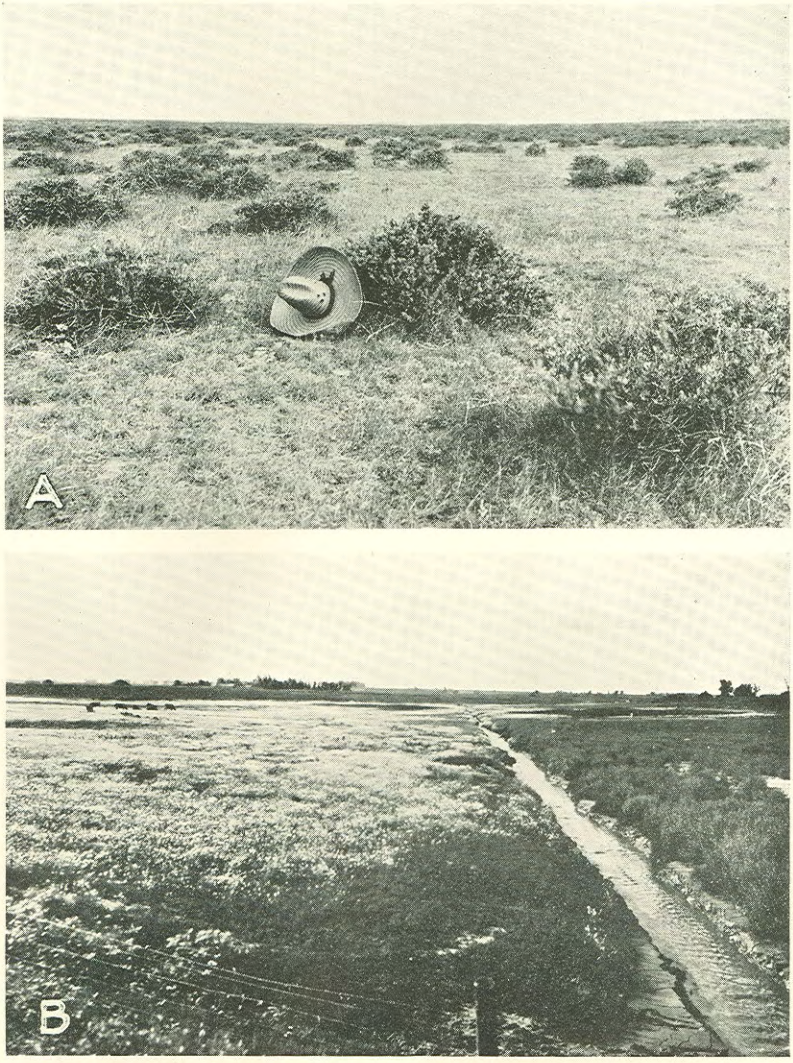
Much drainage, both by means of open ditches and tile, has been done, but more is needed. Areas requiring drainage are increasing from year to year. Each drainage area is a problem within itself requiring the services of a competent drainage engineer for its solution.

In this region practically all areas of seepy soil and a high water table are accompanied by a surface accumulation of alkali. This consists largely of sodium sulphate, magnesium sulphate, and sodium chloride. If present in large quantities the alkali checks or entirely prohibits the growth of cultivated crops, and in smaller amounts it prevents a good stand. It has also proved to be much more harmful in equal amounts on light sandy soils than on heavy clay soils (*6*).

Thorough drainage is the first step necessary in reclaiming soil from alkali. After drainage, the land should be cultivated and seeded to a crop as quickly as possible. When water is available heavy irrigation to wash the alkali down is advisable before seeding. Sweetclover is the most alkali-resistant crop of this region. Sugar beets, alfalfa, and cabbage are somewhat resistant. The use of straw, manure, and weeds or other organic matter plowed under is also useful as these materials increase the moisture-holding capacity of the soil and thus lower the toxicity of the soil solution.

Marshy areas have been indicated on the soil map by marsh symbols. Areas in which there is a harmful accumulation of alkali have been indicated by the symbol "A" in red.

The heaviest rainfall in the area occurs in the spring and is usually sufficient to start crops growing without resorting to irrigation. The



A, Shad scale, an indicator of a heavy soil or a soil with heavy subsoil; B, bearded foxtail, the light-colored growth on left, a reliable indicator of seepy and alkali soil

A, Small grains on Weld fine sandy loam, near Lucerne. Barley in shocks, oats standing. (The trees surround a home site); B, beans grown for seed on Weld fine sandy loam. Irrigation water shows between the rows

texture of the greater part of the soil is such that it is easily irrigated and at the same time retains moisture well.

Water for irrigation is supplied by diversion canals from Cache la Poudre and South Platte Rivers and from numerous large storage reservoirs, both within the area and in the mountains to the west, and by pumping where ground water can be reached at a slight depth. The water supply of the region as a whole is good, although some areas under irrigation frequently have an inadequate supply. Electric power is used for pumping, and the use of individual pumping plants is increasing.

The average depth of water applied for an irrigation is about 0.75 foot. This average is greater in the earlier part of the season when direct-flow water is available. Its use in large quantities reduces the later requirements of stored water. Considering the soil alone, best results would be obtained by more frequent quick irrigations to a depth ranging from 0.4 to 0.6 foot.

The flood stage of the river occurs at a time when irrigation of at least a third of the acreage in crops, chiefly small grains, may be completed with water drawn directly from the river. This leaves the stored water to be used for maturing such valuable crops as sugar beets, potatoes, and alfalfa.

Water brought into the valley from other drainage basins is collected from the highest slopes of the mountains, coming therefore after the peak of the flood has passed. This supply, though not large, is very important because it postpones the time when almost the whole demand must be supplied with stored water.

The total seepage return in Cache la Poudre Valley is approximately 30 per cent of the normal water supply (*2*). The duty of water figured for Cache la Poudre River as a whole is 1.67 acre-feet an acre. The consumption duty for the Platte Valley is estimated not to exceed 1.25 acre-feet an acre. Nonproductive and waste land averages approximately 15 per cent of the area under irrigation.

Furrow irrigation and flooding from field laterals are the only methods of irrigation practiced. The average number of irrigations applied on a large number of fields under investigation ranged from 1.21 for wheat to 3.79 for potatoes. The number of acres irrigated a day by one person ranged from 4.45 for barley to 6.78 for potatoes. The average duty in acre-feet an acre, measured at the head of the farm lateral, was as follows: For alfalfa, 2.57 acre-feet; for wheat, 1.04; for oats, 1.35; for barley, 1.19; for sugar beets, 1.86; for potatoes, 2.20; and for beans, 0.69.

Reservoirs are by far the most important factor governing the proper use of water in the area. By their use water is made available when, and only when, needed. Without them an entirely different type of agricultural development would have resulted. The large number of reservoirs was made possible by natural basins which have been developed with a minimum of expense.

SOILS AND CROPS

Weld County is in a region of widely diversified farming. The Greeley area includes the larger part of the irrigated land of the county and the regions of greatest farm activities. The rank of

crops of the county as a whole and of the Greeley area is, in the order of value, potatoes, hay, wheat, sugar beets, miscellaneous truck crops (which include cucumbers, cabbage, onions, melons, tomatoes, and a few other vegetables), beans, corn, barley, oats, sorghums, rye, and fruits. The acreages of potatoes, sugar beets, and the miscellaneous truck crops fluctuate, from year to year, depending largely on the prices of the preceding year and on seasonal conditions. The acreages of other crops are more nearly stable. All crops are grown on the irrigated land of all types of soil to some extent, regardless of the character of soil. Some are grown extensively also on the unirrigated dry lands. There are, however, certain soil and crop adaptations which are recognized, as the use of certain soils for early potatoes, others for late potatoes, for cabbage, and for onions. It is also recognized that yields on certain types of soil differ, but in these moisture conservation and use seem to be the controlling factors rather than the soil.

Based on inherent productiveness, which bears a close relation to depth of the surface soil, character and depth of the subsoil, and underdrainage, the soils may be divided into six main or major groups as follows: (1) Soils of the Weld group, consisting of well-weathered soils with deep, friable, well-drained subsoils. The textures are intermediate, being neither very heavy nor very light and, together with the depth, good drainage, and good supply of lime and the plant-food constituents, constitute a combination of features favorable in every respect to plant growth. (2) Soils of the Terry group, consisting essentially of soils similar to those of the Weld group in all characteristics except depth. They are shallow soils. The underlying rock, similar to that lying deep beneath the Weld soils, consists of sandstones and shales and lies at a depth of about 4 feet or less. (3) Soils of the Gilcrest group, consisting of deeply weathered soils, usually well drained but differing from those of the other two groups in being underlain by gravel beds. (4) Soils of the Larimer group, consisting of soils much like those of group 3 but in which the gravel bed lies at a somewhat slighter depth and is imperfectly cemented with lime carbonate. (5) Soils of the Valentine group, consisting mainly of wind-blown sand. (6) Soils of the Cass group, consisting of soils in the stream valleys composed of recently deposited alluvium. These soils are dark colored, have gravelly subsoils, and ground water lies at a slight depth.

In soil classification and mapping the soils of an area or county are divided into broad groups which have a few general characteristics. These groups are called series and given a name, usually of some place in which such soils are typically developed. Thus we have in the Greeley area the Larimer series which include reddish-brown upland soils, containing different quantities of sand and gravel and having in the subsoil a well-developed white layer of lime accumulation. Each series is made up of two or more soil types which have the common characteristics of the series but differ in texture or in 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 and the meaning of these is shown in the key or legend on the margin. In many places variations of importance occur within the areas of typical soil and are indicated as phases.

On the accompanying map soils of 10 series, represented by 20 soil types and 14 phases of types, in addition to river wash, are shown. Table 4 shows the acreage and proportionate extent of each soil mapped.

TABLE 4.—*Acreage and proportionate extent of the soils mapped in the Greeley area, Colorado*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Weld fine sandy loam	76,800	14.9	Gilcrest fine sandy loam	9,088	1.8
Weld fine sandy loam, valley phase	11,776	2.3	Gilcrest fine sandy loam, heavy phase	2,176	.4
Weld loam	20,992	4.1	Nunn clay loam	17,024	3.3
Weld loam, heavy phase	4,032	.8	Nunn clay loam, heavy phase	2,880	.6
Terry fine sandy loam	90,432	17.6	Nunn clay loam, silty phase	1,664	.3
Terry fine sandy loam, steep phase	3,200	.6	Larimer fine sandy loam	24,768	4.8
Terry loam	37,184	7.2	Larimer fine sandy loam, shallow phase	4,416	.9
Terry silty clay loam	10,560	2.1	Larimer gravelly loam	1,856	.4
Greeley fine sandy loam	15,040	2.9	Valentine loamy fine sand	35,712	7.0
Greeley fine sandy loam, sandy phase	2,624	.5	Valentine loamy fine sand, heavy-subsoil phase	33,984	6.6
Greeley fine sandy loam, low-lying phase	4,160	.8	Cass fine sandy loam	16,896	3.3
Greeley clay loam	2,432	.5	Cass fine sandy loam, shallow phase	960	.2
Fort Collins loam	1,792	.3	Cass fine sandy loam, deep phase	1,792	.3
Gilcrest sand	2,304	.4	Cass clay loam	6,016	1.2
Gilcrest gravelly sandy loam	41,536	8.1	Kuner silty clay loam	5,248	1.0
Gilcrest gravelly sandy loam, heavy-subsoil phase	13,312	2.6	Kuner fine sandy loam	4,224	.8
Gilcrest gravelly sandy loam, heavy phase	1,344	.3	River wash	4,096	.8
Gilcrest loam	1,600	.3	Total	513,920	

SOILS OF THE WELD GROUP

The Weld group consists of upland soils occupying nearly level or gently rolling areas in which the soil has weathered into three well-defined layers and in which the deep subsoil consists of light-brown or very light brown friable micaceous fine sandy loam to a depth of 5 feet or more.

As seen in a freshly made roadside cut the surface soil of these soils, when moist, is brown or slightly reddish brown to a depth of about 12 or 14 inches. The upper part of the layer, which has a thin, finely granular, slightly crusted surface covering 1 inch thick, to a depth of 5 or 6 inches is friable and easily crumbled, and in grassland areas it is completely filled with grass roots. The lower part, where exposed to weathering, shows a tendency to break into somewhat columnar strips, grass and other plant roots as a rule following the cleavage planes. The soil material breaks into small, sharp, hard clods from one-fourth to one-half inch in diameter, and the reddish-brown color extends through the particles. Below the reddish-brown layer is a lighter, somewhat grayish-brown, layer which extends to a depth ranging from 24 to 30 inches. The material in this layer also breaks into hard irregular clods, most of which are larger than those of the darker surface layer. Distributed through this layer, but most abundant in the upper part, are small whitish-gray irregular spots from one-half to 1 inch in diameter, also many small white specks. These spots, which consist largely of carbonate of lime, effervesce freely on the application of acid. The lower part of this layer is more friable than the upper part and

below a depth of 30 inches grades into micaceous fine sandy loam which is rather compact and has a massive, rather than a cloddy, structure. The material in this layer is uniform in color and texture and, in nearly all parts of the area, extends to a depth of 5 feet or more below the surface. In some places, however, soft sandstone underlies it at a depth of nearly 5 feet, and throughout the area sandstone or shale underlies it at a greater depth.

Soils of this group have developed from deeply weathered soft sandstone modified by a heavy surface deposit of the well-weathered wind-blown material of the region, which has been scoured from the sandstone hills, scooped out of small basins, and carried up from stream flood plains and terraces.

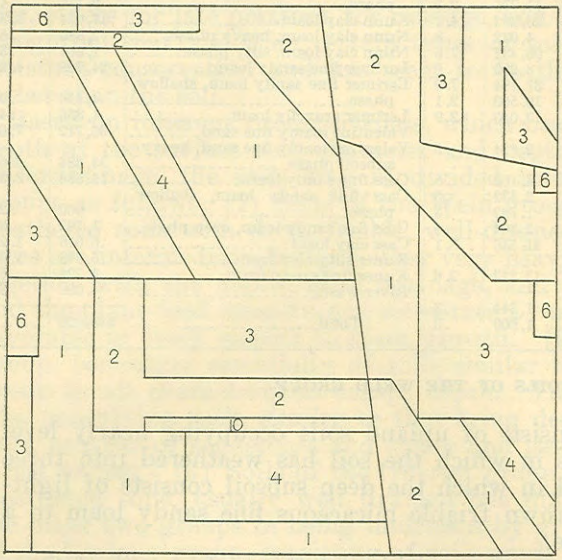


FIGURE 2.—Section 7, T. 6 N., R. 65 W. Proportion of Weld fine sandy loam devoted to various crops: 1, Land in alfalfa; 2, land in sugar beets; 3, land in potatoes; 4, land in small grains; 6, land in miscellaneous crops; and 10, land in sorghum cane

The Weld soils in the Greeley area correspond closely to the Weld soils of the Fort Collins area. Their principal difference consists in a slightly more yellowish-brown or light-brown color instead of the olive-brown tint of these soils mapped in the Fort Collins area. This difference is thought to be due to different parent materials.

Weld fine sandy loam.—Weld fine sandy loam is the predominant upland soil north of Cache la Poudre Valley, west of Greeley and extending as far north as State Highway No. 14 and westward from Ault. It is typically developed around Lucerne and Eaton and westward to Severance. Good exposures may be seen along United States Highway No. 85.

All the land is under irrigation and is intensively farmed. It is considered by many growers to be the best late potato land of the Greeley area, but it is used for a wide diversity of crops. Plate 2, A and B, shows the nearly level relief and the appearance of some of the crops on this soil near Lucerne and Eaton. Figure 2 shows the arrangement of fields and the crops grown in 1929 on a section of this soil along United States Highway No. 85, northwest of Lucerne. The percentage of the section in alfalfa was 39.7; in sugar beets, 25; in small grains, 22; in potatoes, 10.3; in miscellaneous truck crops, 1.9; and in sorghum cane, 1.1.

Weld fine sandy loam, valley phase.—Stretching across the body of Weld fine sandy loam are numerous long narrow strips or belts

of soils, occurring along small drainage ways, and small shallow circular and elliptical depressions probably of wind-blown origin. These areas have a general north-northwest trend, lie slightly lower than the adjacent land, are slightly darker in color, and are heavier in texture, especially in the subsoil. The subsoil in places ranges from loam to clay loam, and in some places the deep subsoil rests on soft sandstone and in others contains thin layers of fine gravel.

Much of the soil of this phase has become seepy through the accumulation of water from irrigation and the rise of the water table. Wherever it is seepy, it contains alkali in different amounts and this has aided in deflocculaton of the soil, causing it to become heavier and more plastic.

Much of the valley phase of Weld fine sandy loam has been drained, and much more drainage is needed. Where well drained, the land is productive and is used for the production of alfalfa, sugar beets, cabbage, sweetclover, corn, and other crops.

Weld loam.—Weld loam covers a large part of the top of the divide between Cache la Poudre and Thompson Rivers and of the divide between Little Thompson and South Platte Rivers. This soil ranges from heavy fine-textured loam to silt loam. Exposures of the typical soil may be seen along the highway leading from Greeley to Loveland, Larimer County, near Smiths Corner, and along cuts followed by the railroad southward from Johnstown.

A large part of Weld loam is not irrigated but is dry farmed, principally to small grains. It is considered the best soil in the area for dry farming. The yields are good and crops are more certain than on other soils so used for small grains. The area south of Johnstown is irrigated, and good yields of alfalfa, sugar beets, small grains, and other crops are obtained. The total area covered by this soil is 32.8 square miles.

Weld loam, heavy phase.—The soil on the top of the divide which extends southeast from Oklahoma School is slightly heavier in texture than the soils on the slopes and has been outlined on the soil map as a heavy phase of Weld loam. This soil, like the typical loam, is used for growing small grains under dry-farming methods.

SOILS OF THE TERRY GROUP

Soils of the second group, which are known as the Terry soils, in general occupy more rolling, slightly hilly, and in some places very hilly country. The color of the surface soil is in many places slightly more yellowish brown and the first and second layers not quite so thick or so well developed as the corresponding layers in the Weld soils. The deep subsoil consists of soft sandstone or shale, which may lie at a depth ranging from 3 to 4 feet or may be within a few inches of the surface. Soils of this group can frequently be recognized by round iron concretions and small, thin fragments of reddish-brown ferruginous sandstone on the surface and through the surface soil and subsoil.

The underlying sandstone is in many places only slightly consolidated, is penetrated by plant roots, and has much the appearance of a friable sandy soil. A thin crustlike layer of harder sandstone or shale occurs in many places, covering the surface of the layer and in most places containing rust-brown and gray mottlings not found

in the soil proper. The shale may be easily recognized by its thin laminated layers and olive-brown or dark grayish-brown color. It also checks the downward movement of moisture, restricts air movements in the subsoil and partly checks downward root growth. A deep cut along Coal Creek shows dark-colored shale at the base and overlying this, soft light yellowish-brown sandstone. This is typical of the material which occurs at a slight depth under all the Terry soils.

These soils differ slightly in color from those of the Terry group in the Fort Collins area, owing to differences in parent material. The sandy soils of the Greeley area are as a rule yellowish brown rather than olive brown, and the parent sandstone is softer.

The Terry soils predominate in the northeastern part of the area, extending from near the river valley south of Gill northward to the limits of the area. A large body extends from near Black Hollow Reservoir northwest to the county line, and another large body extends along Sheep Draw in the southwestern part of the area. A smaller body lies southeast of Lower Latham Reservoir in the southeastern part and small isolated bodies occur throughout the area.

These soils, where deeply weathered or where covered to a great depth by wind-blown material, are highly productive, differing but little in crop value from the Weld soils. As a whole, however, they are more uneven and more difficult to irrigate. There are numerous shallow areas, where the sandstone or shale comes near, or lies at, the surface, and, where the land is irrigated, seepy and alkali spots develop.

Soils of the Terry group are used more extensively for dry farming than any other soils in the Greeley area. The principal crops are beans, small grains (wheat, and barley), corn, Sudan grass, other grain sorghums, and millets of various kinds.

Dry farming to be successful should be carried on by people with resources sufficient to tide over the numerous years of crop failure. It is also more successful in certain areas where the soils hold moisture better, blow less, and where the rainfall is slightly greater than in other places.

Many persons of limited means and with scant knowledge of the requirements for successful dry farming have failed, and the dry-farming regions bear many evidences of such failures in the form of abandoned farms and farm buildings.

The soils of this group are used extensively for open range (pl. 3, A) for both beef and dairy cattle.

Terry fine sandy loam.—Terry fine sandy loam is the most extensive soil in the Greeley area. Most of it is under cultivation. It usually predominates on the tops of ridges but occurs also on the slopes, and in many places has a deep accumulation of wind-blown sand. Under irrigation the land is very productive. It is typically developed around Gill and Galeton.

The soil is used in the production of alfalfa, small grains, sugar beets, beans, and corn. Figure 3 shows the proportion of the various crops grown on an irrigated section of this soil northeast of Galeton in 1929. The percentage of this section in alfalfa is 26.7; in sugar beets, 22.8; in potatoes, 16.7; in small grains alone,

11.1; in small grains with alfalfa, 14.1; in miscellaneous crops, 1.7; in beans, 3.9; and in sorghum cane, 3.

Much of this soil is used for dry farming to beans, corn, small grains and other crops, and a large area is used for native pasture. The principal pasture grasses are grama, buffalo grass, and wire grass. One of the most serious difficulties in the utilization of this soil for dry farming is its tendency to blow whenever the sod has been broken and the surface is left bare. To check this to some extent, corn and beans are frequently planted in alternate belts or strips. Figure 4 shows the proportion of the various crops grown under dry-land conditions on a section composed principally of this soil northwest of Primrose School. This section is particularly favorable for dry farming. The percentage of land used for various purposes is as follows: Small grains, 21.1; corn, 8.6; beans, 26.1; fallow ground, 0.5; grassland, 37.3; millet, 4.2; Sudan grass, 1.1; and buckwheat, 0.5.

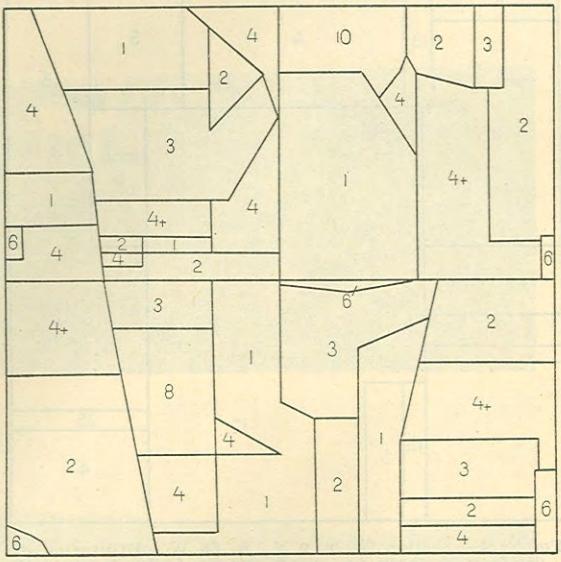


FIGURE 3.—Section 28, T. 7 N., R. 64 W. Proportion of irrigated Terry fine sandy loam devoted to various crops: 1, Land in alfalfa; 2, land in sugar beets; 3, land in potatoes; 4, land in small grains alone; 4+, land in small grains and alfalfa; 6, land in miscellaneous crops; 8, land in beans; 10, land in sorghum cane

Terry fine sandy loam, steep phase.—On the south side of Cache la Poudre Valley south of Windsor, and north of the Thompson River Valley, near Milliken, a steep phase of Terry fine sandy loam has been mapped. As the name implies, the areas are steep, and rock outcrops in a few places. The areas are too steep for cultivation and in places are badly gullied, but they furnish some pasturage. (Pl. 3, B.)

Terry loam.—Terry loam differs from Terry fine sandy loam in having a slightly heavier surface soil, a heavier and, as a rule, a less uniform subsoil, and a more shallow lower subsoil layer. Round iron concretions and small fragments of sandstone are more abundant in this soil than in the fine sandy loam. Thin beds and small lenses of dark-colored shale and, in places, thin beds of limy sandstone lie near the surface, and where the land is irrigated, alkali and seepy areas are more abundant than in the fine sandy loam. Some areas of this soil occupy small valleys and basinlike depressions, the heaviness of the soil in such places being due, in part, to accumulations of finer material, more complete weathering, and slightly more moist conditions.

A large area of this soil occupies the steeper slope which borders the west side of the basin in which Nunn is situated. In this area, thin beds of heavy clay shale are common in the subsoil. From 1 to 2 miles west of Galeton and from Galeton northward to the limits of the area, are numerous small bodies and some larger ones. Some areas are seepy and heavily impregnated with alkali. Gypsum is abundant in places in the shaly subsoil.

In the northeast corner of the area, north of Prairie View School, is a variation of this soil in which the parent material is pinkish-gray soft limy shale or shaly limestone. The resulting soil is deeper, slightly more reddish brown, and as a whole more productive than typical Terry loam.

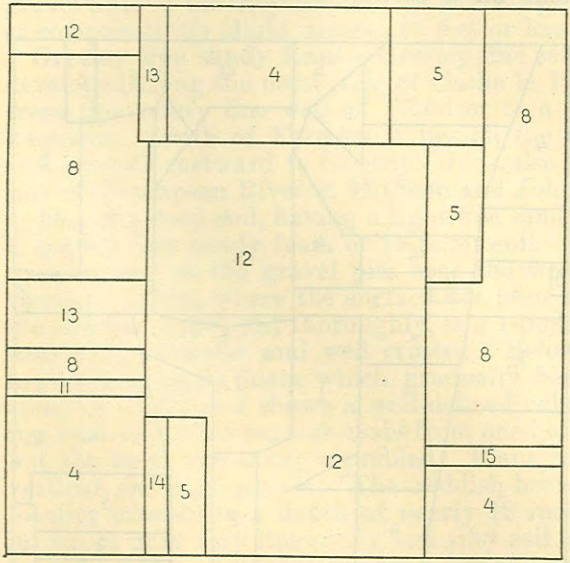


FIGURE 4.—Section 24, T. 9 N., R. 65 W. Utilization of dry-farmed Terry fine sandy loam: 4, Land in small grains; 5, land in corn; 8, land in beans; 11, fallow ground; 12, land in grass; 13, land in millet; 14, land in Sudan grass; 15, land in buckwheat

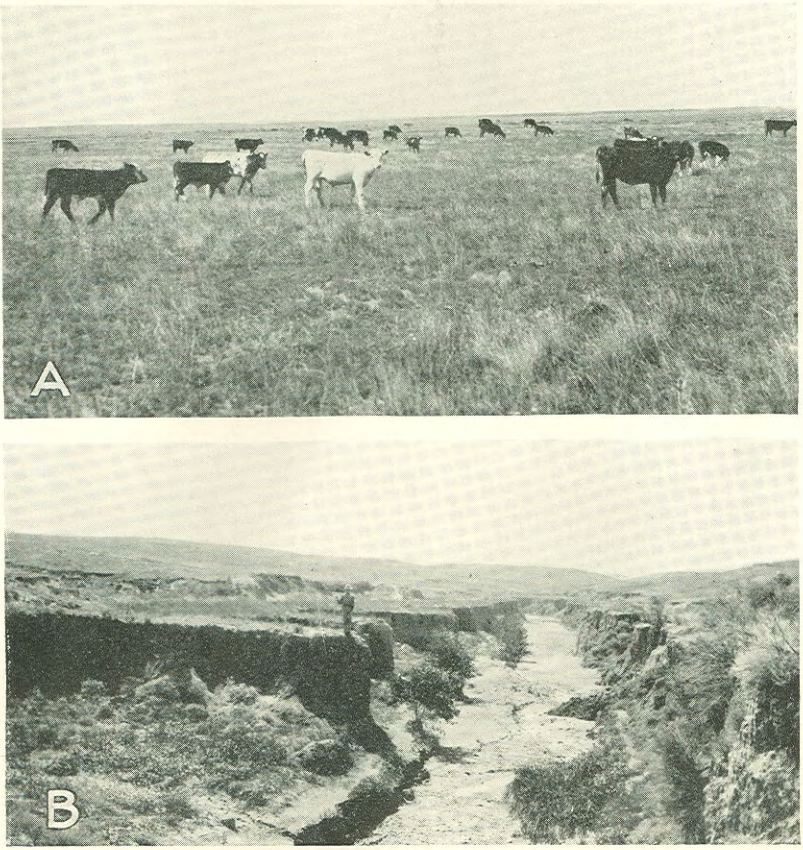
Terry silty clay loam.—Terry silty clay loam is brown or dark grayish brown in color, heavy in texture, and underlain at widely different depths by dull grayish-brown or dark grayish-brown heavy clay shale. Much of the soil has a thin covering of fairly friable brown clay or clay loam, and thin layers of sandstone are common in the subsoil. The soil occurs in two principal positions, on fairly steep slopes, where erosion has uncovered the shale, and in small valleys and basins where water or wind erosion has removed or almost removed the surface soil down to the shale. More persistent moist conditions have also aided in producing a very heavy soil.

In the southern part of Eastman Basin and 1 or 2 miles farther east are upland areas of this soil, some of which are dry farmed to small grains. Smaller bodies occur throughout the northeastern part of the area. A small body lies west of Black Hollow Reservoir, another west of Severance, and another, which is largely an outwash phase of the soil, is east of Windsor.

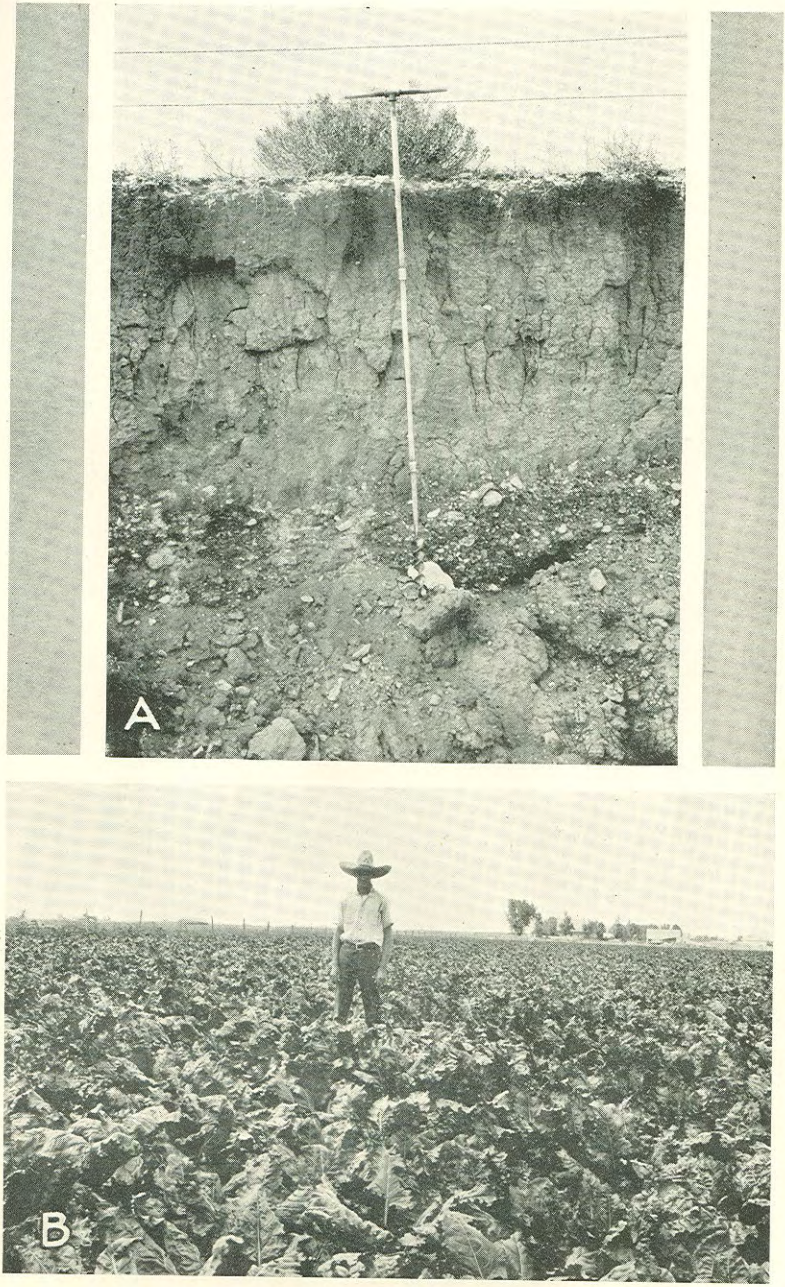
The most characteristic natural vegetation on this heavy soil is wheatgrass. In many places in the valley areas a wild vetch is common, and woolly loco is frequently seen.

SOILS OF THE GILCREST GROUP

The third important group of soils, the Gilcrest group, inclues the terrace or bench soils of the large stream valleys and the terracelike soils of the upland valleys now occupied by small



A, Cattle pasturing on the open range on the Terry soils; B, deep gullies in Terry soils caused by erosion



A, Profile of Gilcrest fine sandy loam near Owl Creek, showing dark surface soil, columnar structure, and gravel subsoil; B, sugar beets on Nunn clay loam near Olive Branch School

streams. They have the following characteristics: A nearly level, smooth surface soil, for the most part sandy and more or less mixed with gravel, a heavier subsoil, in many places having a well-defined layer of lime accumulation and a deep gravel subsoil. The soils of this group have rather important differences influencing the control of moisture, crop adaptation, and production, which justify their separation into several series and types. Soils of the Greeley, Fort Collins, Gilcrest, and Nunn series are included in this group.

The Greeley soils are brown or reddish brown to a depth of about 12 inches. The surface soil is more or less sandy and contains different amounts of waterworn gravel. The lower part of this reddish-brown layer, where exposed to weathering, shows a more or less columnar structure and breaks into sharp hard small clods. The second layer is lighter (more grayish) brown in color, heavier in texture, and the soil material also, particularly in the upper part, breaks into hard, irregular clods with white spots of lime accumulation. The layer also contains some waterworn gravel, heavily coated with deposits of lime. It extends to a depth ranging from 30 to 40 or more inches where it is underlain by well-rounded stream gravel and in many places by very micaceous limy more or less stratified material with a purple or pink tint.

The soils of the Fort Collins series differ from those of the Greeley series in having heavier dark-brown subsoils and in most places heavier surface soils. In thickness and arrangement of layers, they closely resemble soils of the Weld series. These soils are very important in the Fort Collins area, but in the Greeley area they cover only a small acreage.

The Gilcrest soils are less reddish brown in the surface soils than the Greeley soils, contain more fine sharp granite and quartz gravel and sharp coarse sand, and have less lime accumulation in the subsoil. The very deep well-drained subsoil consists of thick beds of fine sharp gravel.

Typical developments of these soils occur along the edge of the terrace a short distance north of La Salle. Here the surface soil, which is very slightly crusted, consists of brown light sandy loam containing small, sharp gravel. The soil material gradually becomes slightly heavier with increasing depth and shows a tendency to break with a columnar structure. The clods so formed are easily crumbled. Grass roots are abundant and tend to follow vertical cleavage planes. Below a depth of 16 or 18 inches, the subsoil is lighter, more grayish, brown, very slightly heavier, and contains a few small spots of lime accumulation and white coating on the small gravel which are abundant. Below a depth ranging from 30 to 36 inches is a thick bed of fine, sharp gravel, largely granite and quartz.

Four types and three phases of the Gilcrest series have been outlined on the soil map. They occupy broad terraces of South Platte River, along the south and southeast side of that stream, the terrace between the mouth of Thompson River and South Platte River, and the one between Cache la Poudre River and South Platte River east of Greeley. The town of Evans is on a narrow terrace of a Gilcrest soil. These soils also occur extensively in the northern part of the area, where they are closely associated with the Nunn soils.

The Nunn soils occupy a long basin or valleylike area extending from the northern boundary of the Greeley area north of Nunn to the valley of Cache la Poudre and South Platte Rivers east of Greeley.

They are characterized by their brown, reddish-brown, or grayish-brown color, by gravel, both sharp and waterworn, on the surface and throughout the surface soil and subsoil, by a large accumulation of lime in the subsoil especially in spots, here and there being of high concentration, by a layer of gray fine sand lying immediately above the gravel of the deep subsoil, and by both waterworn and sharp gravel beds in the deep subsoil. Water for pumping may be obtained at comparatively slight depths, 20 feet or less.

Greeley fine sandy loam.—Greeley fine sandy loam is extensively developed along the north side of Cache la Poudre River, extending from the county line west of Windsor to a point 2½ miles east of Farmers. South of Farmers it lies on the south side of the river and extends eastward to Greeley. It is also developed on the south side of Thompson River at Milliken and Johnstown.

This is a deep soil, having a light fine sandy loam surface soil and a heavier fine sandy loam or loam subsoil. A typical development may be seen at the gravel pits near the west end of Ninth Street, Greeley. Here, where the surface has been bare for some time and the soil has weathered thoroughly, is a 1-inch surface layer which is somewhat granular and well crusted. Below this is dark reddish-brown fine sandy loam which gradually becomes heavier with increasing depth and shows a well-defined columnar structure, breaking into somewhat regular clods from one-half to 1 inch in diameter, but the clods are easily crumbled. Plant roots tend to follow the vertical cleavage planes. The reddish-brown surface soil in this locality extends to a depth of nearly 18 inches. Below it is light-brown or gray very fine sandy and silty soil containing much stream gravel. Lime is present in small irregular spots and as a coating on the stream gravel. Below a depth of 40 inches is stream gravel and sand, the sand occurring in thin layers and lenses.

In the area described the edge of the terrace ranges from 40 to 60 feet or more above the level of the lower river valley and from 20 to 40 feet above the level of the lower terrace on which the greater part of the city of Greeley is situated.

Greeley fine sandy loam, sandy phase.—Southwest of Windsor is a large area in which the typical Greeley fine sandy loam of the terrace has been covered by recent wind-blown loamy fine sand to a depth ranging from 12 to 24 or more inches. Numerous smaller areas of this kind have not been outlined. Between Farmers and Seeley Lake small areas, which are included with the typical soil in mapping, lie slightly lower than the average level of the terrace. Here the soil is heavier in texture, owing to its development under more moist conditions and to deposits of heavier material carried in by rainfall and irrigation water.

Greeley fine sandy loam, low-lying phase.—In places an intermediate or lower-lying terrace lies between the level of the higher terraces on which typical Greeley fine sandy loam is best developed and the flood plain of the river. The larger part of the city of Greeley is situated on such a terrace, the soil of which is mapped as

a low-lying phase of Greeley fine sandy loam. The surface soils as a rule are somewhat more sandy and gravelly and the heavy subsoil is slightly less developed than in the typical soils.

In numerous places where small streams enter the main valleys, as at the mouth of Sheep Draw, small deltas of recently deposited material have formed. At other places at the foot of steep slopes, such as those along the north side of the valley near Milliken, there are alluvial fans. These soils, although somewhat different from those of the low terrace, because more recently deposited and not so well weathered, have been included with the low-lying phase.

All of the Greeley fine sandy loam areas, together with the phases, are under irrigation, highly cultivated, and productive. The low-lying phase near Greeley is used for alfalfa, sugar beets, and miscellaneous crops, as cabbage, tomatoes, melons, flowers, and onions.

Greeley clay loam.—This soil is darker brown and heavier than the other soils of the Greeley group. In texture it ranges from heavy loam to clay. It is not strictly a terrace soil but is partly the result of heavier material washed into the valley by small local streams and partly the result of breaking down of the soil under poor drainage. An area is mapped east of Windsor, and two small areas are south of Neff Lake. This soil is used for the same crops as the surrounding soils. It is productive but more difficult to cultivate.

Fort Collins loam.—In Fort Collins loam the surface soil is heavier and contains less gravel and the subsoil is heavier and deeper than the corresponding layers of Greeley fine sandy loam. One small area of this soil lies on the north side of Thompson River along the Weld County line, and another is southwest of Johnstown. The land is highly productive and is used for alfalfa, sugar beets, small grains, and other crops.

Gilcrest sand.—The surface soil of Gilcrest sand ranges in texture from sand to loose, sharp coarse sand. It is underlain at rather widely different depths by sandy or coarse sandy and gravelly loam and this, in turn, by heavy beds of fine sharp stream gravel. This soil has developed in part from deposits of recent wind-blown sand. An area including about 3 square miles lies along the edge of the terrace northwest of Peckham.

Gilcrest gravelly sandy loam.—Gilcrest gravelly sandy loam has a brown gravelly sandy loam surface soil containing some coarse sharp sand. Where exposed to weathering it is strongly crusted 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 granitic and quartz gravel with very little finer material. The surface is slightly uneven, small mounds and ridges being as a rule more sandy and gravelly than the surrounding soils. The gravel from many areas is used for building purposes.

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

This soil is typically developed on an old high terrace of South Platte River between Gilcrest and Milliken. The largest area lies south of the river, and a smaller one occupies the point of a high

terrace between Thompson and South Platte Rivers east of Milliken. The soil in a part of this last-named area is very light, sandy, and gravelly. Small areas lie along the north side of Cache la Poudre and South Platte Rivers.

In the northern part of the area, at Nunn, south of Pierce, and along the west side of Owl Creek and Lone Tree Creek Valleys are extensive areas which have been included with this soil in mapping. Both of these streams are at present small but must at one time have been much larger, to have carried the immense quantities of gravel now found in the subsoil from the old gravelly outwash plain to the north.

This soil in the northern part of the area differs from that in the southern part in having a slightly finer texture, a shallower surface soil, and a less uniform subsoil. It is also more gravelly and shallower toward the north, or upstream, and grades heavier, deeper, and less gravelly toward the south. The shallower phases may be seen in many places around Nunn where the soil tends to be droughty and has a low crop value. Farther south it is deeper, slightly heavier, and more productive. This heavier phase is well exposed at an old gravel pit 3 miles east of Eaton.

Much of this soil in the northern part of the area is not under irrigation, being dry farmed to small grains or used as grassland.

Gilcrest gravelly sandy loam, heavy-subsoil phase.—This phase of Gilcrest gravelly sandy loam differs from the typical soil in being slightly deeper, a little heavier in texture, and in having, at a depth usually 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 limy material.

This soil extends in a belt along United States Highway No. 85 from La Salle to the southern boundary of the area. Eastward from La Salle it extends along the north edge of the terrace to Kuner, and occupies that part of the terrace lying between South Platte and Cache la Poudre Rivers east of Greeley. East of Gilcrest it grades, with no sharp line of demarcation, into soil which has a deep covering of recent wind-blown sand.

Soil of this phase is more productive than the typical soil. It is used for the production of all crops common to the region but especially for growing early potatoes. It is considered the best early potato soil in the area, because it becomes warm early in the spring, is well drained, yet holds moisture sufficiently well.

Gilcrest gravelly sandy loam, heavy phase.—In places this soil is slightly heavier and deeper than the typical soil, and it contains in the lower part of the subsoil fine and very fine sharp gravel and coarse sharp sand instead of waterworn gravel. It seems to have a slightly higher productive value than the typical soil. An area of this heavy soil is mapped west and south of Cloverly. The Colorado Potato Experiment Station is located on a small area of this soil south of Cloverly.

Gilcrest loam.—The 10 to 12 inch surface soil of Gilcrest loam is dark-brown light-textured loam containing different amounts of fine sharp gravel. Where exposed to weathering, the surface soil is well crusted. Below the surface soil and extending to a depth of about 30 inches is dark grayish-brown heavy loam or clay loam, which

breaks into hard somewhat regular clods where exposed to weathering. Underlying this layer in most places is a bed of fine sharp gravel. This bed, however, is probably thin, and, owing to the position of this soil at the outer edge of the terrace, the gravel bed doubtless in many places overlaps the shale and sandstone of the adjacent slopes. For this reason underdrainage of much of the soil is poor. Seepy and alkali areas are common, and the soil as a whole is of rather low agricultural value.

The principal body of this soil extends along the outer edge of the terrace following the Union Pacific Railroad from Auburn to a point 1½ miles east of Kersey.

Gilcrest fine sandy loam.—The surface soil of Gilcrest fine sandy loam is brown or grayish-brown fine sandy loam which becomes lighter in color below a depth of 6 or 8 inches. Where exposed to weathering it has a well-defined columnar structure. Abundant plant roots and small white specks of lime follow the cleavage planes. Below a depth of 18 inches the material is heavier fine sandy loam containing large white spots of lime accumulation. Below a depth of 30 inches stream gravel is present. (Pl. 4, A.) This soil is partly terrace soil and partly first-bottom soil, but the areas are so closely associated that separation does not seem justified. In the first bottoms it is in places very shallow and gravelly and in others contains much alkali. Very little of the land is under cultivation, and except for grassland it has low agricultural value. This soil extends as long narrow strips along the channels of Owl, Lone Tree, and Crow Creeks, occupying the narrow flood plains and lower parts of the adjacent terraces.

Gilcrest fine sandy loam, heavy phase.—Along Crow Creek east of Gill is an area of gray fairly heavy Gilcrest fine sandy loam which is deep and contains gravel in the lower part of the subsoil. This is shown on the map as a heavy phase of the typical soil. This land is under cultivation and seems to return fair yields of corn, alfalfa, beans, and other crops.

Nunn clay loam.—Nunn clay loam differs from Gilcrest gravelly sandy loam in being darker brown in color, heavier in texture, deeper to the gravel subsoil, and as a whole more productive. It is also more difficult to handle. It stretches as long narrow belts from northwest to southeast and occupies as a rule lower and less well-drained parts of the basin in which it occurs. It is typically developed along the State highway between Olive Branch and Wyatt Schools.

It is used in the production of alfalfa, small grains, late potatoes, sugar beets (pl. 4, B), and other crops. In the northern part of the area it is used for dry farming to small grains and gives fair yields.

Figure 5 shows the crops grown in 1929 on a section of land southwest of Olive Branch School. The soil included is mainly Nunn clay loam and the rest is a good grade of Gilcrest gravelly sandy loam.

The percentages of the various crops on this section are as follows: Alfalfa, 29.2; sugar beets, 20.6; potatoes, 12.2; small grains alone, 12.0; small grains with alfalfa, 4.4; corn, 8.3; miscellaneous crops, 0.8; cabbage, 1.1; beans, 10.0; onions, 0.3; and sorghum cane, 1.1.

Nunn clay loam, heavy phase.—This phase of Nunn clay loam is lighter in color than the typical soil, being more grayish brown. It is heavier in texture, ranging from heavy clay loam to clay, is nearly free from gravel in the surface soil and upper part of the subsoil, and in places includes seepy and alkali spots. The principal area lies west of Alden. The land is of lower agricultural value than the typical soil.

Nunn clay loam, silty phase.—To a depth of about 12 inches, this phase of Nunn clay loam consists of dark grayish-brown silt loam or silty clay loam showing, where exposed to weathering, a well-defined columnar structure. The material is nearly free from gravel. It is underlain by lighter grayish-brown clay loam which below a depth of 36 inches grades into light-gray fine sandy loam and thence into stream gravel. Soil of this phase is rather variable. The larger part of it is well drained and productive. The principal area lies 2 miles south of Gill.

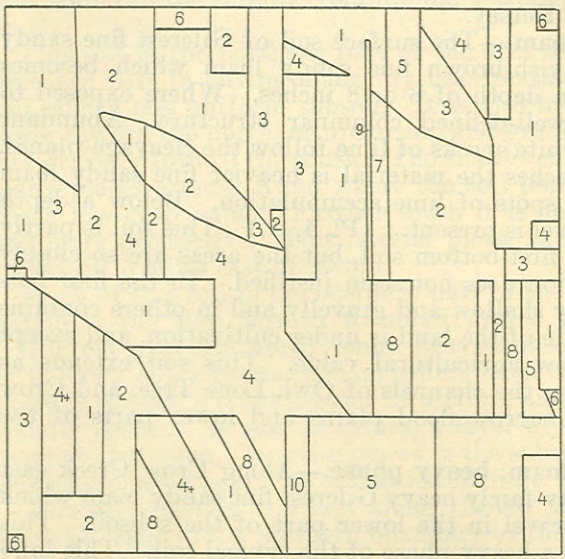


FIGURE 5.—Section 28, T. 8 N., R. 65 W. Proportion of Nunn clay loam devoted to various crops: 1, Land in alfalfa; 2, land in sugar beets; 3, land in potatoes; 4, land in small grains alone; 4+, land in small grains with alfalfa; 5, land in corn; 6, land in miscellaneous crops; 7, land in cabbage; 8, land in beans; 9, land in onions; 10, land in sorghum cane

SOILS OF THE LARIMER GROUP

Covering a small part of the high uplands in the northwestern and northeastern parts of the area and capping lower small hills and ridges, especially near the valleys of the larger streams, are sandy and gravelly soils. The surface soil is in most places shallow and the subsoil is very gravelly, the gravel being embedded in a heavy layer of lime. These lime or hardpan layers are best developed along the edges of terraces and on hill slopes where seepage water has carried lime to the surface and there deposited it. The observation tower at Greeley stands on a narrow ridge of this formation, good exposures of which may be seen along the road to the city reservoir. These areas are remnants of an old high gravelly and sandy outwash plain which probably at one time covered not only this entire region but extended much farther east. They are correlated as Larimer soils and are divided into two types, fine sandy loam and gravelly loam. The fine sandy loam has a shallow phase.

Larimer fine sandy loam.—The 1-inch moderately crusted surface layer of Larimer fine sandy loam is dark brown or dark reddish brown. Below this is dark reddish-brown heavy fine sandy loam

which, in exposed cuts, breaks into long, somewhat regular, fairly hard clods. This material effervesces very slightly with acid. At an average depth of about 16 inches, this layer is underlain by light grayish-brown fine sandy loam, breaking into irregular clods which are fairly easily broken. It contains lime in white spots and as coatings along cleavage planes in the upper part, and as a massive layer in the lower part. Below a depth ranging from 30 to 36 inches this material is underlain by a light-brown gravelly fine sandy loam, the quantity of gravel in many places increasing with depth.

Large amounts of small sharp, and some rounded, granite and quartz gravel are scattered over the surface and through the surface soil and subsoil, the amount differing from place to place and in much of the area being so abundant that the material is gravelly fine sandy loam.

The principal bodies of this soil occupy high fairly level uplands in the northwest and northeast parts of the area. Their total extent is 38.7 square miles. The land is used for dry farming, principally to wheat. It holds moisture well and is productive.

Larimer fine sandy loam, shallow phase.—This shallow soil occupies the higher parts of the uplands near the valley of Cache la Poudre River. The surface soil is brown or reddish-brown sandy and gravelly loam underlain at an average depth of about 10 inches by rounded and waterworn stream gravel embedded in a layer of white material, a large part of which is lime. Below an average depth of about 30 inches the gravel is very abundant in many places, but here the soil material is nearly free from lime accumulation.

This soil is less productive than typical Larimer fine sandy loam, but a large part of it is under irrigation and is used for beans, alfalfa, corn, and other crops.

The principal areas of this shallow soil occupy the uplands north and northeast of Windsor and southwest of Greeley. The total area occupied by this soil is 6.9 square miles.

Larimer gravelly loam.—Larimer gravelly loam consists of reddish-brown shallow gravelly loam in which rounded stream gravel is abundant. At a depth between 8 and 12 inches heavy beds of waterworn gravel are reached. The gravel are coated with lime and embedded in a white layer of almost pure lime. This lime and gravel layer extends to a depth ranging from 3 to 4 feet below the surface and in most places is underlain by uncemented beds of sand and gravel, and these, in turn, by sandstone and shale.

This soil occupies the tops of high small rounded hills and narrow ridges well distributed over the higher parts of the area. The land is nonagricultural except for the small amount of forage which it produces. The total area is small.

SOILS OF THE VALENTINE GROUP

The soils of the Valentine group are developed largely from recent wind-blown material, mainly sand and fine sand. In general, the sand is coarsest near the flood plain and terraces of the South Platte River Valley and grades finer toward the south, indicating that the river bed is the source of at least a part of the material. Valentine loamy fine sand and its heavy-subsoil phase are the predominant soils

in the southeast part of the area south of Kersey and east of Gilcrest. These soils differ but slightly from the sandier types of the Terry group.

Valentine loamy fine sand.—The surface soil of Valentine loamy fine sand consists of brown or slightly dark brown loamy fine sand which is loose and incoherent, or nearly so. Below a depth ranging from 24 to 30 inches this material grades into lighter-brown or more yellowish-brown loamy fine sand and sand. This soil as a rule occurs as broad undulating areas, as ridges, and in places as well-formed dunes. Some of it has been under cultivation, but when the native sod is destroyed the soil blows badly and its agricultural value for cultivated crops is very low.

Included with this soil in mapping is a small body of dune sand lying east of Boxelder Creek, and smaller areas of the same material occupy parts of the divides on both sides of Beebe Draw. North of South Platte River are several belts of the loamy fine sand having a general northwest-southeast trend. As a whole the soil in these areas is somewhat less loose and incoherent than that in the areas south of the river.

Valentine loamy fine sand, heavy-subsoil phase.—Soil of this phase consists of brown or slightly dark brown loamy fine sand and sand to a depth ranging from 30 to 36 inches, where it is underlain by a layer of heavier soil. This heavier material may be due to slight weathering and the carrying down of heavier material, to the deposition of an old soil, slightly darker in color and heavier at the surface, which has been covered up, or to deposition over an old stream-valley, or alluvial, soil.

Because the heavy subsoil conserves moisture well, this soil is fairly productive. A large part of the land is under irrigation and is used for alfalfa, beans, corn, small grains, and other crops of the area.

Figure 6 shows the kind of crops grown in 1929 on a section, composed largely of this phase of soil, 1½ miles south of Kersey. The soil here, however, lacks uniformity and in some of the lower places, under irrigation, many small seepy areas occur.

The percentages of land devoted to various crops are as follows: Alfalfa, 32.8; sugar beets, 4.2; potatoes, 5.3; small grains alone, 8.6; small grains with alfalfa, 10.8; corn, 16.4; miscellaneous crops, 0.3; beans, 16.1; and grassland, 5.5.

East of Pierce and Nunn, in the northeastern part of the area, are some included bodies of Valentine fine sandy loam which are associated with the gravelly soils of the Gilcrest series but which resemble a very light phase of Weld fine sandy loam as mapped in other parts of the area. These differ from the typical soil in being lighter in texture and in having, below a depth ranging from 3 to 5 feet, gravel deposits and in places heavy accumulations of lime. These soils occur, for the most part, on low, broad ridges which have the same general trend as the belts of Gilcrest soil, but they are slightly higher. They are used for dry farming to wheat and beans and are productive. They seem to be partly of alluvial origin but have been modified by a wind-blown covering of sand. They have been included with Valentine loamy fine sand, heavy-subsoil phase.

SOILS OF THE CASS GROUP

Soils of the Cass group are of comparatively recent alluvial origin, dark in color, have no well-developed layers due to soil processes, have a high water table, and in the valleys of the larger streams have a gravelly subsoil. This group includes the Cass and Kuner soils in addition to river wash.

Soils in the flood plains of Cache la Poudre, South Platte, Thompson, and Little Thompson Rivers, which have dark-colored, highly micaceous surface soils and gravelly deep subsoils have been placed in the Cass series.

The soils of the Kuner series have brown or dark grayish-brown stratified surface soils, largely of alluvial origin, and fine sandy loam subsoils which are underlain at a comparatively slight depth by soft yellowish-brown sandstone.

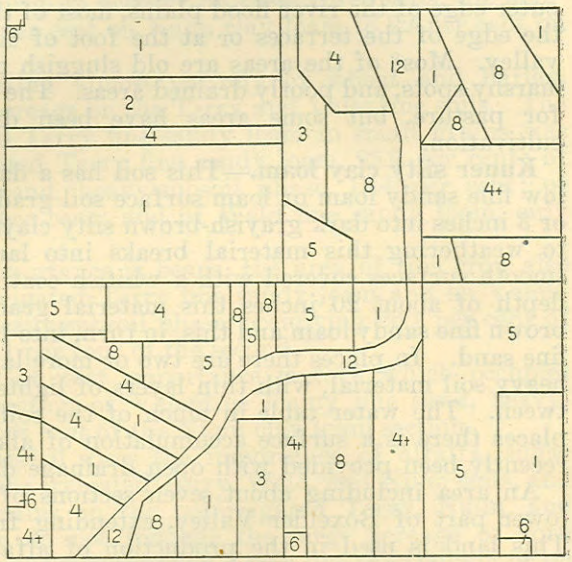


FIGURE 6.—Section 33, T. 5 N., R. 64 W. Proportion of Valentine loamy fine sand, heavy-subsoil phase, devoted to various crops: 1, Land in alfalfa; 2, land in sugar beets; 3, land in potatoes; 4, land in small grains alone; 4+, land in small grains with alfalfa; 5, land in corn; 6, land in miscellaneous crops; 8, land in beans; 12, land in grass

Cass fine sandy loam.—Cass fine sandy loam is the main agricultural soil of this group. It is dark grayish brown or nearly black, in places having a slight purple tint, is very micaceous, usually light in texture in the surface soil, and in places contains stream gravel in different amounts. Below a depth of 8 or 10 inches the material grades into heavier fine sandy loam and this, at a depth ranging from 18 to 24 inches, into lighter-colored sandy loam mottled with rust brown and gray. The mottled layer is only a few inches thick and is underlain by stream gravel. This soil as mapped includes many small areas of gravel and sand, some of coarse sandy loam, and numerous seepy and marshy areas and sluggish, partly filled old stream channels. A large part of Cass fine sandy loam is cultivated, and where drainage is good fair yields of beans, corn, alfalfa, and other crops are obtained.

Cass fine sandy loam, shallow phase.—Areas of Cass fine sandy loam in which the finer material overlying the gravel is very thin have been indicated on the soil map as a shallow phase. The combined thickness of the black surface soil and the lighter-colored upper subsoil layer is less than 18 inches. The average thickness of the true soil is less than 12 inches. The sandy and gravelly substratum is similar to that underlying the typical soil. The agricultural value of this soil is lower than that of the typical soil.

Cass fine sandy loam, deep phase.—A deep phase of this soil, in which the surface soil is somewhat heavier, is free from gravel, and the dark-colored sandy soil ranges from 3 to 5 feet in depth before gravel is reached, has been separated and mapped. This deep soil is fairly well drained and is highly productive.

Cass clay loam.—The 6 to 10 inch surface soil of Cass clay loam is dark-brown or dark grayish-brown loamy micaceous material. It is underlain by dark grayish-brown heavier loam, clay loam, or clay, containing streaks and bands of lighter gray and rust brown, and, where exposed to weathering, showing a well-developed cloddy structure. At an average depth of about 3 feet this material is underlain by stream gravel.

Numerous small and some larger areas of this soil extend along the outer edge of the river flood plains, most of them immediately below the edge of the terraces or at the foot of the slopes bordering the valley. Most of the areas are old sluggish cut-off stream channels, marshy spots, and poorly drained areas. The land is used principally for pasture, but some areas have been drained and are under cultivation.

Kuner silty clay loam.—This soil has a dark grayish-brown shallow fine sandy loam or loam surface soil grading below a depth of 2 or 3 inches into dark grayish-brown silty clay loam. Where exposed to weathering this material breaks into large hard clods having smooth surfaces covered with a whitish coating. Below an average depth of about 20 inches this material grades into light grayish-brown fine sandy loam and this, in turn, into light fine sandy loam or fine sand. In places there are two or more layers of the dark-brown heavy soil material, with thin layers of lighter-brown sandy soil between. The water table in much of the soil is high, and in many places there is a surface accumulation of alkali. A large area has recently been provided with open drainage ditches.

An area including about seven sections of this soil occupies the lower part of Boxelder Valley, extending from Kuner southward. This land is used in the production of alfalfa, sugar beets, small grains, and other crops, and it produces well.

Kuner fine sandy loam.—Kuner fine sandy loam consists of light grayish-brown light-textured fine sandy loam, stratified with lighter and darker colored layers and grading into more or less mottled gray and rust-brown fine sandy loam or fine sand below a depth of 24 inches. At a depth ranging from 3 to 5 feet this material is underlain by soft yellowish-brown sandstone. The water table is high, and numerous seepy and marshy spots occur. Alkali is present and white crusted spots are common. Some areas are under cultivation.

This soil occurs around the border and in the upper part of Boxelder Valley and in Beebe Draw. In many places it has been modified or entirely covered by sand blown in from the adjoining sandy areas.

River wash.—The larger streams of this region flow in broad shallow channels, carry large quantities of sand and fine sharp gravel, and change their channels frequently. The result is a broad strip of gravelly and sandy river-wash material which has no agricultural value except for the pasturage and timber it affords. In places it has a shallow covering of soil and supports a growth of salt grass and other grasses, sweetclover, and cottonwoods.

UTILIZATION OF THE GREELEY AREA SOILS

Figures 2 to 6 show the proportionate acreage of various crops grown on several types of soil in 1929.

The most striking facts brought out by a study of these figures are set forth in the following paragraphs.

The large proportion of the irrigated soils used for alfalfa. This ranges from 26.7 per cent in Terry fine sandy loam to 39.7 per cent in Weld fine sandy loam. This does not include a large acreage of young alfalfa in the grainfields. The crop of second importance in point of acreage on the Weld and Terry fine sandy loams and on Nunn clay loam is sugar beets. This acreage ranges from 20.6 per cent on Nunn clay loam to 25 per cent on Weld fine sandy loam. Potatoes are the third crop in acreage on these three soils, the acreage ranging from 12.2 per cent on Nunn clay loam to 22 per cent on Weld fine sandy loam.

Small grains, consisting almost entirely of wheat and barley, occupy a much larger acreage on the Terry and Valentine soils. The acreage of nonirrigated Terry fine sandy loam in small grains was 30.3 per cent; of irrigated Terry fine sandy loam, 25.2 per cent; of Valentine loamy fine sand, heavy-subsoil phase, 19.4 per cent; of Nunn clay loam, 16.4 per cent; and of Weld fine sandy loam, only 10.3 per cent.

The crop of next importance is beans, the area of this crop also being largest on nonirrigated Terry fine sandy loam and on Valentine loamy fine sand, heavy-subsoil phase, occupying 26.1 per cent of the first section and 16.1 per cent of the second.

The cultivated crop of next importance is corn which occupies 16.4 per cent of the section of Valentine loamy fine sand, heavy-subsoil phase, and 8.3 per cent of the Nunn clay loam section.

Figures 2, 3, 4, 5, and 6 show the importance of alfalfa, sugar beets, and potatoes on the irrigated Terry, Weld, and Nunn soils, and of beans and small grains on the nonirrigated Terry, Nunn, and Valentine soils. They do not indicate the large acreage of corn grown on many sections of nonirrigated Terry fine sandy loam or on Valentine loamy fine sand, heavy-subsoil phase. Figure 2 shows no acreage of beans although Weld fine sandy loam is used in places rather extensively for this crop, especially for seed beans grown under contract.

SOILS AND THEIR INTERPRETATION

The Greeley area lies near the western edge of the Great Plains. The weathered soils are reddish brown to an average depth of about 14 inches. All weathered soils of this region are covered by a thin finely granular, slightly crusted mulch, which is deepest and most strongly crusted in the heavier soils. This mulch, however, is not so deep nor so well developed as in the slightly more arid regions in the southern part of the State. The lower part of the reddish-brown layer shows a tendency in weathered exposures to break with a columnar structure forming sharp hard clods from one-fourth to one-half inch in diameter. Below this is a lighter, more grayish-brown, layer which also breaks into hard clods, most of which are larger than those of the reddish-brown

layer, and in this layer, which extends to an average depth of about 30 inches, are small white spots of lime accumulation, in places forming soft concretionary masses. These are most abundant in the upper part of the layer. Below the lighter-colored layer is the parent material which may be old wind-blown material, sandstone and shale material, old outwash sandy and gravelly material, or old alluvial or stream-terrace material. Separation into soil groups has been based very largely on the character of the deep subsoil, an important factor in conservation of moisture and depth of rooting.

This is a region of short-grass and rather scant natural vegetation. The wind movement is good, and evaporation is rather high. Organic matter in the soil, except in the stream flood plains, is scant. As a whole, however, the soils seem slightly darker at the surface than those of the Arkansas Valley in the southern part of the State. The surface soils of the greater part of the Greeley area do not effervesce with acid, whereas those in the Arkansas Valley do. The layer of lime accumulation is also slightly deeper in the Greeley area.

Owing to the sandy character of the greater part of the soil of this region, leaching is comparatively rapid. Water erosion and gullying on the steeper slopes bordering the larger valleys is in places deep, but over the area as a whole is not serious. Wind erosion, however, is much more serious. Plowed fields left bare and smooth soon have the surface soil swept off and piled high against fences and in roadways. Young crops are cut off by the sand in places and in other places are deeply covered. In very sandy areas "blowholes" are scooped out, and the sand is piled in dunes or spread over the valleys. Many sandy areas have been spoiled for pasture by breaking up of the sod and are of but little value for cultivated crops. Parent soil material of the flood plains and adjacent terraces of the larger streams, except the South Platte, seems to come largely from igneous and metamorphic rocks modified by eroision from the red sandstones. That of the South Platte region consists very largely of granitic and quartz material.

The material of the Terry soils is derived very largely from the light yellowish-brown soft fine-grained sandstone and the grayish-brown or dark grayish-brown soft clay shales of the Fox Hill and Laramie formations of the Upper Cretaceous (*3*). These differ slightly in color, texture, and hardness from the Pierre formation from which the Terry soils of the Fort Collins area are derived.

The wind-blown soil material is very largely of local origin, having been eroded from the sandstone hills and blown up from the river flood plains.

The Larimer soils have a very highly developed carbonate layer. In places the heavy accumulation of carbonate around the gravel has the appearance of a soft hardpan, or caliche, but could not be considered a true lime hardpan. In other soils, especially in the terrace and terracelike soils of the Gilcrest and Nunn series, are numerous spots of high lime accumulation. In the Terry soils heavy lime accumulations occur in places at the top of the underlying sandstone or shale, apparently precipitated at the point where the downward movement of ground water is checked.

The pH determinations by the colorometric method for a large number of soil samples gave practically the same results for all

well-weathered soils, the general average being as follows: From 0 to 6 inches, the pH is 7; from 6 to 15 inches, it is 7.1+; from 15 to 30 inches, it is 7.3−; and from 30 to 60 inches, it is 7.4−.

The average pH determination for a number of samples of Valentine loamy fine sand and of Valentine loamy fine sand, heavy-subsoil phase, was as follows: From 0 to 6 inches, 6.9; from 6 to 12 inches, 6.95; from 12 to 30 inches, 7; and from 30 to 60 inches, 7.1. The heavy-subsoil phase of Valentine loamy fine sand is very slightly more basic than is the loamy fine sand. The sands as a whole are also rather distinctly less basic than the well-weathered soils of heavier texture.

Soils of recent alluvial origin seem to be slightly less dark grayish brown in color and to contain somewhat less, but more finely divided, mica, than the same soils nearer the mountains. This is doubtless due to the influence of material carried in by the small tributary streams.

The large masses of gravel in the subsoil of the Nunn soils have undoubtedly been eroded from the heavier beds of old outwash material to the north. No such beds occur in the valley of Boxelder Creek or Beebe Draw because these streams do not head in, or drain, such gravelly areas.

Owing to the fact that the soils are unleached and as a rule well supplied with plant food, moisture, rather than soil, seems to be the controlling factor, and most soils produce well if water is properly applied. For this reason differences in soil types are not reflected so strongly in crop production as in regions of greater rainfall and leaching.

SUMMARY

The Greeley area covers 803 square miles in the western part of Weld County in the north-central part of Colorado. This is about one-fifth of the area of the county but includes the larger part of the irrigated land.

About three-fourths of the area surveyed is under irrigation. The larger part of it has been under cultivation from 30 to 60 years. Large areas are dry farmed. The leading crops are alfalfa, sugar beets, potatoes, and small grains. Crops second in importance are beans and corn. A number of miscellaneous crops are grown.

Much land is farmed intensively, and farm methods are good. The condition of the soil, farm equipment, and improvements indicate prosperity.

The soils of the area are divided into six main groups, the separation being based largely on subsoil conditions. These are as follows: Well-weathered soils, largely from old wind-blown material, which have deep friable fine sandy loam subsoils, the Weld group; soils which have at widely different depths a subsoil of fine-grained soft sandstone or shale, the Terry group; soils of old flood plains and broad valleys which have deep well-drained gravelly subsoils, the Gilcrest group; sandy and gravelly soils with waterworn gravel embedded in heavy lime layers in the subsoil, the Larimer group; recent wind-blown sand and fine sand, the Valentine group; and dark-colored micaceous recently deposited soils of the larger stream flood plains with gravel subsoils and a high water table, the Cass group.

LITERATURE CITED

(1) COLORADO STATE BOARD OF IMMIGRATION.
1926–1931. YEAR BOOKS OF THE STATE OF COLORADO . . . Compiled and edited by T. R. Ingram. Agriculture. 1926 year book, p. 53–115 illus.; 1931 year book, p. 61–134, illus.

(2) HEMPHILL, R. G.
1922. IRRIGATION IN NORTHERN COLORADO. U. S. Dept. Agr. Bul. 1026, 85 p., illus.

(3) MATHER, K. F., GILLULY, J., and LUSK, R. G.
1928. GEOLOGY AND OIL AND GAS PROSPECTS OF NORTHEASTERN COLORADO. U. S. Geol. Survey Bul. 796B, p. 65–124, illus.

(4) PARSHALL, R. L.
1922. RETURN OF SEEPAGE WATER TO THE LOWER SOUTH PLATTE RIVER IN COLORADO. Colo. Agr. Expt. Sta. Bul. 279, 72 p., illus.

(5) SHANTZ, H. L.
1911. NATURAL VEGETATION AS AN INDICATOR OF THE CAPABILITIES OF LAND FOR CROP PRODUCTION IN THE GREAT PLAINS AREA. U. S. Dept. Agr., Bur. Plant Indus. Bul. 201, 100 p., illus.

(6) SWEET, A. T.
1928 SOIL FACTORS INFLUENCING CROP PRODUCTION IN THE ARKANSAS VALLEY, COLORADO. U. S. Dept. Agr. Circ. 55, 25 p., illus.

(7) UNITED STATES GEOLOGICAL SURVEY.
[1902] GREELEY QUADRANGLE. U. S. Geol. Survey Sheet Ed. 1902.

(8) ———
[1910] EATON QUADRANGLE. U. S. Geol. Survey Sheet Ed. 1910.

○

[PUBLIC RESOLUTION No. 9]

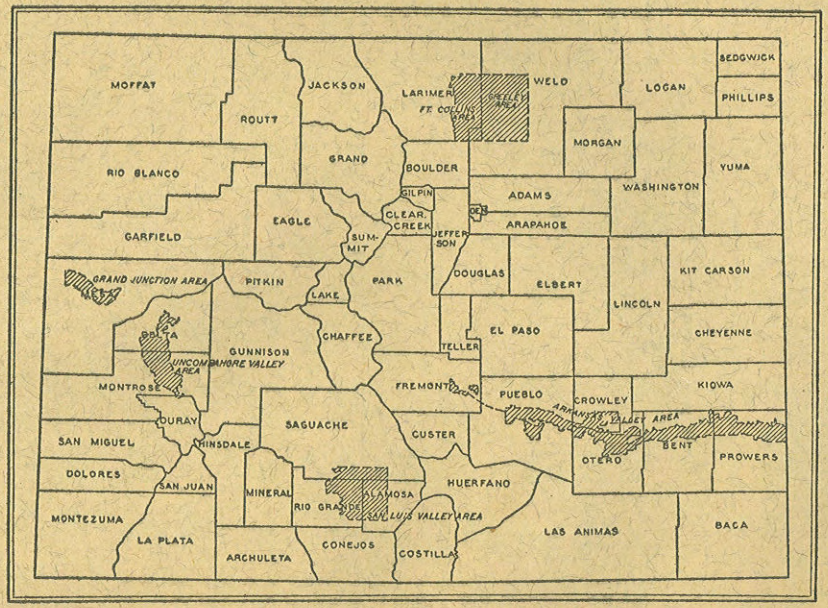
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Colorado, shown by shading

U. S. GOVERNMENT PRINTING OFFICE: 1932

NRCS Accessibility Statement

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at 1-800-457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.