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Soil Survey

Johnson County Wyoming

By
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UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
In cooperation with the
University of Wyoming Agricultural Experiment Station

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CONTENTS

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COUNTY SURVEYED

Johnson County is in the north-central part of Wyoming (fig. 1). The county is nearly rectangular, with a length from north to south of about 75 miles, and a width from east to west of 55 miles. The total area is 4,164 square miles, or 2,664,960 acres.

Johnson County forms a part of two well-marked physiographic regions—the Big Horn Mountains and the Great Plains—which have, in general, sharply contrasted surface features, although minor details of relief determine, to a large extent, the utilization of the land. On the basis of similarity in the features of relief which are of economic importance, the county may be divided into four principal belts: (1) The Big Horn Mountains, (2) the mountain foothills and valleys, (3) the sharply rolling plains, and (4) the gently rolling plains. Figure 2 shows, in a general way, the location and extent of these belts. These divisions are based on the predominance of certain characteristics in the several belts, none of which is uniform over the entire belt, as each belt may include comparatively small areas characteristic of other belts.

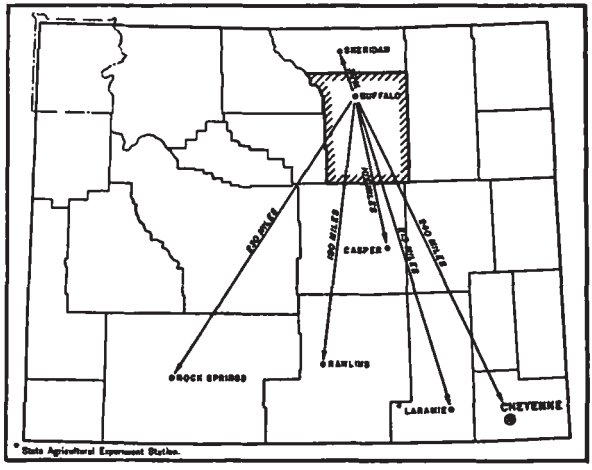

FIGURE 1.—Sketch map showing location of Johnson County, Wyo.

The eastern part of the Big Horn Mountains occupies a belt ranging from 15 to 20 miles in width on the western side of the county, and, for a distance of about 40 miles, the highest ridge of these mountains forms the western boundary of the county. The eastward-facing slope rises abruptly from the general level of the plains, which

are about 5,000 feet above sea level, and, within a distance of several miles, attains an altitude of about 8,000 feet. The mountain slopes are severely eroded, but the greater part of them retains a thin soil covering which supports a forest growth. Numerous streams

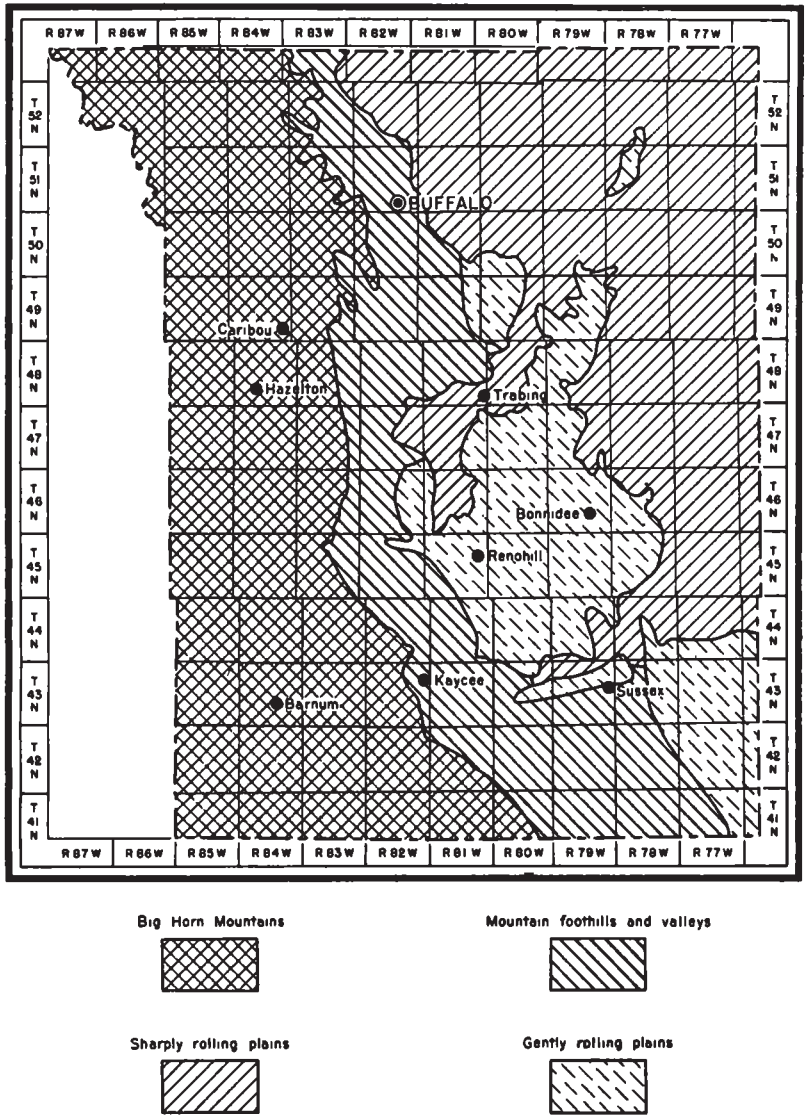

FIGURE 2.—Sketch map showing physiographic belts of Johnson County, Wyo.

descend from the mountains through rocky canyons, but the stream valleys widen rapidly as they emerge onto the plains.

After the first precipitous ascent from the plains, the upward slope of the mountains is more gradual. A belt about 15 miles wide is characterized by less rugged surface features and consists of a succession of rounded ridges, with intervening sharply cut valleys

and gorges, and a few ridges, knobs, and peaks rising above the surrounding country. The tops of a few ridges are nearly flat and include small areas having deficient drainage. An area of undulating land, which is grass-covered except where patches of trees grow on the rockier and shallower soils, lies south and east of Hazelton. West of this belt the more rapid ascent is resumed, and within a few miles the altitude attains a maximum in the highest part of the Big Horn Mountains. In the northwestern part of the county, the dividing ridge ranges in height from 10,000 to 11,500 feet, and it consists of a succession of sharply rounded summits and ridges, with several rocky peaks that rise above the timber line. Cloud Peak, just outside the northwestern boundary, in Big Horn County, has an elevation of 13,165 feet.

The foothills and valleys at the base of the mountains have a great variety of surface features and corresponding soils. The bedrocks are sandstones, limestones, and shales. The unconsolidated material, derived through glaciation and erosion of the mountain slopes, was brought down by streams and deposited as terraces, flood plains, and alluvial fans of gravel, sand, and clay. The deepening of the valleys has left many benches and high mesas between the creek valleys. Most of the deposited land has a smooth surface suitable for irrigation, and it has been included in small irrigation projects wherever water is available. The other land within this belt consists of rather steep hills and ridges and a few small flats. It does not occupy a position or possess the surface features favorable to irrigation, and it is used for pasture.

The sharply rolling plains lie east of the belt of foothills and valleys and slope in a general eastward direction, except along the eastern edge of the county. The broad tabular divides between the large streams are more or less thoroughly dissected by the narrow valleys of the lateral drainageways, and the greater part of the plains is characterized by sharply rounded hills, steep escarpments, and, here and there, small areas of badlands. Many of these features of the landscape are of minor importance when considered in relation to the vast plain as a whole, but they greatly influence the utilization of the land. Where rainfall is hardly sufficient to support cultivated crops, land with unfavorable surface features can be used only for grazing. The roughest areas in the eroded country are in the breaks along Powder River and Crazy Woman Creek, where the land has been carved into rough sharply rolling ridges and deeply cut valleys, and in places the entire surface has been so thoroughly dissected as to form badlands.

In the north-central part of the county, an extremely rough area differs in appearance and agricultural value from the other eroded plains areas. The shales have been oxidized to a red color by the heat developed in the slow burning of interbedded coal veins, and the soils developed over these clinker beds are shallow, red or pink, and contain, as a rule, fragments of the red shale. The soils developed in place over the shales are indicated on the soil map as the Searing soils. Reworked material from these areas, deposited along the streams, is placed in the Twin Creek series.

The gently rolling plains include several areas in this general region, which have escaped thorough dissection and are comparatively smooth. The largest of these, comprising about 10 townships near

the center of the county, extends from Kaycee and Sussex on Powder River northward to Crazy Woman Creek. The relief of a large part of this land is undulating and favorable for farming, and parts of it are topographically suited for irrigation, but all plans for irrigation have been abandoned on account of the scant supply of water available for this purpose. Other areas of land smoother than the average of the plains are in the southeastern part of the county and in smaller areas scattered over the northern part.

The drainage of the county is through Powder River, which flows northward along the eastern edge. Its tributaries, of which the largest are Clear, Crazy Woman, and Buffalo Creeks, join it from a southwesterly direction. In general the streams which emerge from the foothills of the mountains run for several miles in an easterly direction, then turn northeastward toward Powder River.

The distribution of water has a marked influence on the value of land for farming and grazing. The irrigated valleys support the most diversified and profitable agriculture in the county, and the relief would allow the irrigation of much larger areas, were the supply of water sufficient. The value of land for grazing is greatly enhanced in places where a spring, lake, or stream supplies water throughout the year.

Buffalo is the county seat and largest town. It is situated on Clear Creek about 6 miles from the mountains and has an elevation of 4,635 feet above sea level. Kaycee is a village on Middle Fork Powder River. It is only 2 miles from the rough mountainous area to the west. Most of the irrigated valley ranches in this part of the county lie at elevations between 4,300 and 5,000 feet.

The vegetation of the dry land east of the mountains is a typical arid-land cover consisting mainly of grasses, sagebrush, pricklypear, and rabbitbrush. There is very little tree growth, with the exception of a few cottonwoods in the creek bottoms. Windbreaks planted by settlers in the dry country along Nine Mile Creek are successful in the most favorable locations, but most of the trees are only 4 or 5 years old and are small and bushy, and the dry hot weather of the last 3 years has injured many of them. Shrubs, such as pea-shrub (*Caragana* sp.), locally known as wild currant, and chokecherry; young trees, such as green ash, boxelder, Chinese elm, poplar, Russian-olive; and evergreens—ponderosa (western yellow), red, and Scotch pines—are used in these shelterbelt plantings.

The most common grasses in the range-grass areas are grama grass, wheatgrass, buffalo grass, winterfat (sweetsage), and junegrass. Greasewood is common on valley flats and benches where salts impregnate the soils. In the mountains, extensive grassy areas are interspersed with wooded areas; lodgepole pine and ponderosa (western yellow) pine grow on the shallow and more rocky soils; Engelmann spruce, alpine fir, limber pine, and red cedar (*Juniperus virginiana*) are less common; and aspen and willow grow in patches in the moist situations. The top of the range is rougher and more generally forested north and west of the Buffalo-Ten Sleep Highway. The Big Horn National Forest, established in 1897, now (1938) covers 327,312 acres in the northwestern part of the county.

Johnson County (called Pease County until 1879) was set apart by an act of the Territorial legislature in 1875 and included the present Sheridan County (organized in 1887) to the north. Parts

were taken to form Big Horn County in 1897, which, in turn, was used, in part, to form Hot Springs and Washakie Counties in 1913. Johnson County was organized in 1881, and the State was admitted to the Union in 1890. Only 20 white people were in the county in 1875, but by 1881, 500 qualified voters were registered. The courthouse and jail at Buffalo were authorized and erected in 1884. The first white occupants of this general region were hunters, trappers, and traders with the Indians. Cattle were brought in from Texas and Missouri in 1885, and sheep were brought in later. Trouble with the Indians and the establishment of the Bozeman Trail to the Montana mines led to the building of a series of forts or posts including Forts Reno, Phil Kearny, McKinney, and Smith, to protect the emigrants. The Indian troubles were settled in 1877, and permanent settlement dates from that period.

The profitable cattle business was encroached on by extensive settlement between 1885 and 1890, which led to the Johnson County war in 1892. The extensive Nine Mile and Four Mile districts were homesteaded from 1915 to 1920. Dry farming was fairly successful for 10 years, but a series of dry seasons during the last 3 years has greatly discouraged the farmers. The population of the county in 1930 was 4,816, or 1.2 persons a square mile. Buffalo, the county seat, had a population of 1,749, and Kaycee, a population of 161. Other centers, such as Mayoworth, Renohill, Sussex, Bonnidee, Barnum, and Kearny are post offices or stores at crossroads.

This county has but one railroad in operation, the Wyoming Railway, which connects Buffalo with the Chicago, Burlington & Quincy Railroad at Clearmont, Sheridan County. Johnson County has 2,294 miles of highway, 78 miles of which are paved or surfaced and 78 miles partly improved. A new oiled highway, United States Highway No. 87, extends from north to south and United States Highway No. 16 crosses the northwestern part of the county. Dirt or graveled roads connect the main centers of population, and many trails and secondary roads, with gates on land lines, allow travel by car into every township. Sheep-wagon trails follow ridge land, even in the roughest areas.

The Big Horn National Forest attracts many people in summer, and the dude ranches bring in many cabin and hotel guests. Many people live in the mountains in summer, tending the approximately 32,000 cattle and horses and 128,000 sheep grazed by more than 200 grazing-permit holders. Poles, posts, and lumber for building purposes are cut in the forests, and cross ties are cut and delivered to the railroads.

There is a limited market for farm produce within the county. Cattle, sheep, wool, and wheat are shipped east, and dairy products are marketed in Buffalo, Midwest, and Sheridan.

CLIMATE

Johnson County, owing to the range in elevation from about 4,000 feet to more than 12,000 feet within its borders, has wide local differences in temperature and precipitation. These climatic differences have very important effects, not only on the types of farming practiced in different localities, but also on the character of the soil itself.

A belt of relatively heavy precipitation coincides with the higher mountain districts. Climatic records are not available for this section, so it is not possible to give the distribution of precipitation and range of temperature at different elevations and topographic positions. It is known, however, that some localities in the mountains average as much as 27 inches of annual precipitation. The normal mean annual temperature in the mountains is lower than that in the plains, and frost may be expected in every month of the year. The prevailing lower temperature in the mountainous districts, and the protection from winds afforded to a large part of the mountain slopes by the relief and by forests, reduce evaporation and maintain the humidity of the soil to a greater degree than would be expected from the amount of precipitation.

A less humid belt follows the lower mountain slopes and foothills. Climatic conditions differ over this belt, depending on elevation and topographic features, but, in general, a transition takes place between the cold humid mountain heights and the relatively warmer and more arid plains. As in many other mountainous sections, the stockmen adjust their practices of range management to take advantage of climatic conditions. They pasture cattle and sheep in the mountains during the summer but bring them down to the foothills and the plains in winter, in order that the animals may escape the storms and deep snows of the higher elevations.

The climate of the rest of the county, extending eastward from the lower mountain slopes, is characterized by comparatively low precipitation and seasonal extremes of temperature. The seasonal variations in temperature on the plains are much greater than in the mountains, with higher temperatures in summer and lower in winter. The maximum temperature recorded at Buffalo is 104° F., and the minimum is −38°.

In this part of the county, a number of farmers outside the irrigated districts practice a system of dry farming, under which they depend on showers during the summer to supply the moisture necessary for the maturing of their crops. Of the 41,760 acres harvested in 1934, 8,559 acres were dry-farmed and 33,201 acres were irrigated. The mean annual precipitation in this part of the county ranges in different localities from about 13 to 15 inches, nearly one-half of which comes in the spring and early summer. The total amount of precipitation in the driest and the wettest years at Buffalo was 6.19 and 27.24 inches, respectively. The average annual snowfall is 41 inches.

The average length of the frost-free season at Buffalo is 119 days, from May 21, the average date of the latest killing frost, to September 17, the average date of the earliest. Frost has been recorded as late as June 21 and as early as August 22.

The data in table 1, compiled from the records of the United States Weather Bureau station at Buffalo, are believed to be representative of the prevailing climatic conditions in the foothills and the greater part of the plains. The elevation of Buffalo is 4,645 feet above sea level. Elevations in the county increase gradually to the foothills, and thence, as previously described, there is an abrupt rise to mountainous areas which range in elevation from 7,000 to 10,000 feet, with a few higher peaks.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Buffalo, Johnson County, Wyo.*

[Elevation, 4,645 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1889)	Total amount for the wettest year (1923)	Snow, average depth
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	24.9	64	−38	0.52	0.02	0.18	6.7
January	22.1	66	−34	.51	.41	.30	5.6
February	24.7	65	−35	.45	.81	.36	5.2
Winter	23.9	66	−38	1.48	1.24	.84	17.5
March	34.5	76	−27	.78	.13	.91	5.9
April	42.9	82	−1	1.64	.41	2.00	7.9
May	51.2	91	18	2.46	.79	2.89	2.6
Spring	42.9	91	−27	4.88	1.33	5.80	16.4
June	60.7	100	25	1.79	1.49	3.44	(1)
July	68.2	104	36	1.34	.59	4.36	0
August	66.7	104	21	.99	.14	3.49	(1)
Summer	65.2	104	21	4.12	2.22	11.29	(1)
September	56.3	95	18	1.36	.17	7.92	.7
October	41.5	85	−3	.80	.89	1.27	2.2
November	34.6	74	−26	.44	.34	.12	4.2
Fall	44.1	95	−26	2.60	1.40	9.31	7.1
Year	44.0	104	−38	13.08	6.19	27.24	41.0

[1] Trace.

Table 2 shows the differences between day and night average temperatures at the station at Buffalo. These data show that the night temperatures average about 25° cooler than the day temperatures during all seasons of the year.

TABLE 2.—*Average monthly and seasonal day and night temperatures at Buffalo, Johnson County, Wyo.*

Month	Day	Night	Month	Day	Night
	°F.	°F.		°F.	°F.
December	38.0	11.9	June	74.6	46.6
January	35.8	8.7	July	83.0	53.3
February	37.7	11.7	August	82.1	51.3
Winter	37.2	10.8	Summer	79.9	50.4
March	47.5	21.5	September	71.7	41.0
April	55.9	29.9	October	59.9	31.4
May	64.5	37.9	November	48.2	21.0
Spring	56.0	29.8	Fall	59.9	31.1
			Year	58.2	30.5

AGRICULTURE

Agriculture in Johnson County began in 1875. The first settlers were attracted by the extensive grazing lands, both in the dry lands bordering the creeks and in the mountainous grassy areas. Cattle

were driven from the south and east, mainly from Texas, Missouri, and Nebraska, and sheep were brought in later. The range was restricted to certain areas. In winters when the snowfall was deep, supplementary feeding was necessary. The irrigated valley lands produced hay, alfalfa, and grain for a winter supply of feed. An influx of settlers during the period 1890–95 compelled the ranchers to acquire rights to supplies of water necessary for grazing operations, and fencing of the land became more common. The irrigated land was fenced, in order to protect crops from the livestock on the open range. At first, the stockmen owned only enough land to control the water supply, and they used the surrounding free range for grazing; but more recently, as greater competition arose for the land and grass, nearly all of the land has passed into private ownership, and much of it is fenced. Grazing land is valued roughly on the basis of its carrying capacity and its access to water. Good grassland brings the highest price, but if the livestock must travel from 3 to 5 miles in order to reach water, the range is less valuable than in places where available water is nearby. A "forty" of land, which controls water for a large area of dry land around it, may bring as much as $1,500 to $2,500. Good fenced land rents for $50 a section more than unfenced land.

Census figures show that farming, independent of the livestock business, has developed since 1900. Extensive homesteading of range lands in the sections adjacent to Nine Mile and Four Mile Creeks has taken place only within the last 15 or 20 years. The three types of agriculture practiced are the raising of sheep and cattle, farming under irrigation, and dry-land farming. The relative acreages devoted to each in 1934, as reported by the United States census, are approximately as follows:

	Acres
Land in farms:	
Irrigated land harvested	33,201
Dry-farm land harvested	8,559
Land on which crops were a failure	9,179
Idle land	6,128
Grazing land	1,653,259
Other land in farms	4,440
Total land in farms	1,714,766
Unappropriated land:	
Big Horn National Forest	327,312
Grazing land	597,865
School and other land	542,534

Johnson County will remain largely a grazing country, because of the extensive areas to which native grasses are best adapted. Dry farming is hampered by seasons of deficient rainfall, and the area used for this purpose is not likely to be expanded. Irrigation cannot be extended much further, unless expensive reservoirs are built. Large areas of dry land can be reached easily by canals, but water is not available for irrigation. All the streams are appropriated or overappropriated, and in dry years water is short for the irrigation of lands now in irrigation projects.

Table 3, giving census data on the number of farms, improved land, occupancy, and values of land and buildings, livestock, and machinery, shows the trend of agriculture since 1900.

TABLE 3.—*Selected data regarding farms in Johnson County, Wyo., in stated years*

Year	Farms	Improved land [1]	Farms operated by—			Average value per farm of—		
			Owners	Tenants	Managers	Land and buildings	Livestock	Machinery
	Number	*Acres*	*Percent*	*Percent*	*Percent*	*Dollars*	*Dollars*	*Dollars*
1900	300	31,150	83.7	7.0	9.3	5,561	8,393	254
1910	338	53,471	81.1	16.6	2.3	15,918	13,283	532
1920	624	71,232	90.2	6.3	3.5	16,694	7,078	821
1930	536	199,907	78.2	19.2	2.6	18,035	8,555	1,033
1935	574	130,243	81.3	16.4	2.3	13,796	(2)	(2)

[1] Includes cropland harvested, land on which crops were a failure, idle or fallow land, and plowable pasture.
[2] Not reported.

The largest acreage of cultivated land is devoted to alfalfa. Wheat is the second most important crop, followed by oats, barley, corn, and potatoes, in the order named. Much of the grassland is in permanent meadow and is never cultivated. With the increase of farming by machinery, the numbers of sheep, cattle, and horses on farms has decreased since 1910. Sugar beets are grown on a small acreage in Clear Creek Valley since the railroad has been built, but the clean-cultivated crops, such as beans, potatoes, sugar beets, and corn, have not found favor in this county as they have in other sections of the State. The average ranchman plans to feed enough livestock to use up the alfalfa, other hay, and grain produced, and most of the products of the land are marketed as beef, mutton, and wool. A few dairy herds produce milk, cream, and butter for use in Buffalo and for shipment to Sheridan or south to Midwest and Casper.

Table 4 gives the acreage of the principal crops, as reported by the Federal census for the years 1899, 1909, 1919, 1929, and 1934.

TABLE 4.—*Acreage of principal crops in Johnson County, Wyo., in stated years*

Crops harvested	1899	1909	1919	1929	1934
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
Corn [1]	12	9	84	3,481	1,743
Wheat	1,502	2,386	5,624	6,481	3,149
Oats	1,693	6,441	2,572	5,787	2,790
Barley	139	428	785	4,342	1,275
Hay (all kinds)	13,963	26,085	27,635	37,799	31,967
Alfalfa	6,208	19,173	23,679	29,216	26,133
Potatoes	101	246	214	229	225

[1] Most of the corn is grown for forage; less than one-half of the acreage represents corn cut for grain

Alfalfa is grown extensively on the irrigated flats and benches of the valleys. Two cuttings are made each year, and the yield on irrigated land ranges from 2 to 5 tons an acre. The greater part of the alfalfa hay is stacked in the field and fed from the stack to livestock. Only a small proportion is baled and sold. Most ranchers leave the land in alfalfa until the crop is winter-killed, or until dandelions, junegrass, and other undesirable plants take possession of the fields. Bacterial wilt has damaged the crop considerably in some parts of the county. Better average yields over a long period could be ob-

tained by alternating alfalfa with cultivated crops at intervals of 5 or 6 years. Poor yields, especially on some of the older fields, may be due to a lack of available phosphorus. In experiments not yet completed in Sheridan County, where conditions are essentially the same as in this county, greatly increased yields of alfalfa have been obtained by small applications of superphosphate.

Wheat is grown on both irrigated and dry land. Yields are larger and more certain on the irrigated land, except in years of heavy rainfall. In exceptional years the crop has yielded from 20 to 35 bushels an acre on dry land in the Nine Mile Creek area. In about 3 years out of 7, however, the yield is reduced by drought in the dry-farming area.

Oats are produced chiefly for feed for cattle and horses. On irrigated land, yields range from 50 to 75 bushels an acre; on dry land, the crop is cut for hay in very dry seasons.

Barley is grown chiefly under irrigation and does best on the fertile irrigated soils of the valleys. Much of this crop also is consumed by livestock.

Most of the corn is grown on the dry-land farms, and in favorable years it produces from 20 to 30 bushels of ear corn. The stalks are very small, ranging from 2 to 3 feet in height, but often good solid ears are produced. In some years, corn withstands drought better than do small grains, and some yield is made when oats and wheat are parched by the drought.

Potatoes yield from 75 to 150 bushels an acre and sugar beets from 10 to 14 tons. The acreage devoted to these crops is not large. Beets are shipped by rail to a beet-sugar factory at Sheridan. Potatoes are used largely within the county, but a few are shipped to outside markets.

The number of domestic animals on farms, for the census years from 1900 to 1935, inclusive, is given in table 5.

TABLE 5.—*Number of domestic animals on farms in Johnson County, Wyo., in stated years*

	1900	1910	1920	1930	1935
	Number	*Number*	*Number*	*Number*	*Number*
Horses	7,835	9,967	9,497	8,686	6,804
Cattle	35,895	56,254	44,757	42,167	50,800
Hogs	1,385	2,619	3,729	5,048	2,131
Sheep	399,524	312,283	107,923	214,749	212,159

In the dry-farm sections, small bands of sheep or cattle are pastured in connection with farming operations. Fallowing is not extensively practiced, but probably would improve crop yields in dry years. More labor is hired on the irrigated ranches than on the dry-land farms, where the farm families do most of the work. A few combined threshers and harvesters are used on some of the large irrigated ranches. Horses, tractors, and trucks are in common use throughout the county.

The large size of the average farm is due to the great amount of range land controlled by many ranchers. The largest group of farms includes farms between 500 and 5,000 acres in size. The average size of farms has increased from 757 acres in 1920 to 2,987.4 acres in 1935.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers, or horizons, called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [1] and its content of lime and salts are determined by simple tests.[2] Drainage, both internal and external, and other external features, such as relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, especial emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics, soils are grouped into mapping units. The three principal ones are (1) series, (2) type, and (3) phase. Areas of land, such as coastal beach or bare rocky mountainsides that have no true soil, are called (4) miscellaneous land types.

The most important group is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus the series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Thus, Renohill, Ulm, and Wolf are names of important soil series in this county.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Wolf fine sandy loam and Wolf loam are soil types within the Wolf series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the soil unit to which agronomic data are related.

A phase of a soil type is a variation within the type, which differs from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of

[1] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values indicate alkalinity, and lower values indicate acidity.

[2] The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline reaction.

accelerated erosion frequently are shown as phases. For example, within the normal range of relief for a soil type, there may be areas that are adapted to the use of machinery and the growth of cultivated crops and others that are not. Even though there may be no important differences in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such instances, the more sloping parts of the soil type may be segregated on the map as a sloping or hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS

The soils of Johnson County may be placed in the following three groups on the basis of their use: (1) Soils of the irrigated districts; (2) soils of the dry-farming districts; and (3) soils of the grazing districts. Many soil types are found in more than one use group, but these inconsistencies are of little importance. Soils of the grazing districts have little use other than for grazing and forestry, but, as mapped, they include very small areas that are dry-farmed or irrigated.

A dark color and a slightly acid to basic reaction are common features of the soils of the irrigated districts. Many of them are characterized by accumulations of lime in the subsoils, and many of the freshly deposited alluvial materials are calcareous throughout. Soils of the irrigated districts, for the most part, are used for the production of alfalfa and small grains. In general, the soils of the flood plains and of the younger terraces and alluvial fans are more productve than those of the older terraces and alluvial fans. The heavy claypans in subsoils of the latter tend to limit the yields of crops. In many places erosion has removed the productive surface soils and exposed the intractable clays of the subsoils.

Dry farming is practiced on the Great Plains of the eastern part of the county and on the smooth ridges in the northern part of the Big Horn Mountain section, but most of the area involved is better suited to grazing than to the growing of cultivated crops. Soils of the Great Plains are similar to, though lighter colored than, those of the irrigated lands.

Most of the agriculture in Johnson County is contributory to the raising of livestock. Small grains produce feed for livestock and flour for human consumption. Practically all of the alfalfa is used for feed, although some is grown for seed and only the straw is fed to the animals.

The total area of grazing and forest land in this county far exceeds the combined areas of irrigated and dry-farmed land. The best grazing is to be had in the mountain-park lands during the warmer months of the year; and the rougher and more arid areas of the plains section furnish pasturage during the winter.

In the following pages, the soils of Johnson County are described in detail, and their agricultural relationships are discussed; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 6.

TABLE 6.—*Acreage and proportionate extent of the soils mapped in Johnson County, Wyo.*

Type of soil	Acres	Per-cent	Type of soil	Acres	Per-cent
Wolf loam	26,048	1.0	Laurel clay loam	3,520	0.1
Wolf loam, gravelly phase	5,248	.2	Laurel fine sandy loam	256	(1)
Wolf loam, stony phase	9,664	.4	Harlem fine sandy loam	960	(1)
Wolf loam, steep phase	64	(1)	Harlem stony fine sandy loam	576	(1)
Wolf fine sandy loam	17,600	.7	Renohill clay loam	283,264	10.6
Wolf fine sandy loam, steep phase	128	(1)	Renohill loam	116,608	4.4
Wolf silty clay loam	5,696	.2	Ulm loam	53,184	2.0
Big Horn loam	30,016	1.1	Ulm loam, steep phase	5,504	.2
Big Horn silt loam	5,056	.2	Ulm fine sandy loam	149,952	5.6
Big Horn clay loam	10,368	.4	Ulm fine sandy loam, steep phase	5,632	.2
Big Horn clay	39,296	1.5	Searing loam	23,232	.9
Big Horn fine sandy loam	2,304	.1	Searing loam, rolling phase	3,264	.1
Story clay loam	9,152	.3	Searing clay	1,216	.1
Story clay	256	(1)	Lismas loam	199,168	7.5
Bridgeport loam	11,648	.4	Lismas clay	8,064	.3
Bridgeport fine sandy loam	2,624	.1	Beckton loam	18,880	.7
Bridgeport clay	320	(1)	Beckton clay	6,016	.2
Bridgeport gravelly sandy loam	1,152	(1)	Arvada clay	7,808	.3
Twin Creek fine sandy loam	1,216	.1	Rough stony land	1,350,400	50.7
Twin Creek loam	8,320	.3	Burgess loam	37,824	1.4
Twin Creek silt loam	1,344	.1	Willow Creek silt loam	118,528	4.5
Twin Creek clay	512	(1)			
Laurel loam	83,072	3.1	Total	2,664,960	

[1] Less than 0.1 percent.

SOILS OF THE IRRIGATED DISTRICTS

The most desirable soils for irrigation are those that have a sufficiently smooth nearly flat surface for easy distribution of water, but with enough slope to provide drainage and prevent an excessive accumulation of ground water. The alluvial terraces and river bottoms, extending from the foothills of the Big Horn Mountains eastward, have this favorable relief, and, as location as well as the supply of water determine the extent of the land under irrigation, this group of soils is irrigated only in part, and the proportions of irrigated land in each soil type differ to a considerable extent. In other words, the part of the soil that is irrigable because it lies below the canal level and the part that is not irrigable because it lies above this level are not separated in this survey, although it is well known that irrigation and cultivation cause important changes in the composition and profile of the soil. Because of their favorable situation as regards the distribution of water, production of supplemental feed crops for livestock, protection afforded the herds in winter, and accessibility to summer pasture in the mountains, the soils of the irrigated district are the most highly developed and valuable. The relief is chiefly of the foothill character, with narrow bottom lands along the creeks. Gentle slopes or level bench flats, interspersed with considerable steep and rough stony land, have value only for pasture. The irrigated soils differ greatly in texture and color, as well as in relief. In some of the upper valleys the soils are black or dark brown, colors imparted by a high accumulation of organic matter, whereas the soils on bench lands and slopes generally are light brown

or yellowish brown and the soils on the flats and slopes in the valleys farther away from the mountains are gray. The irrigated districts include: (1) Soils of the older terraces and alluvial fans, (2) soils of the younger terraces and alluvial fans, and (3) soils of the flood plains.

SOILS OF THE OLDER TERRACES AND ALLUVIAL FANS

The older terraces and alluvial fans are covered mainly by soils of the Big Horn and the Wolf series, and to less extent by the Story soils. Soils of the Big Horn series have a 3- to 8-inch dark grayish-brown surface soil, a 6- to 15-inch very heavy brown gumbo subsoil, and a thick accumulation of silty lime in the alluvial substratum. Alluvial gravel of various composition is present in places at a depth of 4 or more feet. The upper layers of the Wolf soils resemble those of the Big Horn soils, but the surface soils and subsoils are shallower in the Wolf soils and gravel appears within a depth of 3 feet. The surface soils of both the Big Horn and Wolf soils range from neutral to alkaline in reaction; hence, little benefit can be expected in most areas from applications of lime, except so far as lime may help to improve the structure of the subsoil. Other conditions being equal, the Big Horn soils are more productive than the Wolf soils, because the latter are more leached and do not hold moisture well. A few small areas and spots of both these soils contain harmful quantities of soluble salts. Soils of the Story series resemble those of the Big Horn and Wolf series, but the Story soils are distinguishable by the much darker color of their surface layers, owing to a moister climate and more abundant grassy vegetation. Although the Story soils are among the naturally most fertile soils in the county, their actual productivity is limited by the climatic conditions of the higher elevations in the foothills of the Big Horn Mountains where they occur.

The soils of these three series are used mainly for the production of alfalfa, wheat, oats, and barley, and to a small extent for the production of sugar beets. The yield of alfalfa for the first few years after seeding often exceeds 3 tons an acre, but in the following seasons it gradually declines to 1 or 2 tons. Results of experiments by the county agent of Sheridan County suggest that this reduction in yield is due to depletion in available phosphorus, and tremendous increases in yield followed the application of 120 pounds an acre of superphosphate. Apparently the Story soils retain their productivity in this respect longer than do the Big Horn or Wolf soils.

Wolf loam.—The topmost 1-inch layer of Wolf loam, which is mulchlike, consists of loose grayish-brown silty very fine sandy loam. The next lower 7-inch layer is laminated dark grayish-brown loam. This is underlain by light-brown heavy loam or clay loam, which is very stiff and has a well-defined prismatic structure. Below a depth ranging from 16 to 24 inches is grayish-yellow or olive-drab loam or clay loam, containing white streaks and spots of accumulated lime. Rounded loose gravel and cobblestones of various composition are reached at an average depth of 30 inches. The layers of this soil may differ somewhat in thickness. The depth to the gravel layer ranges from 16 to 36 inches. In most places, a few gravel are scattered through the layer containing accumulations of lime.

The parent material of this soil was deposited by streams as alluvial fans radiating from the mountains. These old deposits have

been eroded by streams, leaving only remnants in the form of high ridges or mesas with nearly flat tops. On the nearly level areas, the soil, having been undisturbed for a long time, is mature and has developed a series of sharply defined layers.

Extensive areas of this soil are mapped around the heads of Nigger Creek and Bull Creek, near the city of Buffalo which is situated on one of the lower bench remnants; one area occurs along the south side of Rock Creek on a bench on which the airport is located; and other small bench remnants are in the valleys of Clear Creek and Piney Creek.

Most of this soil on the higher benchlands is above the reach of irrigation water, and is used only for pasture. On the lower benches and terraces the land is irrigated, and excellent crops of alfalfa, wheat, barley, and oats are grown. Alfalfa yields from 2½ to 4 tons an acre; corn, 25 to 40 bushels; barley, 35 to 50 bushels; and oats, 50 to 80 bushels. Consistent rotations are practiced by a few farmers. Alfalfa is left on the land until it winter-kills or is crowded out by grasses and weeds. The land is then reseeded to alfalfa, with grain for the nurse crop. Many old fields show the lack of available phosphorus by their response to applications of superphosphate. Fertilization and rotation of crops will improve the yields on many of these old fields. The decrease in the yield of alfalfa is often due to wilt which causes wilted stunted plants with black rings in the roots. Removal of alfalfa from wilt-infected fields for a few years will tend to reduce the ravages of this disease. Some varieties of alfalfa are somewhat resistant to wilt.

Wolf loam, gravelly phase.—The gravelly phase of Wolf loam occupies slopes where the older and higher benchlands approach the mountains. The material from which the soil is developed consists largely of debris brought down from the mountains and spread in fan-shaped areas over the terraces. This material is of various degrees of fineness, but it contains large quantities of gravel and stone fragments. In places, a soil has developed, which is similar in thickness and character to typical Wolf loam of the level terraces, but over the greater part of its area, the soil is so shallow and gravelly as to prevent irrigation and cultivation. All this gravelly soil is used for pasture.

Wolf loam, stony phase.—Areas of Wolf loam on the high benches and on knolls and ridges have been designated on the soil map as a stony phase of that soil. Large stones, cobbles, and rock fragments of various sizes are scattered over the surface and through the soil mass in quantities sufficient to prevent cultivation. This soil differs from Wolf loam, gravelly phase, mainly in that the gravel and stone fragments are larger. The texture of the fine material ranges from loam to clay loam. The benches which this soil occupies are above the reach of irrigation water. The land is used only for pasture, and it has a low value for grazing.

Wolf loam, steep phase.—The steep phase of Wolf loam occupies steep slopes that mark the drop from the bench level, on which typical Wolf loam is developed, to a lower level. This soil is much more variable than the typical soil. The surface layer, in places, is almost as thick as that of the typical soil, but in other places it is thinner, and in some places the entire layer is removed. The layers of gravel and lime outcrop in many places on the steeper slopes.

The productivity of this soil depends on the thickness of the layer of original soil that remains. Over most of the very small area of this soil, the slope is too steep to allow cultivation or irrigation, and the land is used only for pasture. Only 64 acres are mapped, mainly in sec. 19, T. 53 N. R. 83 W.

Wolf fine sandy loam.—The topmost 1-inch layer of Wolf fine sandy loam is the usual surface mulch which develops in this general region and in this soil consists of grayish-brown fine sandy loam. It is underlain by an 8-inch layer of brown or grayish-brown fine sandy loam or sandy loam. The material is firm in place but not compact. The next lower layer consists of brown slightly compact sandy loam, in which, in most places a well-defined prismatic structure is developed below an average depth of 16 inches. This heavier layer is underlain by grayish-brown or olive-brown loam or sandy loam, spotted and streaked with white calcareous material. Below a depth of 30 inches the finer soil material is underlain by gravelly fine sand or fine sandy loam. In many places this lower layer consists of a mass of gravel of various sizes and cobblestones, embedded in silty calcareous loam.

Wolf fine sandy loam occupies scattered patches on the older benches and terraces along the streams and on high mesas or bench remnants near the mountains. Narrow strips of this soil are developed along Bull Creek, Nigger Creek, Clear Creek, and Crazy Woman Creek, especially in the vicinity of Buffalo.

The greater part of the land is under irrigation. The crops commonly grown are alfalfa, fruits, wheat, and potatoes. This soil is better suited to the cultivated crops, because of its ease in handling, but, on account of its open texture, it requires more water for irrigation than do the heavier soils. It is also productive of beans, corn, and beets. It is a warm soil, suitable for early intensive cultivation. Large yields of grain and alfalfa are obtained, but alfalfa often is left on the land too long. Rotation and careful cultivation are needed in order to make this soil produce best results. The more sandy areas, when dry and exposed to wind, tend to blow, and cover crops must be grown to maintain the supply of organic matter and to protect the land from wind erosion.

Wolf fine sandy loam, steep phase.—Wolf fine sandy loam, steep phase, occupies slopes from the higher terraces on which typical Wolf fine sandy loam is developed. These slopes are subject to rapid erosion when the soil is cultivated or irrigated. The surface soil in general is thinner than that of the typical soil, in some places being less than 3 inches thick. In places, the finer soil material has been entirely removed, and the gravelly and limy substratum is exposed. Owing to the thinness of the soil and the steepness of the slope, this steep soil is difficult to cultivate. Almost all of the land is used for pasture, for which it has a rather low value. A small area borders Sayles Creek.

Wolf silty clay loam.—Wolf silty clay loam has the same general features as has Wolf loam, except that the texture, to a depth of 18 or 20 inches, is much heavier. The 8-inch surface soil consists of light-brown or yellowish-brown clay loam. It is underlain, to a depth of 20 inches, by grayish-brown clay which contains scattered gravel. Below this depth, the soil becomes more gravelly and is

underlain by the bed of gravel and sand, that characterizes the Wolf soils. Some variations in the character of this soil occur, but they are not of great agricultural importance. Small knolls covered with gravel and boulders are included within areas of this soil. On the farm connected with the Soldiers and Sailors Home, many of the stones have been dug and removed from the cultivated fields.

A small area is along Clear Creek west of Buffalo, and several bodies are northeast and south of Klondike and along Crazy Woman Creek southeast of Klondike.

This soil is very productive of alfalfa and grain, but it is somewhat heavy for cultivated crops. All the land is under irrigation. Yields of wheat range from 30 to 50 bushels an acre; alfalfa, 2½ to 4 tons; oats, 50 to 70 bushels; and barley, 30 to 40 bushels. No definite crop rotation, except the common one of alfalfa and grain, is practiced.

Big Horn loam.—The 7-inch surface layer of Big Horn loam consists of light-brown loam. This is underlain, to an average depth of 16 inches, by yellowish-brown compact loam, and below this, to a depth of 40 inches, by yellowish-brown clay loam, in which a few gypsum crystals are present. The soil material is calcareous at a depth ranging from 8 to 20 inches below the surface.

Big Horn loam occupies the lower valley benches bordering the smaller streams near the mountains. It is the most desirable soil of the terraces, as it is of good texture and is easily worked. The land is flat and favorably situated for irrigation. These secondary terrace lands do not everywhere show the distinct horizons, due to soil development, which are seen on the older benchlands, as the material has been more recently deposited and they have not been subjected to the soil-developing processes for so long a time.

The largest areas of this soil border Powder River and its tributaries in the southern part of the county, the several forks of Crazy Woman Creek, and Clear Creek in the northern part.

Big Horn loam has been developed on secondary fans or terraces in the stream valleys. Nearly all of the areas are irrigated, and the land is very productive. As on all irrigated soils, alfalfa hay and grain are the chief crops. Yields are similar to or even better than those obtained on the older Wolf soils. Alfalfa yields from 3 to 5 tons an acre; oats, 50 to 80 bushels; barley, 35 to 50 bushels; and wheat, 30 to 50 bushels. Sugar beets are grown on the area along Clear Creek, and yields ranging from 12 to 14 tons are obtained. Next to the dark-colored soils of the valleys, this is probably the best soil of the irrigated district. Irrigated land of this type sells for a good price. In more prosperous periods, the price of land near Buffalo was higher than it is now.

The tendency in farming this soil is to leave it in alfalfa too long, thus depleting the supply of available phosphorus. Although the introduction of more cultivated crops in the rotation would be of benefit to this land, as they do not draw so heavily on the supply of plant nutrients, they do not fit in well with the range livestock business, in which hay and grain are the chief crops required.

Big Horn silt loam.—Big Horn silt loam differs from Big Horn loam principally in having a siltier surface soil. This soil, to an average depth of 12 inches, is grayish-brown loam. Below this, to an

average depth of 24 inches, it is yellowish-brown heavy loam. The material becomes heavier textured with depth and passes into calcareous clay loam which continues to an average depth of 40 inches. Lime appears at a depth of about 20 inches below the surface, but there is no distinct zone of lime accumulation.

This soil is developed on the higher stream terraces, well above overflow. The land is nearly level, and almost the entire area can be irrigated.

The total area of this soil is slightly less than 8 square miles. It is associated with Big Horn loam, principally along North and South Forks of Crazy Woman Creek and along Clear Creek in the northern part of the county.

Alfalfa is the principal crop, and yields range from 3 to 5 tons an acre. The greater part of this crop is stacked in the field for winter feeding of cattle. Small grains do well, wheat yielding from 30 to 50 bushels an acre; oats, 50 to 70 bushels; and barley, 30 to 50 bushels.

Big Horn clay loam.—Big Horn clay loam is similar to Big Horn loam, except for the texture of the surface soil which, to a depth ranging from 9 to 14 inches, is light-brown or grayish-brown clay loam. It overlies compact clay loam or clay.

The greater part of Big Horn clay loam is included in areas scattered along Powder River and in some of the valleys south of Buffalo. The soil is somewhat heavy for cultivation, but it holds moisture well and does not have the areas of salt accumulation and hardpan development, that characterize Big Horn clay. Good crops of hay, alfalfa, and small grains are grown under irrigation.

Big Horn clay.—The surface soil of Big Horn clay, to an average depth of 8 inches, consists of brown or dark grayish-brown laminated clay. The topmost 2 inches of this layer in many places is loose and mulchlike, and the soil breaks to a mellow tilth. Below the surface layer is a 14-inch layer of brown compact heavy clay which is exceedingly tough and intractable and forms hard clods when exposed to the air. The material in the lower part of this heavy layer is not so heavy and tough as that in the upper part, and it contains a few spots of silty lime. The next lower layer consists of olive-gray clay which is looser than the material in the layer above. In places gypsum salts are abundant. This layer rests, at a depth of about 3 feet, on stratified alluvial material which may or may not include thin layers of gravel. Lime has been leached from this soil to a depth ranging from 4 to 30 inches. In small areas, injurious quantities of salts have accumulated in the surface soil, and in other areas hardpan has developed under the surface layer, through the action of salts. General experience has shown that the limy horizons of virgin soil become more porous under irrigation in this area.

Over 60 square miles of this soil are mapped in this county. About 12 square miles are in the valleys northwest, southeast, and south of Buffalo, and large areas are along the streams forming the headwaters of Powder River in the southern part of the county.

Owing to its heavy texture and tendency to seep under irrigation, only a small part of this soil is cultivated; the rest is used largely for pasture and the production of hay. In a few places, fairly good crops of alfalfa and grain are grown under irrigation. In some areas south of Kaycee, where the proportion of sand in the surface soil is

larger than elsewhere, dry farming is fairly successful. In these areas, grain, hay, and potatoes are grown to some extent. In general, however, the soil has little value for farming and is used to best advantage for pasture.

Big Horn fine sandy loam.—Big Horn fine sandy loam is the lightest textured and the least extensive member of the Big Horn series mapped in this county. The 8-inch surface layer consists of laminated dark-brown fine sandy loam. The characteristic layer of heavy clay and accumulated lime underlie it.

This soil is well adapted to grains, alfalfa, and vegetables, good yields of which are obtained under irrigation. Some areas are irrigated for pasture. This soil is better adapted to dry farming than are Big Horn clay and Big Horn silty clay loam. Bordering areas of those soils are a few areas having poor drainage, in which salts have accumulated in places. Big Horn fine sandy loam occupies a few areas on the terraces in the vicinities of Sussex and Kaycee.

Story clay loam.—The surface soil of Story clay loam, to an average depth of 10 inches, consists of very dark brown or black clay loam, rich in organic matter. This overlies grayish-brown or yellowish-brown clay, the upper part of which has a prismatic structure. This layer reaches a depth of 18 or 20 inches, where it grades into olive-drab or light-brown calcareous clay. In the larger area of this soil in Shell Creek Valley, the soil below a depth of 2 feet is underlain by mottled gray and brown sandy loam which contains pockets and seams of limestone gravel washed in from the high benchlands at the head of the valley.

The total area of Story clay loam is 14.3 square miles. The soil is developed on well-drained terraces and alluvial fans. It occurs mainly in the valleys of Piney, Shell, Johnson, Rock, and French Creeks.

This is one of the better soils of the county. It has a large content of organic matter and is a highly productive soil. Hay grasses, grain, and alfalfa are the most important crops.

Story clay.—Story clay, like Story clay loam, has a nearly black heavy clay or silty clay surface soil. The upper part of the subsoil is very stiff heavy clay with a prismatic structure. Below this, at an average depth of 18 inches, is olive-drab or light-brown calcareous clay loam. This soil has a very small total area. Cultivation is difficult on account of the heavy texture, and almost the entire area is used for hay land and pasture.

SOILS OF THE YOUNGER TERRACES AND ALLUVIAL FANS

An important group of agricultural soils, although not the most extensive, occupies the younger alluvial fans and terraces bordering the valleys of the rivers and creeks near the mountains. This group includes soils of the Bridgeport and the Twin Creek series. The Bridgeport soils have dark grayish-brown surface soils, and they are mellow and friable at all depths. The Twin Creek soils are developed from sediments washed down from areas of red fine-grained sandstones and in some places contain material from the red clinker beds.

Bridgeport loam.—The 10-inch surface soil of Bridgeport loam consists of dark grayish-brown loam. Below this and continuing to

a depth of 22 inches is light grayish-brown compact loam. The next lower layer, which reaches a depth of more than 40 inches, is grayish-brown or yellowish-brown highly calcareous silty clay loam containing gravel and cobbles.

This soil occupies the well-drained bottoms and gentle valley slopes near the mountains. Under the influence of moisture and a heavy grass vegetation, this soil has accumulated larger quantities of organic matter than have the soils on the more arid plains. Lime has been leached to a depth ranging from 12 to 20 inches.

About 18 square miles of this soil are in Johnson County. The largest areas are in the valleys of Piney, Little Piney, Shell, Rock, Sand, Clear, and Bull Creeks. All the land is under irrigation.

Bridgeport loam is one of the most productive soils in the county and is highly valued by the farmers. Hay, alfalfa, and grain are the principal crops, and sugar beets are grown to some extent near the railroad in Clear Creek Valley. The soil is generally uniform, except for small areas that are subject to seepage.

A variation of this soil is developed in several small areas. It differs from the typical soil mainly in having a siltier surface layer. Like the typical soil, it is developed on the younger alluvial fans along stream valleys. The largest included area, which is in Little Piney Creek Valley west of Kearny, covers about one-half square mile. All this soil is under irrigation and produces excellent crops of alfalfa and small grains.

Bridgeport fine sandy loam.—The 9-inch surface soil of Bridgeport fine sandy loam is dark-brown fine sandy loam. The next lower layer, which is about 8 inches thick, is yellowish-brown compact fine sandy loam or loam. Below this and continuing to a depth of more than 48 inches, is grayish-brown gravelly sandy loam. This soil covers low terraces in Clear Creek and Bull Creek Valleys east and southeast of Buffalo. The total area is small.

All this land is irrigated, and it produces good crops of hay grasses, alfalfa, and grain. Near the mouth of Bull Creek too much water has been used on the irrigated fields, causing the water table to rise, and in places patches of marshy and reedy meadows have been produced.

Bridgeport clay.—Bridgeport clay resembles Bridgeport loam in most respects, but it has a very heavy and stiff surface soil and subsoil. It must be plowed at the proper time; otherwise it will form clods which are exceedingly difficult to break. Internal drainage is very slow, and when irrigated the soil tends to become seeped. It is fairly well adapted to alfalfa, but sometimes the plants are damaged badly by being lifted from the ground by freezing and thawing in the spring or by shrinking and cracking of the ground during the dry summer months. The uncleared land is covered by sage and greasewood. The total area of this soil is small. The largest body, which is in T. 50 N., R. 81 W., covers about one-half square mile.

Bridgeport gravelly sandy loam.—The surface layer of Bridgeport gravelly sandy loam, to an average depth of about 6 inches, is brown sandy loam, in most places containing a small percentage of gravel. This is underlain, to a depth of about 12 inches, by yellowish-brown or grayish-brown gravelly sandy loam. Below this and continuing to a depth of more than 60 inches, the material consists of gravel or gravelly sandy loam. This soil occupies low ridgelike

remnants of fans in the stream valleys. The parent material consists of water-laid sediments so recently deposited that very little soil development has taken place.

The largest areas of this soil are 3 miles south of Buffalo and at the northern end of Lake De Smet. The total area is less than 2 square miles.

This soil is irrigated but, owing to its open character, requires frequent watering. Alfalfa or grain suffer from drought within a short time after irrigation. The gravelly character of the soil also interferes with plowing and cultivation. Oats are best adapted to this soil, but average yields of all crops are low.

Twin Creek fine sandy loam.—The surface soil of Twin Creek fine sandy loam, to an average depth of 12 inches, is reddish-brown or dark reddish-brown fine sandy loam. The color is darker near the surface and grades downward to light reddish brown. This material is underlain, to a depth of 18 inches, by yellowish-red or light reddish-brown loam which changes with depth into calcareous red heavy loam or clay loam. The next lower layer is highly calcareous pink very fine sandy loam which in many places contains seams of gypsum. On high terraces east of Barnum, the underlying material contains a large proportion of gravel. Irrigated areas of this soil produce good crops of alfalfa, small grains, and hay grasses.

Twin Creek loam.—The 8-inch surface layer of Twin Creek loam consists of reddish-brown fine sandy loam. It is underlain by compact yellowish-red heavy loam or clay loam, which continues to a depth ranging from 16 to 20 inches and in many places has a prismatic structure. This material, in turn, is underlain by loose fine sandy loam or loam, containing seams of gypsum. Twin Creek loam is the most extensive of the red soils, comprising an area of 13 square miles.

This soil is harder to manage than Twin Creek fine sandy loam, on account of its heavier texture, but in places where it is irrigated and properly drained and managed, it is about as productive. The principal crops are alfalfa, hay grasses, and small grains.

Twin Creek silt loam.—Twin Creek silt loam is similar to Twin Creek loam, except that its surface layer is siltier. The topmost 7-inch layer consists of reddish-brown or dark reddish-brown silt loam. This is underlain by a 6-inch layer of slightly heavier yellowish-red silt loam containing some lime. The next lower layer is red highly calcareous silt loam or clay loam. Twin Creek silt loam is probably the most productive soil in this series of red soils. It is of little agricultural importance, however, as it occurs in only a few small bodies, and the total area is slightly more than 2 square miles.

Twin Creek clay.—Twin Creek clay is a soil of minor importance, which occurs in an area of less than 1 square mile north of Renohill. The surface layer consists of heavy clay loam or clay, the latter texture predominating. The lower layers are very similar to the corresponding layers of Twin Creek loam, except for a slightly heavier clay content. The soil is difficult to cultivate. Yields are lower than those obtained on Twin Creek loam, and the agricultural value of the clay member is consequently somewhat lower than that of the loam member.

SOILS OF THE FLOOD PLAINS

The creeks and rivers that flow through the agricultural districts have deposited material, composed of silts, sands, clays, and gravel, on their flood plains in areas of various widths. Some of these materials comprise soils suitable for cultivation. Owing to the presence of limestone fragments in these water-deposited soils, they are all more or less calcareous. The group of soils of the flood plains includes soils of the Laurel and the Harlem series. Soils of the Laurel series are light colored and generally contain large quantities of soluble salts. They occur along the streams in all parts of the county. The Harlem soils, developed near the mountains, are nearly black.

Laurel loam.—Laurel loam belongs to a group of soils immaturely developed on the flood plains of streams, which have been built up of silts, sands, clays, and gravel. The topmost 6-inch layer is light grayish-brown friable calcareous loam. In places it has a thin surface covering of dark soil, and in other places side streams have deposited a thin covering of sand or gravel over the surface. Below the surface layer are alternating strata of buff and grayish-brown silt loam and loam or, in a few places, thin layers of clay.

Laurel loam is the most extensive soil of the Laurel series. It borders the larger streams and covers a total area of nearly 130 square miles.

A part of this soil is used for the production of the crops commonly grown, as alfalfa and small grains. A large part of the land is not irrigated, and much of it is not cultivated. The native grasses make fairly good growth, and the value of this land for pasture is above the average for the dry-farming section. Hay is cut in the bottoms, where seepage, overflow waters, or a high water table keeps the soil moist. Much of the land supports a growth of brush, trees, and tall coarse grasses. Many feeding pens are built under the protection of the trees or below overhanging banks bordering the bottoms, where cattle and sheep are sheltered and fed during the winter.

Laurel clay loam.—Laurel clay loam is similar to Laurel loam in that it is calcareous and stratified, but its surface soil is heavier and slightly darker. The larger areas are along Clear Creek east of Buffalo, at the head of Boxelder Creek, and west of Lake De Smet. Most of these bodies range from 200 to 400 acres in size, and the total area comprises only 5.5 square miles. This soil is fairly productive of small grains and alfalfa.

Laurel fine sandy loam.—Laurel fine sandy loam resembles Laurel loam, except in the texture of the surface soil, which is sandier. The surface layer is variable in thickness, and the character of the successive layers below varies to some extent. Typically, a light grayish-brown fine sandy loam is underlain by heavier textured material. In the subsoil all the layers may be heavier than the surface soil, or clay layers may be interspersed with sandier or gravelly layers. Small bodies within this soil as mapped have subsoil layers of sand and gravel, but they are too small to be indicated separately.

In seasons when irrigation water is abundant, good crops of alfalfa and hay grasses are produced. This soil is well suited to the production of truck crops, but there is no market for such products. Much of the land is not cleared but remains covered by brush, weeds, and coarse grasses, which provide some low-grade pasture. Wild hay

is cut on marshy land or along sloughs. Less than one-half square mile is mapped, principally along Rock Creek.

Harlem fine sandy loam.—Harlem fine sandy loam has developed over sandy materials at the heads of creek valleys near the north line of the county west of Kearny, and southwest of Buffalo. The total area is only 1.5 square miles.

The soil is variable in some respects, but in all areas it contains a large quantity of organic matter which imparts a dark-brown or black color to the surface layer. The texture varies somewhat, but fine sandy loam or sandy loam predominates. The average thickness of the dark-colored surface layer is 9 inches. Below this is a 10- or 12-inch layer of yellowish-brown fine sandy loam or loam. The material in the next lower layer is coarser in texture—generally grayish-yellow fine sandy loam containing varying proportions of gravel. In most places the lime has been leached to a depth of 20 inches, but the lower gravelly layer is calcareous, and the gravel are coated with lime. A part of the area on Clear Creek, south of the Soldiers and Sailors Home, is more shallow and gravelly and is less productive than the average for this soil. With an adequate supply of water for irrigation, Harlem fine sandy loam produces good crops of alfalfa and grain, also excellent native hay.

Harlem stony fine sandy loam.—Harlem stony fine sandy loam is the name given to a soil composed of a heterogeneous mass of material which has been deposited on outwash fans and in old stream channels, consisting of rock debris brought down by mountain streams, and including boulders, cobbles, gravel, and a small quantity of fine material. It scarcely can be called a soil, as little weathering or soil development has taken place. In places the entire surface of the land is covered by boulders piled in ridges parallel to the flow of water.

The largest body of this soil is in Clear Creek Valley west of Buffalo. The land is too stony for cultivation, and very little of it can be used for hay land. As pasture land it has low value, as the greater part of the coarse soil supports only brush and weeds; and, although a relatively small proportion is open grassland, the pasture is of poor quality.

SOILS OF THE DRY-FARMING DISTRICTS

This group includes the soils of the Renohill, Ulm, Searing, Lismas, Beckton, and Arvada series. These soils are farmed to greater or less extent without irrigation, but none of them is completely or even largely under cultivation at present. Dry farming, on the whole, has been less successful in this county than it is farther north and east. This seems to be due partly to the distribution of the rains, which are less dependable here in summer, and partly to the shallower soils, which hold less moisture, with the result that crops suffer more severely in dry years than on the deeper soils farther north.

The soils of this group that average highest in production under dry-farming conditions are those of the Ulm series. These soils have sandy surface soils, with heavier subsoils, and they make most efficient use of small amounts of moisture; but even on these soils crops are severely damaged in dry years, although good results are ob-

tained in moist seasons. The Renohill soils have favorable relief for dry farming and support an abundant short-grass cover which has tempted many people to homestead tracts of land for the purpose of growing cultivated crops. Experience, however, has demonstrated that these soils are best suited for pasture and that any type of agriculture, to be permanently successful, must depend largely or entirely on the grazing of livestock. Good corn, grain, and hay are produced in favorable years, but periods of several years in succession are experienced, when the returns from crops are very meager. The same conditions prevail over the areas of Searing, Lismas, Beckton, and Arvada soils. Good crops are grown only in years of unusually heavy rainfall or in favorable situations in valleys or on slopes where more moisture or less evaporation than normal occurs.

The soils of the Ulm and Renohill series have grayish-brown surface layers. The Renohill soils are developed over heavy shales and the Ulm soils over sandstones and sandy shales. The Searing soils are derived from red sandstones and from the clinker and scoria beds in the north-central part of the county. The Lismas soils have gray surface layers which grade into gray cloddy subsoils and gray partly decomposed shale. For the most part, they are shallow and not very productive. The Arvada soils are similar to the Beckton soils in some respects, but the subsoil of the Arvada is light brown, whereas the subsoil of the Beckton is predominantly gray. The difference between the members of the two series is due to the character of the parent materials—the Arvada soils being formed from alluvial-fan material washed from buff and gray sandstones and shales, whereas the Beckton soils are derived from alluvial-fan material washed entirely from gray shales. Numerous white bare spots occur, which produce poor yields of cultivated crops, owing to the presence of harmful quantities of soluble salts, the leaching of the plant nutrients, or the failure of capillary water to rise through the heavy intractable subsoil.

Renohill clay loam.—Renohill clay loam is extensively developed on smooth upland. In virgin areas the topmost layer is the common mulch of this section, consisting of loose light grayish-brown silty clay loam. In places there is a thin crust over the loose powdery material. The next 4-inch layer consists of firm brown loam, with a laminated structure. Below this is a 5-inch layer of dense compact olive-brown clay which, in most places, is massive and structureless but, in some places, is indistinctly columnar. From 10 to 20 inches below the surface is the zone of lime concentration, in which the material is olive-brown clay or clay loam, containing spots and streaks of lime. The underlying material, which begins at a depth ranging from 20 to 30 inches, generally is lighter in texture, that is, loam or fine sandy loam. This material is underlain, at a depth of several feet, by olive-brown partly disintegrated shale. The soil is leached to a depth ranging from 6 to 10 inches, but below this depth free lime is abundant.

Renohill clay loam is one of the most extensive and uniform soils in the county. The section covered by this soil is known as the "Nine Mile Country." Beginning southeast of Sussex, it extends 30 miles northwestward across Crazy Woman Creek and, with a few breaks, from Powder River 20 or 25 miles westward to the vicinity of United States Highway No. 87 west of Renohill. The total area covered is

442.6 square miles. Most of the land is undulating or gently rolling and is interspersed with a few flat areas.

This large expanse of undulating grass-covered plain was grazing land for cattle and sheep until about 1910. During a series of moist years, when crops were unusually good, it was taken up by homesteaders, and homesteads and farmhouses now are scattered over the territory. Roads have been developed and most of the land is fenced, although only a small part of the total area is cultivated, each farmstead having from 20 to 80 acres in cultivation. The rest of the land is pastured to cattle, sheep, and horses. Most of the farm buildings are small, but many are very comfortable and are well equipped. Wells have been drilled to a depth ranging from 275 to 300 feet, and windmills have been installed. Many homesteaders have planted shelterbelts of trees, now from 3 to 10 years old, which seem to endure the dry weather remarkably well when cultivated.

The crops grown include oats, wheat, barley, corn, and vegetables. In favorable years, as much as 25 or 30 bushels of wheat an acre are reported, but during about 3 years out of 7, crops suffer from drought. The last several years have been dry, and crops have suffered severely.

Renohill loam.—The 1-inch surface layer of Renohill loam is mulchlike, consisting of light grayish-brown fine sandy loam. The next lower layer, which is 5 inches thick, consists of brown compact loam. Below this, and continuing to a depth of 12 inches, the material is light in texture, being a lighter loam or fine sandy loam. The heavier soil layers are underlain to a depth of several feet by very fine sand or sandy loam.

Renohill loam occupies large and uniform areas, the largest being in the vicinity of Bonnidee and northwest of Trabing. Smaller areas are developed in the smoother parts of the upland. The total area covered is 182.2 square miles. The land, for the most part, is undulating and encloses flat areas of considerable size.

This soil is developed from shale, which probably contains more fine sand than the parent rock of Renohill clay loam. Both surface drainage and internal drainage are good, and the soil is fairly retentive of water. In the northeastern part of the county dry farming on this soil has had some measure of success, and fair to good crops are obtained about 4 years out of 7. Corn, oats, wheat, and potatoes are the most important crops. In places alfalfa has been tried on the dry land with some success. The unbroken land supports a thick cover of grass which provides good pasture for livestock.

Ulm loam.—Ulm loam, although not the most extensive soil of this series, is the best developed. The parent rock consists mainly of sandstones and sandy shales, together with some beds of heavy shales on limestones. The surface layer of Ulm loam is grayish-brown or brown loam, the color of which is lighter in the lower part. The material in this layer gives way abruptly to heavy stiff brown clay loam or clay, which breaks into somewhat symmetrical angular clods. This heavy layer ranges from 4 to 12 inches in thickness. Below this is friable buff sandy clay loam with a high content of lime. At a depth ranging from 16 to 30 inches, the soil is underlain by partly decomposed sandstone or sandy shale.

Ulm loam occupies undulating to rolling uplands. Drainage is adequate with a low regional rainfall. The largest areas are south of Buffalo and southwest of Lake De Smet.

A small proportion of this soil is dry-farmed, and a few small areas are irrigated, but by far the greater part is used for pasture. The native vegetation consists of grasses, sage, and pricklypear. The soil has only fair value for dry farming. The chief crops are small grains and alfalfa, and a small acreage is in corn. On the small patches of irrigated land, good crops of grain and fair crops of alfalfa are grown. Owing to the impervious subsoil, irrigated land is damaged in places by seepage and accumulations of salt. All the salty areas are indicated on the map by appropriate symbols.

Ulm loam, steep phase.—The steep phase of Ulm loam represents areas of Ulm loam, that have been subjected to severe erosion. Soil of this phase includes slopes on which machinery for dry farming is difficult to handle and on which damage would result from erosion if the land were irrigated. The greater part of this soil has a moderately thick layer of soil material and produces a good cover of grass. Where cultivated, the steep slopes erode, and crop yields are so small that they do not repay the farmer for his trouble. It is much better to leave this soil in sod, in order that it may furnish pasture for livestock. Many of the side valleys along Clear Creek are grazed both winter and summer, and springs in the heads of these valleys supply water even in the driest seasons.

Ulm fine sandy loam.—Ulm fine sandy loam resembles Ulm loam in some respects, but has a sandier surface layer, and the underlying layer is not so heavy and compact. The depth of the soil differs considerably with the degree of slope, greater erosion, and shifting of soil material taking place on the steeper slopes. This soil consists of grayish-brown or brown fine sandy loam, ranging from 3 to 20 inches in thickness, underlain by brown slightly compact sandy loam or sandy clay loam. At a depth ranging from 20 to 30 inches, the parent rock is reached, which, in most places, is pale olive-drab partly decomposed sandstone or sandy shale. This is a very extensive soil, totaling 234.3 square miles in area.

Ulm fine sandy loam, steep phase.—In places where the slope is so steep or the land is so badly gullied as to make the use of machinery very difficult in dry farming, areas of Ulm fine sandy loam are separated on the soil map as a steep phase. This soil occurs in a number of irregular strips north of Rock Creek, in the section between Buffalo and Lake De Smet. The surface soil everywhere is thinner than in areas of the typical soil, and on very steep slopes it may be entirely removed. This soil supports a fair growth of range grasses and is used almost entirely for pasture. The land should be left in grass, in order to prevent erosion.

Searing loam.—The clinker or scoria beds from which Searing loam is derived consist of red hardened shales in great irregular masses of red and black clinkers formed by the burning of beds of coal.

Searing loam has a 9-inch reddish-brown friable loam surface soil which contains a fair amount of organic matter. In many places the topmost 1 or 2 inches is grayish brown. Between depths of 9 and 18 inches the soil material is light-pink silt loam and contains much red angular gravel and a large quantity of white silty lime. This layer is abruptly underlain by hardened red shale. The depth of the soil profile differs considerably, and in some places the quantity of accumulated lime is small. Many outcrops of clinker

and shale, too small to map separately, are also included. These outcrops are known by some as scabland.

Searing loam is developed in a number of irrigated areas in the section east of Lake De Smet and extending in a southeasterly direction. Despite its shallowness this soil is very productive and is used to some extent for dry farming, but the greater part is used only for pasture. It is especially well adapted to alfalfa and oats.

Searing loam, rolling phase.—The rolling phase of Searing loam is indicated on the soil map where the slopes of Searing loam areas are unusually steep and erosion has been active. In places erosion has been accelerated by attempts to cultivate the land. Sheet erosion and small gullies have greatly reduced the thickness of the surface soil. Small areas of this soil occur at the southeastern end of the belt where typical Searing loam is extensively developed. The total area of the phase is 5.1 square miles. This soil is not cultivated, and the land should be kept in grass, in order to control erosion.

Searing clay.—Comparatively small areas of red clay, classed as Searing clay, are associated with areas of Searing loam. The heavy texture may be derived from the weathered products of unburned shale mixed with the red clinker material. This soil has a 7-inch surface layer of reddish-brown clay underlain to a depth of 20 inches by heavy yellowish-brown clay containing a few red clinker flakes. Between depths of 20 and 30 inches the material is deep brick-red loam containing 30 percent or more of clinker flakes. This material rests on beds of shale, generally burned. This layer is calcareous, but the overlying layers in most places show no free lime. In a few places, the soil has been cultivated, and fair crops of hay and grain have been harvested. The soil is too heavy and bakes too hard to allow the practice of the best dry-farming methods.

Lismas loam.—Lismas loam is a thin immature soil developed over shales. The surface soil consists of an 8- to 10-inch layer of gray or olive-gray loam. It is underlain by gray cloddy clay that contains streaks and spots of lime. At a depth ranging from 15 to 20 inches, the soil is underlain by the parent rock of partly decomposed gray shale streaked with iron rust. In places it contains streaks of sulphur and coaly material.

This soil occupies 311.2 square miles of the more rolling and steep land in the eastern half of the county. The rolling surface has prevented the uniform development of mature soils like the Renohill soils. The Lismas soils are thicker and produce better pasture than does rough stony land. The soil dries thoroughly in summer, but fall rains and snow revive the grass, so that good winter grazing for sheep and cattle is obtained.

Lismas clay.—Lismas clay consists of a 12-inch layer of olive-gray clay underlain by gray cloddy clay containing streaks and spots of lime and crystals of gypsum. The parent rock lies at a depth ranging from 15 to 20 inches below the surface and consists of decomposed shale similar to that underlying Lismas loam.

Lismas clay occurs in several widely scattered areas which aggregate 12.6 square miles.

This soil supports a sparse growth of sagebrush and grasses. It is better suited for pasture than for the growing of cultivated crops, but its value for pasture is inferior to that of most of the other soils of the county.

Beckton loam.—The Beckton soils are developed on low terraces and fans. The parent materials are variable, and floods are constantly adding more material to the surface. The surface layer of Beckton loam is a mulchlike covering of ash-gray fine sandy loam about 1 inch thick. This is underlain to a depth of 8 inches by gray loam. Below this the material is grayish-brown or yellowish-brown compact loam. The lower layers are gray or olive-gray fine sandy loam or fine sand. This soil produces good yields of grain, alfalfa, and hay grasses. Losses on this land may occur from sudden floods which come in from side valleys.

The principal areas are along Powder River and Crazy Woman Creek.

Beckton clay.—Beckton clay consists of a 6- or 8-inch layer of flaky gray or olive-gray clay underlain by olive-gray gritty clay or sandy clay to a depth of 30 or more inches. The parent material consists of poorly assorted clayey materials washed from nearby hills of shale and sandstone and deposited along the sides of valleys as nearly flat fans. The subsoil materials are, for the most part, calcareous, and in places there is some lime in the surface soil. This soil, in general, is too heavy to be suitable for dry-farming practices, but it will produce fair yields of hay and small grain when the rainfall is sufficient. It is characterized by numerous slick spots. The total area is not large, and the soil has little agricultural significance.

Arvada clay.—Arvada clay is a gray soil developed on alluvial fans and terraces. The largest areas are in the central part of the county in the valley of Crazy Woman Creek, and some are along Piney Creek in the northern part.

The surface soil, to an average depth of 4 inches, is gray laminated clay. The subsoil, to a depth of 15 inches, is light grayish-brown or olive-brown heavy impervious clay which cracks when dry into nearly perfect 6-sided prisms. This heavy layer, when reached by the plow or exposed by erosion, is difficult to handle, and crop yields are low. Below the heavy layer, the material consists of layers of olive-drab sandy clay loam or clay of alluvial origin. The soil contains lime from the surface downward. In places salts are present in harmful amounts and bare spots, called slick spots, are scattered over the surface.

Arvada clay, under virgin conditions, affords a fair growth of grasses, with a considerable quantity of sagebrush and greasewood on the salty spots. A few attempts have been made to cultivate this soil by dry-farming methods, but the results have not been encouraging.

SOILS OF THE GRAZING DISTRICTS

Various proportions of the agricultural lands described in the foregoing pages are devoted to pasture, and a small proportion of the land classed as grazing land is used for the growing of crops. The soils of this group are unsuitable for cultivation and are used to a very large extent for pasture. Shallow stony soils, rough relief, frequent flooding by nearby streams, poor drainage, salt accumulation, and short growing season because of high elevation are some of the reasons why these soils are better suited for grazing than for cropping.

These soils comprise considerably more than one-half of the total area of the county. They furnish both winter and summer grazing for livestock. Small plots are irrigated for gardens or for the production of winter feed crops, but farming under irrigation will never be an important activity. Utilization of these soils for grazing is largely dependent on supplies of water and on the forage available for supplementary winter feed when the ranges are closed by storms or deep snows. Rough stony land, and soils of the Burgess and the Willow Creek series are included in this group, but here and there many areas of poorly drained or steep land also can be regarded as grazing land. The soils of this group include both the rough land of the dry sections and the rough and partly forested mountainous areas. During the summer, many cattle and sheep are driven up to the mountains to spend the summer in the Big Horn National Forest, where they remain until late September or October. The variety of soils in the mountains is large, and the type of summer pasture afforded differs correspondingly. Between the areas of forest land on the gently undulating to hilly interior of the mountains, are open areas covered with luxuriant pasture grasses. These grassland soils include members of the Burgess and Willow Creek series.

Forest land occupies a larger total area in the Big Horn Mountains than does grassland, but it is less important for grazing. Parts of the foothills and lower mountainsides are covered mainly with a growth of ponderosa (western yellow) pine, the rolling to undulating interior of the mountains supports a dense stand of lodgepole pine over much of the area, and in moist situations at moderately high altitudes are patches of Engelmann spruce. Cottonwood, particularly the narrow-leaved varieties, grow along the creeks in the canyons which face the plains. One of the most important benefits accruing to the ranchers of this county from the forested lands of the Big Horn Mountains is the supply of pure water they furnish for domestic use and irrigation purposes. The forests hold in check the melting of the heavy snowfall, so that the water supply from this source extends well into the summer. Without the forest cover, the snow would disappear much earlier, and many of the streams would become dry before the end of the growing season.

Rough stony land.—Land mapped in this county as rough stony land comprises more than one-half of the total area. Land that is too steep, stony, or rough for farming operations is given this designation and it includes a large variety of the soil types and phases previously described. Very small isolated patches of arable land are cultivated by the ranchers. This grouping is a land type rather than a single soil or group of definite soils. It includes both the rough land on the plains and the rough broken mountainous areas.

The best pasture afforded by rough stony land is in the foothills of the Big Horn Mountains. The precipitation in this strip of territory is heavier than that farther east; hence, the growth of grasses is better. Needlegrass, grama grass, bluegrass, white clover, and some alsike are common. On plains east of the mountains, strips of rough stony land occur along all the present streams. The Powder River breaks in the northeastern corner of the county comprise a large area of rough land produced by stream erosion. A small acreage along Powder River and along the tributary valleys to the south is in cultivation, but this is essentially a grazing country. The red-hills

section also includes a large area of rough land. In the plains section, the steep narrow tributary valleys furnish water and protection for the winter grazing of numerous flocks of sheep, but during the summer the sheep are moved to the mountains to graze on the open lands of the national forest.

Burgess loam.—Burgess loam has a 6-inch layer of dark-brown or nearly black loam underlain by yellowish-brown acid loam which varies greatly in thickness. In places, this underlying material is thin and overlies solid rock, and, in other places, it attains a maximum thickness of 10 inches. The parent material in most places is decomposed granite and in other places is glacial or alluvial granitic debris. This soil occurs in that part of the Big Horn Mountains where granitic rocks are exposed. The largest area is in the vicinity of Hazelton. Burgess loam supports a rather sparse growth of grass and flowers, and it is used largely as summer pasture for cattle.

Willow Creek silt loam.—Willow Creek silt loam is developed either from limestone in place or from colluvial debris which consists largely of limestone fragments. To an average depth of 12 inches, the soil is black or very dark brown friable silt loam which has an acid or neutral reaction. The subsoil is yellowish-brown finely cloddy silty clay loam to a depth of 15 inches. Beneath this and continuing to a depth ranging from 30 to 50 inches is yellow silt loam heavily mottled with lime and containing fragments of limestone. The lower layers consist mainly of masses of limestone fragments and, in most places, a smaller proportion of sandstone. Large areas of this soil are in the southwestern part of the county. The better areas furnish fair grazing, but in places a heavy growth of sagebrush checks the growth of grass.

ALKALI AND DRAINAGE

The problem of salt and alkali accumulation does not involve a large acreage, although a few areas have moderate to heavy accumulations of white alkali, black alkali, or both. Salt, or "white alkali," consists mainly of the chlorides and sulphates of sodium, magnesium, and calcium, and alkali, or "black alkali," is mainly sodium carbonate. It is spoken of as black alkali because it produces a dark color in the surface soil through its action on organic matter.

The areas of salty soils are mainly along the creek bottoms, and the salts probably originated in the shales that are exposed along the slopes. Some of the salty areas are of recent formation and are due to a high water table produced by seepage from canals, and in other places the salts already present have been brought to the surface by this raising of the water level.

The common way of ridding the soil of salts is to install tile or ditch drains and then to irrigate the land. As the water seeps down through the soil and out through the drains, it carries the dissolved salts with it. Where the proportion of salts is medium or high, it is difficult to remove them merely by washing, because sodium carbonate causes excessive puddling of the soil and prevents water from passing through it. The only known practical method of overcoming this difficulty is to treat the soil with heavy applications of sulphur, gypsum, or lime before attempting to wash out the salts. Under this treatment, the soil particles coagulate into grains, and water may then pass through.

In most areas affected by salts, the land is too low in value to justify the expense of reclamation or drainage. In Clear Creek Valley, a few attempts have been made to reclaim salty land by constructing ditches and dikes to cut off seepage and run-off water, but most of the stockmen prefer to make use of well-drained land.

Many small areas of soil in the irrigated districts and low poorly drained bottoms along the streams in the eastern part of the county carry more or less salts and are indicated on the soil map by symbol. Poorly drained areas are nearly everywhere salty, and salts crystallize around the edges of the marshy areas. Drier areas of salty land can be identified readily by the salt crust over the surface where the percentage of salts is high, and by barren slick spots, stunted vegetation, and the growth of salt-tolerant plants, such as greasewood and saltgrass, where the salt concentrations are only moderate or low.

MORPHOLOGY AND GENESIS OF SOILS

An opportunity was afforded the soil scientist in Johnson County, as he passed through the semiarid plains to the humid mountain regions, to observe an interesting succession of soils, including those of several great soil groups. This variety of soils is the result of many climatic and geological factors. The development of the soils of the region and their relationship to environment were studied and described in the report on the Soil Survey of Sheridan County, Wyoming,[3] and in other publications,[4] but the soils of this county have never before been mapped and described in detail.

In the Big Horn Mountains the annual precipitation greatly exceeds that on the plains. Furthermore, the cooler temperature of the mountains so reduces the evaporation that the difference in soil humidity between the mountains and the plains is greater than the difference in precipitation would indicate. The annual precipitation in the mountains of this county ranges from 20 inches to possibly as high as 40 inches, according to the locality. At Buffalo, the average annual precipitation is about 13 inches, and it is probably slightly less in the eastern part of the county. The mean annual temperature in the mountains is about 34° F., and in Buffalo is 44°. Rainstorms, which originate in the mountains during the spring and summer months, drift eastward and drop considerable moisture on the land at the bases of the mountains. In the rest of the Great Plains country precipitation is more uniform.

Underlying the soil covering, and in places outcropping on the surface are many kinds of rock, both sedimentary and crystalline.[5] The crystalline rocks are mainly granites, cut in places by numerous diabase dikes, and they are extensively exposed in the high mountainous areas. The sedimentary rocks comprise a variety of limestones, sandstones, shales, and loosely consolidated beds of gravel and sand, and these rocks in many valleys are covered by sedimentary materials and glacial deposits.

[3] THORP, JAMES, GLASSEY, T. W., DUNNEWALD, T. J., and PARSONS, B. L. SOIL SURVEY OF SHERIDAN COUNTY, WYOMING. U. S. Bur. Chem. and Soils ser. 1932, Rept. 33, 48 pp., illus. 1939.

[4] THORP, JAMES. THE EFFECTS OF VEGETATION AND CLIMATE UPON SOIL PROFILES IN NORTHERN AND NORTHWESTERN WYOMING. Soil Sci. 32 : 283–301, illus. 1931.

[5] United States Geological Survey Folios 141, Bald Mountain-Dayton, Wyoming; and 142, Cloud Peak-Fort McKinney, Wyoming. 1906.

The broad soil groups follow vegetational and climatic differences without regard to geological differences. These groups include (1) soils of the humid mountains, (2) soils of the subhumid foothills, and (3) soils of the semiarid plains. Only small areas of soil were developed over many of the rock formations of the mountains, and the difficulty of outlining such areas was so great that they have been included with the areas of rough stony land. These soils are skeletal, maintaining a precarious position on steep slopes or a more secure position on narrow rock shelves or in small valleys where the soil is partly protected from erosion. In the higher mountainous regions these small patches of soil are well-developed Podzols. Only two soils in the mountains are developed in sufficient areas to be indicated on the soil map. These are developed in parks or open areas and under the influence of a grass vegetation. Burgess loam is developed over granite or granitic debris, and Willow Creek silt loam is developed over limestone or limestone fragments. The well-developed soils of the foothills and Great Plains fall mainly in the Chernozem and Chestnut soil groups, but it is possible that the soils of the more arid part of the plains may be grouped with the Brown soils. The Chernozems are developed in narrow areas in the foothills. The Story and the Harlem soils may be placed with this soil group.

The Chestnut soils are lighter colored than the Chernozems, and they have a more or less well developed Solonetz type of profile. The materials of the upper subsoil layers are heavier and stiffer than those of the Chernozems, and the lower A horizon shows the influence of salts. The tops of the prisms of the B horizons, where these are well developed, generally are covered with thin layers of gray silt particles. A few areas east of the mountains have a normal development of the soil profile, and without doubt the development of a Solonetz in this section is due to the effect of salts.

The soils of the Wolf and the Big Horn series are representative of the Chestnut soils, with a slight tendency toward a Solonetz structure. Following is a description of a profile of Wolf loam, as observed at Seneys Airport 2 miles northwest of Buffalo:

0 to 1 inch, grayish-brown flaky porous fine sandy loam. This material forms a mulchlike layer.

1 to 5 inches, dark grayish-brown platy porous friable loam containing many grass roots.

5 to 10 inches, brown clay loam which is compact in place but breaks out in small prisms that, in turn, break readily to a nut structure.

10 to 20 inches, yellowish-brown or light-brown clay loam which is stiff when moist, becoming cloddy when dry, and is heavily impregnated with a silty accumulation of lime.

20 inches +, rounded gravel coated with a deposit of white lime. The interstices are filled with silty lime. At a depth of about 40 inches below the surface, the gravel is not coated with lime.

Extensive soils of the Ulm and the Renohill series may be classed with the Chestnut soils group, although they are very near the boundary between the Chestnut and the Brown soils.

Soils of the Beckton and Arvada series are solodized Solonetz. They have leached surface soils which are pale gray or nearly white when dry, exceedingly heavy upper subsoil layers which exhibit a strongly columnar form, and underlying layers containing some accumulation of lime and gypsum. The tops of the columns are covered with gray silt and are somewhat rounded. The parent material of

the Beckton soils consists of deep outwash from neighboring cretaceous gray shales, and that of the Arvada soils is alluvial-terrace and alluvial-fan material of mixed origin.

The Bridgeport and Twin Creek soils are developed from alluvial-fan materials of comparatively recent origin. They show a slight development of the B horizon and some accumulation of lime and gypsum. In many places these soils are superimposed upon a series of old soil profiles.

The results of pH determinations of a number of soil profiles are given in table 7. These samples are taken in Sheridan County which adjoins Johnson County on the north. The samples are representative and closely resemble soils of the same series in Johnson County.

TABLE 7.—*pH determinations on nine soils from Sheridan County, Wyo.*[1]

Soil type and sample No.	Depth	pH	Soil type and sample No.	Depth	pH
Burgess fine gravelly loam:	*Inches*		Big Horn loam:	*Inches*	
480712	0 − 6	6.1	480705	0 − 3	6.9
480713	6 −15	5.2	480706	3 −12	6.7
480714	15 −36+	4.9	480707	12 −18	7.0
Twin Creek silt loam:			480708	18 −24	7.4
480783	0 − 2	7.9	480709	24 −48+	8.1
480784	2 −12	7.4	Wolf clay loam.		
480785	12 −18	8.0	480701	0 − 5	6.8
480786	18 −48	8.1	480702	5 −13	6.8
Lismas clay:			480703	13 −24	8.1
480787	0 − 1½	8.1	480704	24 −36	8.2
480788	1½−12	8.1	Ulm fine sandy loam:		
480789	12 −24	7.6	480732	0 − 2	7.0
480790	24+	6.9	480733	2 − 9	6.8
Arvada clay loam:			480734	9 −24	6.4
480721	0 − 4	6.7	480735	24 −35	6.8
480722	4 −13	6.7	Big Horn clay:		
480723	13 −21	7.5	480710	0 − 4	7.6
480724	21 −48+	8.5	480711	4 −12	7.7
Beckton loam:			480712	12 −18	8.1
480765	0 − 3	7.3	480713	18 −24	8.4
480766	3 − 3½	8.4	480714	24 −50+	8.1
480767	3½−10	8.5			
480768	10 −20	8.6			
480769	20 −36+	7.9			

[1] Determinations made by E. H. Bailey, in the laboratories of the Bureau of Chemistry and Soils, U. S. Department of Agriculture. The hydrogen-electrode method was used.

SUMMARY

Johnson County is in the north-central part of Wyoming. The western part of the area surveyed lies within the Big Horn Mountains and the rest within the Great Plains region. Numerous rivers and creeks send from the mountains a supply of water to irrigate the lands of the terraces, alluvial fans, and stream bottoms near the foot of the mountains. The eastern half of the county comprises a highly intersected plateau, most of which is suited only for grazing. The relatively small acreage of arable land in the stream valleys and on the ridges is used either for pasture or for dry farming.

The climate of the mountains is cool-temperate to subarctic and is moist. That of the Great Plains is cool-temperate and is semiarid.

Agriculture is mainly subsidiary to livestock raising, and alfalfa is the main crop. Wheat, barley, oats, and sugar beets (to a small extent) are also grown. Beef cattle, sheep, and horses are raised in

large numbers, and they consume practically all of the alfalfa and a large part of the grain produced.

The soils are discussed under three main headings: (1) Soils of the irrigated districts, (2) soils of the dry-farming districts, and (3) soils of the grazing districts. The first group comprises the soils on the terraces, alluvial fans, and bottom land, most of which are within a few miles of the foot of the mountains. The mature soils of this group have dark grayish-brown or nearly black surface soils, very heavy and stiff brown upper subsoil layers, and lower subsoils with an accumulation of lime. The mature soils developed on the lower terraces and alluvial fans are members of the Big Horn, Wolf, and Story series. The younger soils on the terraces and alluvial fans are of more recent origin and include soils of the Bridgeport and the Twin Creek series. These soils are dark grayish brown, the upper subsoil layers are somewhat heavy, and the lower subsoil layers contain a slight accumulation of lime and gypsum. The soils of the Laurel and Harlem series occupy flood plains along the stream courses.

The principal soils of the dry-farming districts are the Ulm, Renohill, Lismas, and Searing soils of the uplands and the Beckton and Arvada soils of the alluvial fans. The Ulm soils are mature brown soils derived from sandstones and shales, the Renohill soils are derived from heavy shales, the Lismas soils are shallow gray soils derived from shale, and the Searing soils are red shallow soils derived from scoria. The Arvada soils resemble the Beckton soils but are derived from a different kind of alluvial deposit.

Grazing land comprises the rough broken and stony areas in the Great Plains as well as all the land in the mountains. Burgess loam and Willow Creek silt loam are differentiated on the map; the rest of such land is designated rough stony land.

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