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Soil Survey
of
The Basin Area, Wyoming

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By JAMES THORP, in Charge, and E. G. FITZPATRICK, U. S. Department of Agriculture, and T. J. DUNNEWALD and F. T. GORSUCH, University of Wyoming

AREA SURVEYED

The Basin area is in northwestern Wyoming, in the great basinlike desert region, known as Big Horn Basin, which is bounded by the Big Horn Mountains on the east, the Absaroka Range of the Rocky Mountains on the west, the Pryor Mountains on the north, and the Owl Creek Range on the south. (Fig. 1.) The Basin area, which is named for the county seat of Big Horn County, includes lands under irrigation and lands which may be irrigated in the future, bordering Big Horn River and some of its principal tributaries.

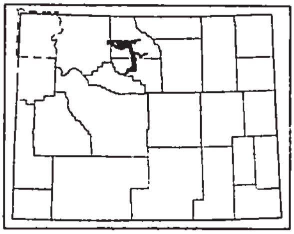

FIGURE 1.—Sketch map showing location of the Basin area, Wyo.

The western edge of the northern part of the area adjoins the Shoshone area[1] on range line 98 W. From this line eastward the irrigable lands along Dry Creek and Greybull River are included, as well as a strip of irrigated land extending eastward from Greybull up Shell Creek to the edge of the Big Horn Mountains. The area extends southward from Greybull up the valley of Big Horn River. The width of the surveyed area varies widely, being 4 miles at Basin, 7 miles at Manderson, 6½ miles at Rairden, 7 miles at Worland, and 3 miles at Winchester. A narrow strip of land following Nowood and Paint Rock Creeks to the edge of the Big Horn Mountains and an isolated area comprising about 10 square miles in the vicinity of Ten Sleep are included. The irrigable lands along the smaller tributaries are very narrow in some places and much broader in others.

The elevation at Basin is 3,837 feet, at Worland 4,061 feet, and at Ten Sleep 4,513 feet.

Under natural conditions the regional surface drainage of practically the whole area is good. However, it is necessary to drain nearly all the land when it is put under irrigation, because underdrainage is not sufficiently good to take care of the large amounts of irrigation water used. The waste water collects in the small natural depressions of the river terraces, raises the water table of the whole terrace, and in a comparatively short time evaporation of the excess capillary water causes an accumulation of alkali at the surface. The soils with gravelly substrata, which, theoretically, should be free from this difficulty, are in fact most subject to it. This is because they lie in a flat position and because many reefs of uneroded sandstone and shale rocks underlie the gravel, checking the underground

[1] DUNNEWALD, T. J., PEARSON, C., CARPENTER, E. J., FITZPATRICK, E. G., and THORP, J. SOIL SURVEY OF THE SHOSHONE AREA, WYOMING. U. S. Dept. of Agr., Bur. Chem. and Soils Ser. 1927, Rpt. 38, 50 p., illus. 1932.

movement of water and causing it to approach the surface. The soils lying on the rolling uplands and alluvial fans are less subject to the ponding of waters and hence are in less need of drainage. However, on the broad, gently sloping alluvial fans it is necessary to construct drainage ditches to keep the water table low enough to prevent interference with the growing of crops. Big Horn and Greybull Rivers and Dry, Shell, and Nowood Creeks are the principal natural drainage courses of the area. These streams, with their tributaries, remove all the run-off from this part of the country.

Big Horn County was organized in 1897 from parts of Fremont and Johnson Counties. Part of this territory was taken in 1911 to form Park County, and other parts were taken in 1913 to form Washakie County and a part of Hot Springs County. The area surveyed includes parts of Park, Washakie, and Big Horn Counties, the major part lying in the last two counties.

The first white settler known to have made his home in the Big Horn Basin was John White Woodruff, who built a cabin near the head of Owl Creek which lies outside the boundary of the Basin area. He was the first to introduce domestic cattle and sheep into this part of the country. However, there was no important colonization of Big Horn County until 1900, when a band of 800 Mormons migrated from Utah and entered into an agreement to irrigate about 18,000 acres of land. Two years later 200,000 acres were under irrigation. In 1910, the year before the county was subdivided, there were more than 50,000 cattle, 13,000 horses, and 270,000 sheep on the farms and ranges.

Most of the population of Big Horn and Washakie Counties are native-born Americans of more or less mixed ancestry. A colony of people, largely of German descent, is established on the Emblem bench, and at Ten Sleep and Hyattville are many people of Scotch and English birth or descent. A few Japanese families have settled in various parts of the area, particularly near Worland. Only a very few negro families live in the Big Horn Basin. During the summer many itinerant Mexican laborers come into the area.

According to the 1930 Federal census report,[2] the population of Big Horn County is 11,222 and of Washakie County is 4,109. Figures regarding the density of population of the Basin area are impossible to obtain without a special census because the area is not a civil unit. On the lands which are now under irrigation one or more families live on each unit. The units range from 40 to 160 or more acres in size. In the northwestern part of the area, where irrigation has not yet been established, the population is very sparse, and for distances ranging from 10 to 12 or more miles no human habitation, except the covered wagons of sheep herders, is to be seen.

The principal towns of the area are Greybull, with a population in 1930 of 1,806; Basin, with 903; and Worland, with 1,461. They are on the Denver, Black Hills, and Billings division of the Chicago, Burlington & Quincy Railroad, which line follows the course of Big Horn River through the area. These towns are not large enough to furnish markets for more than a small proportion of the agricultural

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

products of the area. Most of the fruits and garden truck find a local market, but the greater part of the other crops is shipped from these points to the larger markets to the east, south, and north.

The Atlantic-Yellowstone-Pacific Highway, commonly called the Yellowstone Highway, passes through Worland, Manderson, Basin, and Greybull and thence extends westward up Dry Creek Valley toward Cody, passing out of the area on its extreme western border. About 5 miles from Greybull a road branches off northward toward Billings, Mont., by way of Lovell, Deaver, and Frannie, in the Shoshone area. Most of these roads are graded and graveled and are in good condition except immediately following the infrequent rains or snows of this region. A fairly good highway connects Burlington and Otto with Basin, and other roads follow Shell and Nowood Creeks. An excellent road connects the Yellowstone Highway at Worland with Buffalo and Sheridan by way of Ten Sleep and across the Big Horn Mountains.

Side roads connecting with the main highways are in good condition in the settled communities, except in a few places near Otto and Burlington, where excessive alkali accumulation and lack of care of waste water keep them in an almost constant poorly repaired condition. A few of the feeder roads are impassible except for horse-drawn vehicles. This condition will be improved when an adequate drainage system has been constructed and the water table lowered.

CLIMATE

The climate of the Basin area is arid, making irrigation necessary for the successful production of cultivated crops. The United States Weather Bureau records show an average annual precipitation of 6.44 inches at Basin and of 7.51 inches at Worland. These stations report a maximum annual precipitation of 11.09 and 12.15 inches and a minimum of 2.63 and 3.03 inches, respectively. The Basin area is a true desert, as only in the wettest years does the precipitation approach that of a semiarid climate. The greater part of the moisture falls in the 8-month period from March to October, inclusive, with the spring months showing slightly greater rainfall than either the summer or fall months. Although the precipitation of the summer months nearly equals that of the spring and exceeds that of the fall and winter, the soils are drier during this period than at any other time because the heat of summer increases evaporation and causes a low relative humidity. During July and August the soils which are not irrigated become very dry and hard, and large cracks open up in the heavier soils. The occasional violent thundershowers of summer do not wet the soil to a depth of more than a few inches, and the moisture is usually evaporated a few hours after the passing of the storm clouds. Hailstorms of sufficient force to severely damage crops are very rare. Snowfall in the Basin area is practically never heavy enough to interfere with road travel for more than a day or two at a time.

The winters are cold, with minimum reported temperatures of −51° F. at Basin and −43° at Worland. The average winter temperature at Basin is 18.8° and that at Worland 17.5°. The highest temperature recorded at Basin is 114° and at Worland 104°. July averages the hottest month of the year. The frost-free season, that is, the time between the last killing frost and the first, averages 127 days at Basin and 132 days at Worland. Occasionally killing frosts occur after the first of June and before the middle of September. No figures are available for the outlying districts near Burlington, Shell, Hyattville, and Ten Sleep, but according to local information these places have a slightly shorter frost-free season than the districts near Basin and Worland.

Tables 1 and 2 give the normal monthly, seasonal, and annual temperature and precipitation at Basin and Worland.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Basin, Big Horn County, Wyo.*

[Elevation, 3,837 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1902)	Total amount for the wettest year (1924)	Snow, average depth
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	18.1	59	−38	0 35	(1)	0 59	3 0
January	17 0	60	−39	.33	0 16	27	3.4
February	21.3	68	−51	.35	.14	1 96	2.9
Winter	18 8	68	−51	1.03	.30	2 82	9.3
March	34 3	78	−26	55	27	5 21	3 6
April	46.0	87	3	74	.85	56	1.2
May	56.3	97	20	1 09	.61	.32	.6
Spring	45.5	97	−26	2 38	1 73	6.09	5.4
June	67.2	110	24	.86	24	.44	0
July	74.1	114	36	.48	.21	.79	0
August	71 8	110	34	.24	04	05	0
Summer	71.0	114	24	1.58	.49	1 28	0
September	60 4	98	22	.67	.08	.36	(1)
October	47 0	88	8	.52	(1)	.48	.7
November	33.1	74	−24	.26	.03	.06	1.3
Fall	46 8	98	−24	1.45	.11	90	2.0
Year	45 6	114	−51	6 44	2 63	11 09	16 7

1 Trace.

TABLE 2.—*Normal monthly, seasonal, and annual temperature and precipitation at Worland, Washakie County, Wyo.*

[Elevation, 4,061 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1919)	Total amount for the wettest year (1923)	Snow, average depth
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	17.3	60	−38	0 25	0.09	0 18	2 6
January	14 4	55	−43	35	.02	.17	3 2
February	20 8	66	−36	.22	.14	07	2.2
Winter	17 5	66	−43	.82	.25	.42	8.0
March	32 8	77	−23	.45	.06	.18	4.4
April	44 5	84	9	.87	73	.61	2.2
May	53 8	96	20	1 10	.04	1 27	1
Spring	43 7	96	−23	2.42	.83	2 06	6 7
June	65 5	104	31	1 29	.21	2 00	0
July	71.1	102	39	56	10	1 97	0
August	68 0	100	34	.48	(1)	92	0
Summer	68 2	104	31	2.33	31	4 89	0
September	57.9	96	24	1 01	67	3 84	1
October	45 7	87	−1	62	76	56	1 4
November	31.2	79	−26	.31	.21	.38	1 5
Fall	44 0	96	−26	1,94	1 64	4 78	3 0
Year	43.6	104	−43	7.51	3 03	12 15	17 7

[1] Trace.

AGRICULTURE

As the Basin area is not a civil unit, but includes parts of Big Horn, Washakie, and Park Counties, accurate data regarding the agriculture of the area can not be given. The part of the area in Park County is not under irrigation and has no influence on the agriculture; a large section of irrigated land in the Shoshone River Valley, Big Horn County, lies outside the Basin area; but practically all the important irrigated lands of Washakie County are within the area. In Table 3 are given crop data for Big Horn and Washakie Counties for the years 1899, 1909, 1919, and 1927. The data for Big Horn County for 1899 and 1909 include data for Washakie County, as that county was not separated from Big Horn County until 1913. The data given for 1927, except those on beans, are from a joint bulletin of the United States Department of Agriculture, Bureau of Agricultural Economics, and the Wyoming State Department of Agriculture. Estimates of the bean crop were obtained from the county agent of Big Horn County and from the Big Horn Cooperative Marketing Association which handles most of the crop. These estimates are conservative. The data for the years other than 1927 were compiled from the figures of the United States Bureau of the Census.

TABLE 3.—*Acreage and production of crops in Big Horn and Washakie Counties, Wyo., in stated years*

Crop	Big Horn County					
	1899		1909		1919	
	Acres	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*
Corn	132	3,700	231	4,216	223	5,589
Wheat	2,207	42,150	6,093	103,394	12,223	171,176
Oats	5,065	148,180	10,222	270,042	6,371	126,445
Barley	108	2,476	630	13,523	327	7,673
Potatoes	203	34,402	580	113,942	554	61,986
Beans	2	23	47	452	124	1,249
		Tons		*Tons*		*Tons*
Tame hay	15,063	36,610	33,072	86,844	54,700	100,387
Wild hay	6,518	8,016	879	1,100	580	640
Grains cut green	1,327	2,056	552	774	2,485	1,825
Sugar beets	----------	----------	836	9,031	2,647	30,460
	Trees	*Bushels*	*Trees*	*Bushels*	*Trees*	*Bushels*
Apples	1,838	71	8,622	5,731	27,702	13,315
Plums	----------	----------	1,261	366	3,661	1,621
Cherries	----------	----------	247	20	518	156

Crop	Big Horn County		Washakie County			
	1927		1919		1927	
	Acres	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*
Corn	1,400	42,000	97	3,434	500	20,000
Wheat	6,200	179,900	3,197	41,811	2,100	67,800
Oats	6,300	283,500	3,560	86,780	3,200	160,000
Barley	1,000	47,000	408	8,373	3,500	175,000
Potatoes	600	120,000	178	24,523	500	102,500
		Pounds				*Pounds*
Beans	[1] 6,000	[1] 6,000,000	147	637	[2] 4,000	[2] 4,500,000
		Tons		*Tons*		*Tons*
Tame hay	39,000	93,600	16,411	37,772	15,000	36,000
Wild hay	1,200	1,560	147	184	800	1,040
Grains cut green	----------	----------	760	993	----------	----------
Sugar beets	7,000	85,400	2,973	25,560	4,800	62,880
	Trees	*Bushels*	*Trees*	*Bushels*	*Trees*	*Bushels*
Apples	----------	----------	802	542	----------	----------
Plums	----------	----------	293	91	----------	----------
Cherries	----------	----------	68	32	----------	----------

[1] Estimate, by county agent, for that part of the county in the Basin area.
[2] Estimate by Big Horn Cooperative Marketing Association.

The foregoing statistics show that the trend of agriculture in the area is toward more cash crops. In the early days, as at present, hay was the principal crop, and sufficient quantities of wheat, oats, barley, and potatoes were grown to largely take care of local consumption. The hay, oats, and barley were used for feed, and wheat was ground in local mills and used mainly at home. The chief source of revenue was the sale of cattle, sheep, and wool. The installation of sugar factories at Worland and Lovell, the last-named town being about 36 miles from the north edge of the area, has given great impetus to the culture of sugar beets.

No dry farming is carried on in the Basin area, and the climate is so dry that irrigation will always be necessary. In the discussion of present agricultural trends and practices it should be borne in mind that the crops grown are on irrigated land entirely.

The largest acreage has always been devoted to the hay crop and will probably continue to be for a long time. This crop consists mainly of alfalfa, but much sweetclover and less amounts of other hay crops are grown. Alfalfa not only furnishes feed for dairy and beef cattle, sheep, and horses, but it adds nitrogen to the soil. This is a great benefit to the farmer because nitrogen is the one element which is conspicuously lacking in all the irrigable lands of the region. Alfalfa fed on the farm is doubly beneficial to the soil, as the manure from the animals is returned to the land. It has the one disadvantage of using up a large amount of the available phosphorus in the soil. Sweetclover is grown not only for hay but for seed and to be used as green manure for the fixation of nitrogen. Sweetclover will grow on land that contains too much alkali for the successful producton of alfalfa, and it is used very widely in reclaiming alkali lands.

The most important trend at the present time is toward the production of sugar beets and dry edible beans. Table 3 shows very rapid gains in the production of both crops. On the lighter types of soil it has been found that Great Northern beans will frequently produce as high as 2,500 pounds an acre. As a rule, the gross income from beans is considerably less than that from beets, but the overhead cost of growing beans is so much less that the net profit is greater than on beets. Seed beans of various kinds are grown, but they usually become blighted and the profits are diminished on this account.

Sugar beets grow well on most of the good soils of the area and are especially well adapted to the heavier types of soil, particularly the loams. They are more tolerant of alkali than beans and will grow on land where bean growing is out of the question. The production of sugar beets involves much hand labor both in thinning and weeding the crop in the spring and in topping the beets in the fall. The beet lands of Big Horn and Washakie Counties produce beets containing a higher percentage of sugar than any other lands in Wyoming, Colorado, or Nebraska, according to sugar refiners' reports, and the farmer receives 50 cents more a ton than growers elsewhere in this region. Prices in 1927 were $8.50 a ton in the Basin area. A great expansion of the beet industry will probably take place if a branch line to the railroad is built up Greybull River or Dry Creek, as has been proposed. At present farmers in the outlying districts are obliged to depend for their cash income on crops with a greater unit value than beets.

Some of the finest corn in Wyoming is produced in the Basin area, but yields are not sufficiently high for the crop to become of commercial importance at present prices. All the corn grown is used locally for feed, and much is shipped in to be used in fattening turkeys.

Most of the vegetables and small fruits common to the North Temperate Zone will grow well in the Basin area, and most farmers have gardens in which they produce enough of these crops for their own use and frequently some to sell in the neighboring towns. A few Japanese families have gone into the truck-crop business on a larger scale, and they are not only selling large quantities of vegetables and melons locally but are shipping some to Cody, Thermopolis, Casper, and other towns outside the area. It is probable that this industry could be profitably extended.

Table 4 gives the number and value of the most important classes of livestock, of poultry, and of bee colonies in Big Horn and Washakie Counties.

TABLE 4.—*Number and value of livestock, poultry, and bees in Big Horn and Washakie Counties, Wyo., in stated years*

Class	Big Horn County					
	1900		1910		1920	
	Number	*Value*	*Number*	*Value*	*Number*	*Value*
Cattle	42,845		50,325	$1,418,991	41,604	$2,286,947
Sheep	357,797		270,423	1,380,222	126,878	1,620,264
Horses	15,488		13,384	1,122,575	10,306	813,013
Swine	2,558		7,213	48,803	5,059	78,611
Poultry		$9,791	38,249	20,296	47,490	46,047
Bee colonies	43	344	1,251	6,307	4,850	67,135

Class	Big Horn County		Washakie County			
	1927		1920		1927	
	Number	*Value*	*Number*	*Value*	*Number*	*Value*
Cattle	14,084	$362,769	16,527	$960,981	10,721	$260,341
Sheep	65,859	420,589	101,109	1,262,566	91,243	679,374
Horses	6,282	139,295	5,259	430,280	5,435	101,160
Swine	1,108	7,027	2,393	40,645	1,036	7,244
Poultry			17,171	19,584		
Bee colonies	7,000		356	4,729	2,750	

Accurate data on the number of poultry kept in the area are not available at the present time, but there has been a very significant increase in the number of turkeys raised in the last few years. The Big Horn Cooperative Marketing Association estimates that about 7 carloads of turkeys, or about 13,000 birds, were shipped from the Basin area alone in 1928. The United States census gives the number of poultry other than chickens as 2,955 in Big Horn and Washakie Counties in 1920. Of this number probably about 2,000 came from the Basin area, and probably most of the fowls were turkeys. From these figures it is estimated that there has been an increase of at least 650 per cent in the number of turkeys raised and shipped during the 8-year period ended in 1928. The climate and natural surroundings are very favorable to the raising of these fowls, and it is likely that their numbers will further increase.

The decrease in the total number of cattle, sheep, and horses between 1920 and 1927 was very marked, and the numbers of these animals, particularly cattle, continued to decrease in 1928 because the owners converted the cattle into cash during the period of high prices.

It is generally recognized that unseasonable frosts are less likely to occur on the lands lying on the terraces and uplands than on areas of lowland along the streams. In the lowlands the air and soil warm up more quickly than on the uplands during the daytime; but at night the cold air settles in these places, and tender plants or fruit blossoms are likely to be frosted in the spring. The sandy soils of the area are recognized as warmer soils because they do not hold so much moisture and hence warm up more quickly in the spring. They usually produce earlier crops than the colder heavy soils. Soils with a slope suitable for irrigation are necessary to successful farming.

The adaptation of soils to crops is influenced largely by the soil texture. Farmers generally recognize that sandy soils are particularly suited to beans, loams to potatoes, and loams and clay loams to grains. Alfalfa, sweetclover, and beets are grown indiscriminately on all soils where stands can be obtained. Sweetclover and beets are especially popular on soils that are being reclaimed from an alkali condition.

Fall plowing is common practice in the Basin area. The land is usually plowed before Christmas and allowed to lie fallow all winter. Many farmers irrigate the soil early in the spring and allow the weeds to sprout, after which the land is thoroughly harrowed with a disk harrow. By this means it is possible to greatly reduce the expense of weeding the crops later in the season. Beet and bean seeds are planted with modern drills which have attachments for making shallow furrows for the irrigation water between the rows. The crops are cultivated after each irrigation during the early part of the season. Young beets are thinned and weeded by hand and occasionally, when cultivators do not thoroughly do the work, beans must be weeded and hoed by hand.

The land is irrigated by allowing water to flow from the ditches down the shallow furrows between the growing crops until the soil is thoroughly moistened. For grains and alfalfa, very shallow furrows for the water are made about 18 inches apart at the time of planting. The waste water is usually collected in a small ditch at the lower end of the field and conducted to a drainage ditch or to a near-by creek or draw. Some farmers let the waste water run at will, but this practice leads to the bogging of lower-lying lands.

No fixed crop rotation is practiced at present in the Basin area, but several common practices are in use. Most farmers plant alfalfa with wheat, barley, or oats as a nurse crop. Where the land is too salty for alfalfa, sweetclover is planted after some of the alkali has been removed. The land is usually left in alfalfa for several years, after which it is plowed and planted to beets or potatoes, or sometimes to beans, though beans do not thrive very well immediately following alfalfa. The land may be kept in beets for several years, but potatoes are seldom grown more than one season without rotation. When the land begins to lose productivity it is put back into alfalfa, with a grain as a nurse crop. When it is desired to get the land quickly into condition for growing cultivated crops, sweetclover is sown with a nurse crop in the spring, the grain is harvested that summer, and the sweetclover is plowed under the following June. The land is then ready for beans.

Commercial fertilizers are not used in the Basin area. Stable manure is applied to the land, and sweetclover or alfalfa is plowed under. The only element lacking in the soils of this region is nitrogen, and a good supply of this is provided by alfalfa or sweetclover.

Most of the farms have fairly comfortable houses, and the number of homes with modern conveniences is increasing. There are very few good barns in the area, a small shed for cattle or machinery usually being considered sufficient. Most farmers own modern machinery of good quality, and many have tractors. The work animals are of medium weight, but the heavier breeds of horses are on the increase.

Most farmers keep a few dairy cows, mostly grades, though there are many Holsteins and Jerseys scattered throughout the area. Most of the range cattle are of the Hereford breed, and a few are Shorthorns.

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The farm labor employed in the Big Horn Valley and adjacent lands where beets are produced is mainly Mexican. These people live in small houses provided by the farmers and work under contract, receiving about $26 an acre for thinning, weeding, and topping the beets, with a bonus when the yield exceeds 12 tons an acre. The labor on the farms along Greybull River and Dry, Shell, and Nowood Creeks is mainly native-born American. About 51 per cent of the farms in Washakie and Big Horn Counties reported the hiring of labor, at an average cost of $632.83 a farm, in 1925. The laborers are in general efficient, but close supervision is commonly practiced.

In 1930, 70.8 per cent of the farms in Big Horn County and 69.9 per cent of those in Washakie County were operated by the owners, a few were operated by managers, and the remainder by tenants. The common form of rental is a share of the crop rather than cash. The proportion of the crop received varies, but the tenant usually receives the following shares: Beets, five-sixths of the crop; beans, from three-fourths to four-fifths; hay, two-thirds; and grain, three-fourths. The owner pays water rent and taxes, and the renter furnishes all labor and most of the machinery.

Rates paid for irrigation water vary greatly in different parts of the area. They are on a flat-rate basis and range from nothing in some parts of the Greybull River Valley to $2.50 an acre under the Upper Hanover Canal. The rate under the Big Horn Canal on the west side of Big Horn River is $1.75 an acre. In the Greybull River Valley rates are very low because the farmers cooperate in caring for the ditches and hence do not have to pay for having the work done. On the higher benches this is impossible, and the rates vary according to the amount of engineering expense involved.

The average size of farms in Big Horn County is 198.2 acres, and of farms in Washakie County is 786.2 acres. However, the number of farms in the Basin area ranging from 40 to 120 acres in size is much greater than the number of those of the average size given by the census, as a few very large ranches greatly increase the average size for the area.

Land values range from almost nothing for the areas badly affected with alkali to $150 or more an acre for the best lands. It is probable that land values of soil which has been or can be freed of danger from alkali will increase in the next few years.

At the present time it is difficult to make recommendations for the improvement of the soils of the Basin area, because practically no experimental work along this line has yet been accomplished. Several problems of importance are to be considered, and a small start has been made in this direction. One problem is that of supplying nitrogen in the soil. The methods in general use for accomplishing this have been discussed. From experiments carried on by one of the large sugar companies at Wheatland, Wyo., where the soils are somewhat similar to those of the Basin area, it has been found that continuous cropping without fertilization of the soil has resulted in a large reduction of the available phosphorus in the soil, with a corresponding reduction in crop yields. It has been found there that beet yields can be greatly increased by the addition of only 50 pounds of superphosphate (acid phosphate) to the acre. The results of these experiments are as yet incomplete. The Wyoming Agricultural Experiment Station is planning an experimental field to be placed on some of the very heavy alkali soils of the Basin area with a view to finding some practical way of making these soils productive. The present method of handling the land is to plant sweetclover with a nurse crop and plow it under the second year, then follow it with alfalfa. Much alkali land can be brought into production within a few years by this method. Another problem on which the experiment station is working, but on which it has not as yet obtained results, is the problem of reduced yields from old alfalfa fields. Alfalfa makes remarkable growth on virgin land, but after the soil has been cropped for a few years the yields are greatly reduced. Chemical analyses have as yet shed no light on the cause of the decreased yield.

SOIL SERIES AND TYPES

The soils of the Basin area are separated into series, types, and phases. A soil series includes several soil types, and a soil type may include several phases. A soil series is a group of soils which are essentially the same in every respect except in the texture of the upper few inches commonly known as the plow depth, or surface soil. The series name is taken from the name of a locality in or near which soils of the series were first mapped. A soil type is a member of a given series with a particular texture in the upper few inches. A phase represents a local variation or inclusion within a soil type, which is of insufficient importance or extent from the viewpoint of soil classification to be recognized as a separate type. An example of a soil name will further explain the meaning of the terms used. All soils in the Basin area which have pale grayish-brown surface soils, yellowish-brown subsurface soils, subsoils which contain a large amount of white lime accumulation, and which are underlain at a depth ranging from 2 to 3 feet by waterworn gravel have been classified as belonging to the Ralston series. A soil of this series with a surface soil of fine sandy loam is known as Ralston fine sandy loam, this being the type name. If this type should be too moist for agricultural purposes, owing to the fact that it happens to lie in a depression, it would be called Ralston fine sandy loam, poorly drained phase. Other type names are loam, silt loam, and clay, according to the texture, and other phases are designated as hilly, eroded, or otherwise.

In describing soil types the terms "profile" and "horizon" are frequently used. A soil profile is a vertical cross section such as is exposed in a road cut or along the edge of a vertical stream bank. Profiles of most soils show several more or less distinct but usually uneven horizontal layers. Most soils, except those on steep eroded hills and on river bottoms, have three main horizons. The topmost horizon is the part which is cultivated and hence is of most importance to the farmer. The middle horizon is usually more compact than the topmost horizon and in many places in the Basin area is rich in lime. The third, or bottom, horizon is the parent material, or the material from which the soils have been formed.

In the Basin area 9 series of soils, including 26 soil types and 18 phases of types, in addition to 3 classes of miscellaneous nonagricultural materials, are mapped.

All the soils of the Basin area must be irrigated in order to produce crops. An endeavor was made to include in the area only those soils which could be watered. In some places, however, the engineering problems involved in getting water to the lands will be very difficult and expensive, so much so, in fact, as to preclude the irrigation of some tracts until land values are much higher than they are at present. Another problem, coincident with that of irrigation, is the problem of the removal of waste water from irrigated lands. This involves artificial drainage, and there is no extensive area of land in the whole Basin area which does not need a thorough system of drainage ditches, tile drains, or both. On many of the alluvial fans, which lie between the river terraces and the uplands, there are many farm units which would not require drainage other than that provided by nature, but the waste water from these farms will invariably cause seepage and alkali accumulation on the farms of the flat lands just below. The gravel layer underlying soils of the Ralston series will act as a natural drainage channel for removing excess waters, but the soils in the numerous slight depressions will become seep spots if no ditches or drains are provided to remove the ground water. Another cause of poor drainage is that the underlying shale, sandstone, or other rocks have been unequally eroded, leaving small ridges or reefs of rock which impede the circulation of underground waters.

With equally satisfactory conditions of irrigation and drainage, the soils of the Basin area rank in agricultural importance approximately as follows: The soils of the Ralston and Billings series are about equal in importance. The Ralston soils will produce any staple crop of this region and are especially adapted to alfalfa, potatoes, grains, sugar beets, beans, peas, and truck. The same may be said of the Billings soils, except that they are better adapted to beets and not so well adapted to potatoes as the Ralston soils. The fine sandy loam of the Worland series should prove to be equal in value, for general crops, to the Ralston and Billings soils, but at present practically none of this soil is under irrigation and most of it lies at elevations where it would be necessary to pump water to it. The other member of the Worland series is light textured and would require large amounts of water. The Meeteetse soils are highly productive of all local crops, but they are very inextensive. They produce especially good crops of beans, grains, and alfalfa. Soils of the Chipeta and Greybull series are very extensive, but their agricultural value is low because they are too shallow to allow satisfactory drainage. In most places, except on some moderate slopes, they are sure to become affected by alkali within a few years after they are first irrigated. The Chipeta soils are more subject to alkali accumulation than the Greybull soils because they contain more soluble salts in the parent materials. The Shoshone soils, with the exception of the terrace phases, are so near the level of the streams that they are in most places affected with alkali and it is difficult or impossible to drain a large part of these soils. Where they are not affected by accumulations of alkali, however, they are rather productive, though not so productive as the Ralston or Billings soils. Soils of the Moffat series are very well adapted to the production of alfalfa, grains, beans, and potatoes. Sugar beets would doubtless do well on these soils, but the production of this crop would not be profitable because the soil areas, the largest of which are near Ten Sleep and Hyattville, are too far from the railroad. The soils of least agricultural value are those of the Pierre series. These are thin salty soils underlain at a very slight depth by impervious shales, and they invariably accumulate alkali as soon as they are irrigated. Their dark color gives the inexperienced farmer a false idea of their fertility, and several newcomers have been deceived in this way. These soils can not be subdrained. Such lands afford fair pasture for sheep and should be left for that purpose. Practically all the nonagricultural lands, with the exception of bare rock wastes, furnish valuable winter pasture for sheep and should be used for that purpose. The soil types and phases of each series are described in detail in the following pages, and their agricultural importance is discussed. Their acreage and proportionate extent in the area are given in Table 5.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in the Basin area, Wyoming*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Ralston fine sandy loam	48,640	16.8	Meeteetse loam	3,456	0.8
Light-textured phase	448		Meeteetse clay loam	768	.2
Alluvial-fan phase	8,768		Chipeta fine sandy loam	9,920	3.0
Gravelly phase	13,504		Gravelly subsoil phase	2,816	
Ralston loam	20,224	5.3	Chipeta gravelly fine sandy loam	192	.1
Poorly drained phase	704		Chipeta loam	17,664	4.1
Stony phase	2,112		Chipeta loamy fine sand	3,648	.9
Ralston clay loam	1,408	.3	Greybull fine sandy loam	6,784	1.6
Ralston sandy loam	3,776	1.1	Greybull loam	6,272	1.5
Poorly drained phase	768		Shoshone fine sandy loam	19,008	6.2
Ralston gravelly loam	6,528	1.5	Terrace phase	3,264	
Billings fine sandy loam	26,624	8.7	Poorly drained phase	4,480	
Dark-colored phase	256		Shoshone loam	7,040	1.9
Brown phase	10,112		Terrace phase	1,280	
Billings loam	37,120	13.2	Shoshone clay loam	4,544	1.1
Dark-colored phase	4,544		Moffat very fine sandy loam	2,880	.7
Brown phase	14,592		Moffat silt loam	1,792	.4
Billings clay loam	3,072	1.9	Pierre loam	6,016	1.4
Poorly drained phase	1,280		Pierre clay loam	5,440	1.3
Brown phase	1,216		Rough broken and stony land	87,488	20.5
Dark-colored phase	2,368		Dune sand	896	.2
Worland fine sandy loam	8,320	1.9	River wash	1,728	.4
Worland loamy fine sand	8,384	2.0			
Meeteetse fine sandy loam	3,648	1.0	Total	426,240	......
Gravelly subsoil phase	448				

RALSTON FINE SANDY LOAM

In a virgin condition the topsoil of Ralston fine sandy loam in most places consists of 1½ inches of very pale grayish-brown loamy fine sand, with a thin surface crust, underlain by 3 or 4 inches of light yellowish-brown laminated fine sandy loam containing many grass and sage roots. This material is friable and works up very readily with a plow or harrow. The upper subsoil layer, beginning at a depth of about 6 inches, is light yellowish-brown slightly compact fine sandy loam which forms weak columns when exposed in a road cut. This layer is pierced by many roots and root holes, the last being partly filled with an accumulation of white lime carbonate resembling mold. Between depths of 12 and 22 inches is grayish-white or yellowish-white fine sandy loam or loam containing streamers of yellowish-brown lighter-textured materials extending downward through it. These streamers seem to follow the more or less bunched roots of the natural vegetation. The white color of the main body of soil in this layer is caused by the presence of large amounts of soft white lime accumulation. Below this layer and extending to a depth ranging from 5 to 10 feet is a layer of alluvial gravel consisting mainly of dark-colored igneous rocks mixed with sand of a similar color. The upper 10 or more inches of this layer contains a white lime deposit similar to that in the layer above. The lime disappears at a depth ranging from 30 inches to 5 feet, depending on the locality. This profile represents about the average conditions.

In general the Ralston soils on the higher terraces have a thicker layer of lime accumulation than those on the lower terraces. The depth to, and thickness of, the different layers vary greatly with the locality. In some places the gravel layer occurs at a depth of 15 inches or even less. In many places, particularly in slight depressions, there is a slight accumulation of gypsum under the lime layer or, more commonly, in the upper part of the gravel layer. This is much more frequently developed in the heavier soils of this series than it is in Ralston fine sandy loam. The entire profile contains lime, but the lime is concentrated in the subsoil.

Ralston fine sandy loam occurs mainly on the higher river and creek terraces, and in most places the land lies suitably for irrigation. The terraces have enough slope downstream to cause the water to run readily over the land, even where it appears perfectly flat to the eye. At the edges of the terraces the land breaks away abruptly in steep slopes, and numerous steep-sided draws indent the land. Large areas of this soil are on the terraces of Greybull River, Dry Creek, and Big Horn River.

In a natural state this soil supports a growth of sagebrush, rabbitbrush, grama, and pricklypear. In some places the vegetation is mainly grasses and pricklypear, and where these prevail the land can be much more easily prepared for irrigation.

Under natural conditions drainage is good on this soil, but artificial drainage is necessary under irrigation, except in very small areas where the soil lies at slight elevations or where it occupies isolated points of land. The usual method of draining this land, which is thoroughly effective, is by constructing large open ditches through the low ground and laying lateral tile drains from the ditches. Much work has been done in draining this soil and associated soils on the Emblem bench and on the terrace lands west of Big Horn River between Basin and Worland. There is an urgent need for the same kind of a system on the lands surrounding the town of Burlington, where thousands of acres of this and associated soils could be reclaimed by ditching and tiling.

Practically all of this soil which is under the ditch is cleared and under cultivation, or about 60 per cent of its total area. The principal crops are alfalfa, beans, potatoes, oats, and wheat. On areas near the railroad much of the soil is devoted to the production of sugar beets, but it is not so well adapted to this crop as are the heavier-textured soils of the Ralston and Billings series. Where this soil is unaffected by alkali the average yield of alfalfa is 2 tons to the acre, of beans 1,800 pounds, of wheat 30 bushels, of oats 60 bushels, of potatoes 100 sacks, and of sugar beets 12 tons. These yields vary greatly according to the manner in which the soil is handled. Potatoes require large amounts of organic matter and will not thrive unless this is provided. Beans often produce as high as 2,500 pounds an acre, and at the present time (1928) this crop is by far the most profitable that can be raised on Ralston fine sandy loam. Many farmers report a profit ranging from $60 to $100 an acre from Great Northern beans. Practically no commercial fertilizers are used at present.

Ralston fine sandy loam, light-textured phase.—As typically developed in this area the light-textured phase of Ralston fine sandy loam has a 4-inch surface layer of pale grayish-brown or yellowish-brown fine sand overlying a layer of pale yellowish-brown loamy fine sand. The topsoil shows a very slight accumulation of organic matter which comes from decayed grass roots. No organic matter is visible in the second layer. At a depth of 18 inches is pale brownish-gray or light grayish-brown loamy sand with small specks of white lime accumulation. This layer is rather hard and compact when dry and is penetrated by a few grass roots. At a depth of 36 inches is a layer of yellowish-brown or pale reddish-brown fine sandy loam mottled with white lime accumulation. This layer overlies the usual substratum of dark-colored igneous river-terrace gravel which in many places occurs at a depth of less than 3 feet. The red color of the deeper part of the subsoil is caused by the close proximity of soils of the Meeteetse series, which evidently contributed part of the materials. In some places this layer has a more olive-drab color. All the layers are calcareous, but the subsoil layers are most decidedly so.

Areas of this phase of Ralston fine sandy loam range from undulating to hummocky, and in many places the land must be leveled before irrigation can be practiced to advantage. Drainage of most areas is sufficient without ditching or tiling. In fact the soil is so leachy that in few places would it pay to try to farm the land, as larger quantities of water than would be economical are required to keep it moist.

This soil in a natural condition supports a growth of rabbitbrush, sagebrush, and grama. No large areas occur in the Basin area, and only a small acreage is under irrigation. The largest area is 3 miles northeast of Worland, one small area is on the edge of a terrace about 1 mile southwest of the State industrial school, and another is just south of Dry Creek close to the western boundary of the area surveyed.

This soil is of minor agricultural importance because of its very light texture. A large proportion of it on a farm consisting mainly of the heavier soils of the Ralston series would tend to detract from the value of the farm.

Ralston fine sandy loam, alluvial-fan phase.—The upper 3 inches of the alluvial-fan phase of Ralston fine sandy loam is light grayish-brown loamy fine sand mixed with small quantities of gravel. It is slightly laminated when in a virgin condition and is full of grass roots. A very slight amount of organic matter has accumulated in this layer. Between depths of 3 and 12 inches the soil is light yellowish-brown friable fine sandy loam which is somewhat porous, owing to the presence of many fine roots and root holes. Below this and continuing to a depth of 28 inches is heavy rather compact light yellowish-brown fine sandy loam containing splotches of white lime accumulation. This layer, like the one above, is porous. Between depths of 28 and 40 inches the soil is similar to that in the layer above, but it is lighter textured and contains more gravel. Below this layer the soil materials consist of stratified alluvial-fan materials containing more or less scattered gravel. Scattered pebbles, which are coated with lime on the undersides, occur throughout the soil. The soil, with the underlying alluvial-fan materials, stands in vertical columns where exposed along natural drainage courses and road cuts.

Ralston fine sandy loam, alluvial-fan phase, occurs on alluvial fans having moderate or steep slopes, which have been built up largely from materials washed down from the higher river and creek terraces to the inner edges of the lower terraces. Most of the materials are reworked Ralston soil materials. Soil of this phase has the same composition and the same color as the typical Ralston soils, but it has no definite layer of gravel in the substratum. Most of this soil lies in positions which are favorable to irrigation, although some of the land is too steep for best results.

Natural drainage conditions average better on this soil than on any other soil in the Basin area, and in very few places is artificial drainage necessary. The soil is well adapted to the production of all crops common to the region, but it is especially well adapted to beans and is being used for that purpose by a large proportion of the farmers. It is somewhat more productive than typical Ralston fine sandy loam, and the fact that it rarely becomes affected by alkali makes it more valuable than the typical soil. The main drawback to land of this kind is that it generally has a steeper slope and is therefore harder to irrigate than the typical soil. It is usually sold in connection with other soils, and where it constitutes a large proportion of a farm it raises the value somewhat.

This soil is of moderate extent. A series of small fanlike areas occur along the lower edges of the higher terraces and uplands from Greybull to Worland, chiefly on the west side of the Big Horn River Valley. Similar strips of smaller extent occur along the terraces of Dry, Shell, and Nowood Creeks and Greybull River.

Ralston fine sandy loam, gravelly phase.—Ralston fine sandy loam, gravelly phase, consists of very light textured gravelly fine sandy loam of pale brownish-gray color to a depth of about 20 inches. At that depth some accumulation of lime occurs, but it is not pronounced. Practically no compaction occurs in most of this soil as mapped in the Basin area. The substratum consists of a deposit of sandy gravel which is composed largely of dark-colored igneous rocks. The soil is very leachy and is of little agricultural value, as it requires almost continuous irrigation to keep it moist. Sparse crops of alfalfa and sweetclover may be obtained from it.

Small areas of this soil occur along the terraces of the rivers and creeks of the Basin area.

RALSTON LOAM

In its typical development the surface layer of Ralston loam consists of about 3 inches of pale-brown loam which in the virgin condition is highly laminated and full of fine pores. It crumbles in the hands into small thin flakes. A thick crust and mulch forms at the surface, and when the soil is under cultivation small seedlings have difficulty in breaking through. A few roots are present in the surface layer. Below this to a depth of 7 inches the soil is pale yellowish-brown friable loam penetrated by a few roots and root cavities. This material breaks up into irregular prisms and tends to stand in columns where exposed along stream banks and road cuts. The upper subsoil layer, which is about 10 inches thick, is light reddish-brown or yellowish-brown heavy compact loam full of blackened roots and root holes. It breaks into prisms and stands in columns like the layer above. Between depths of 17 and 32 inches the material is pale-brown friable loam containing much lime which is not segregated in the upper 3 inches. The lower part of this layer is highly mottled and splotched with white lime accumulation and also contains a noticeable amount of rotten gravel consisting of dark-colored igneous rocks. Many roots extend into this layer. In many places an accumulation of gypsum occurs in the lower part of the layer and in the upper part of the underlying material. The soil is underlain by a substratum of dark-colored igneous river gravel and sand.

In the locality where the sample described was taken, the substratum contained a rather large quantity of alkali salts. This was owing to the fact that the sample was taken near irrigated land which had recently been affected by alkali accumulations. The alkali had been washed out of the upper layers but had not been washed from the lower ones. The soil contains lime carbonate throughout, but the lime is concentrated in the subsoil. Small quantities of gravel are scattered throughout the soil, and these are coated on the undersides with a crust of lime resembling a thick coat of whitewash. In some localities the thicknesses of the different layers vary somewhat from those given above.

This soil occurs on the higher terraces of the rivers and large creeks of the area. In most places the surface is level or slightly undulating. The natural vegetation is sagebrush, winter fat, and some grama, these plants being replaced by greasewood where the land is affected by alkali.

Natural drainage conditions of this soil are nearly the same as those of Ralston fine sandy loam, except that more of the Ralston loam occurs in slight depressions having poorer drainage. The same methods of draining and the same system of ditches and tiles that are used for draining the fine sandy loam will take care of the loam, since the two soils are intimately associated.

Practically all this soil which has been put under the ditch has been cleared and leveled for irrigation purposes, but there are many areas which are not now under cultivation because of alkali accumulation. The alkali-affected areas are especially numerous near Burlington. On the Emblem bench and on the terrace between Basin and Worland, drainage districts have largely taken care of the alkali problem on this soil.

Probably 50 per cent of the land of this kind is under cultivation, mainly to alfalfa which produces about 2 tons to the acre. The soil is especially well adapted to the production of potatoes, but it is not being used for potatoes to a great extent in the Basin area. The same type of soil near Powell, in the Shoshone area, produces as high as two hundred and fifty 100-pound sacks of potatoes to the acre. The plowing under of alfalfa, sweetclover, or barnyard manure is necessary to produce such yields, however. Beans produce nearly as well on this soil as they do on Ralston fine sandy loam. Wheat yields from

30 to 60 bushels to the acre; barley sometimes yields as high as 100 bushels, with perhaps an average of 60 bushels; and sugar beets produce from 12 to 20 tons. Where free from alkali this soil is a somewhat stronger general-farming soil than Ralston fine sandy loam.

There is a wide range in the selling price of Ralston loam, depending on the nearness to railroads and towns and on the presence or absence of alkali. Where badly affected by alkali, soil of this kind, or any other soil type in the area, has no market value unless there is immediate prospect of reclamation by drainage.

Ralston loam, poorly drained phase.—The poorly drained phase of Ralston loam occurs in low places associated with the typical soil and with other members of the Ralston series. The soil is very wet during the irrigation season and puddles on the surface. The profile differs from that of typical Ralston loam only in having reddish-brown iron stains and mottlings throughout. This soil is badly affected by accumulation of alkali salts.

Most of the land was covered with greasewood before irrigation, but this plant dies out when the land becomes too wet, and the soil now supports a growth of cattails, wild barley, foxtail, horsetail, and other moisture-loving plants. This soil is valued only for the rather poor pasturage it provides for cattle. It is being drained in some places and will doubtless be nearly as productive as typical Ralston loam after the alkali has been washed out. Practically none of this poorly drained land changes hands unless it is sold with a farm which consists largely of better-drained soils.

Soil of this phase is inextensive, small areas occurring near Burlington and on the Emblem bench.

Ralston loam, stony phase.—Ralston loam, stony phase, is a nonagricultural soil, too stony to be plowed successfully. It resembles Ralston gravelly loam in profile but contains 30 per cent or more of cobblestones 3 or more inches in diameter. It supports a growth of rabbit brush, grama, and pricklypear, and it is valued only for the slight pasturage it affords.

RALSTON CLAY LOAM

The topmost 7 inches of Ralston clay loam consists of brown clay loam having a platy and fine-granular structure. On the surface is a thin crust which is underlain by a very fine granular mulch about 2 inches thick. The crust and mulch are generally somewhat lighter textured than the soil directly beneath. Between depths of 7 and 30 inches is very heavy compact light-brown clay loam containing many dark-colored roots and many root holes. This layer is very sticky and plastic when wet. Below this and continuing to a depth of 40 or more inches is yellowish-brown or olive-drab fine sandy loam containing streaks of yellowish-white lime accumulation. A few roots penetrate to this depth, and in many places some gypsum is present in the lower part of the layer. The substratum consists of dark-colored igneous river gravel and sand, with, in places, some lime accumulation in the upper part. The soil is calcareous throughout, but the lime is most concentrated in the subsoil.

Ralston clay loam occurs associated with other members of the Ralston series on the river and larger creek terraces. It lies in flat or depressed places and hence is more subject to alkali accumulation than other members of the Ralston series. The land supports a growth of sagebrush and winter fat, the last being the more abundant. Alkali areas support a growth of greasewood.

All the Ralston clay loam must be drained in order to prevent the accumulation of alkali. If this work is done at the time the land is put under irrigation little trouble with alkali ensues, but if it is left until alkali has accumulated, the land is returned to a state of productivity with great difficulty because the presence of alkali salts tends to deflocculate the clay particles and cause puddling of the soil. Deflocculated clays are impervious to water, or nearly so, and it is very difficult to get the water to run downward through the soil and out into the drainage ditches. Under normal conditions the clay particles flocculate; that is, they cling together in groups and give the soil a granular structure.

Where not affected by alkali this land has about the same agricultural adaptations as Ralston loam. It is harder to get a good stand of crops on this heavy soil, but when once started they produce yields fully as bountiful as those on the loam. The soil is not so well adapted to bean growing as it is to alfalfa, potatoes, grains, and sugar beets. Exceptionally good yields of grain are often reported on this soil, yields of 60 bushels of wheat and 100 bushels of barley being common.

Ralston clay loam is not very extensive. Fair-sized areas occur east of Worland and on the Emblem bench between Emblem and Lower Emblem School. About 80 per cent of this soil is under cultivation. The land value is about the same as that of Ralston loam.

RALSTON SANDY LOAM

The upper 5 inches of Ralston sandy loam is pale grayish-brown or somewhat yellowish brown friable laminated sandy loam containing many roots. In places a very thin crust occurs on the surface, but this usually disappears when the land is plowed. The next 6-inch layer is light yellowish-brown very slightly compacted sandy loam or fine sandy loam containing many roots. This material breaks into rough, irregular, friable clods. Between depths of 11 and 28 inches the soil consists of vertical streaks of yellowish-white loam and olive-drab sandy loam with yellowish-white splotches. Roots and root holes give this layer a porous character. The white material in this layer consists mainly of accumulated soft lime carbonate which presumably has been, in part at least, carried down from above by percolating waters. The substratum consists of light olive-drab sandy gravel. In the upper part of this layer the gravel are coated on the undersides with white lime accumulation but in the lower part no visible lime is present. The substratum rests on sandstone and shale bedrock at a depth ranging from 5 to 15 feet, more commonly at 5 feet than at 15. The soil contains lime throughout, but the upper two layers contain only very small amounts. In this soil, as in other members of the Ralston series, the thicknesses of the different layers vary somewhat from this typical profile.

Ralston sandy loam, like the other members of the Ralston series, occurs on the higher terraces of the rivers and larger creeks, in undulating or slightly rolling areas which render the soil well suited to irrigation. The land supports a natural growth of sagebrush, rabbit brush, grama, needle grass, and in places a little winter fat.

Drainage conditions are the same as on the Ralston fine sandy loam. The only large area of the sandy loam under cultivation is just east of Worland. Here a system of tile drains keeps the water table sufficiently low to allow the production of all crops common to the region.

This soil is suited to the same crops as Ralston fine sandy loam, but it is perhaps not quite so productive as that soil, as it is somewhat lighter textured and averages a little shallower. Ralston sandy loam should bring about the same price as, or slightly less than, Ralston fine sandy loam when distance from markets, drainage, and other factors are the same. About 70 per cent of this soil is farmed at the present time.

The largest area of Ralston sandy loam extends northeast and southwest from a point about 1 mile east of Worland. An area of this soil is about 6 miles southwest of Burlington.

Ralston sandy loam, poorly drained phase.—The poorly drained phase has essentially the same profile as typical Ralston sandy loam, except that the profile of the poorly drained soil shows more or less mottling of reddish-brown iron stains. In many places a very thin coating of black decomposed organic material covers the surface. The soil is wet for a large part of the year and is puddled at the surface. It generally contains accumulations of alkali salts.

This poorly drained soil supports a growth of wild barley, foxtail, horsetail, and other moisture-loving plants. The only use to which the land can be put in its present condition is pasture ground for cattle and horses. Practically all of it can be reclaimed by ditching and tiling to lower the water table and leach out the soluble salts. After such treatment, this soil should become practically as productive as the typical soil.

Soil of this phase is inextensive. It occurs west and northwest of Burlington and northwest of Lower Emblem School.

RALSTON GRAVELLY LOAM

The 6 or 8 inch surface soil of Ralston gravelly loam consists of light-brown or pale grayish-brown mellow gravelly loam. The upper subsoil layer consists of moderately compact dull brownish-gray or dull grayish-brown loam or clay loam, which is rather calcareous and which has a slight suggestion of a jointed or columnar structure. The lower subsoil layer, to a depth of 40 or more inches, consists of brownish-gray compact gravelly sandy loam or gravelly loam which is very calcareous. Below this depth the material is less calcareous and somewhat less compacted or cemented. The alluvial deposits rest on sandstone or shale at depths ranging from 6 to more than 20 feet. Gravel and cobbles in the lower part of the subsoil constitute from 40 to 60 per cent of the soil mass. The gravel consists of rounded waterworn fragments of granite, limestone, and dark igneous rocks.

Ralston gravelly loam occupies gently sloping or almost flat alluvial terraces. A few areas are eroded and have become rolling or hilly. Drainage is excessive under natural conditions, and under irrigation this soil requires more water than the heavier-textured soils of the series. Less than 1 per cent of the land is under cultivation, and it produces fair yields of wheat, oats, and alfalfa. Alfalfa, on account of its deep rooting system, is better adapted to this soil than are the shallower-rooted crops. Uncultivated areas are covered with a sparse growth of native grasses, sagebrush, and rabbit brush.

BILLINGS FINE SANDY LOAM

The surface soil of Billings fine sandy loam consists typically of about 8 inches of pale yellowish-brown or brownish-gray strongly calcareous fine sandy loam. It is laminated and breaks up readily into small flakes but when moist loses its structure. A thin crust forms on the surface after every rain, even where the soil has been plowed. This crust is not thick enough, however, to interfere with the growth of seedlings. Between depths of 8 and 20 inches is very pale grayish-brown slightly compacted heavy fine sandy loam containing many roots and root cavities. A few flecks of lime occur in this layer, but nowhere in the area do the typical soils of the Billings series show a well-defined layer of lime accumulation. Below this and extending to a depth of several feet the soil material is arranged in stratified layers of fine sandy loam, loamy sand, and loam. Many of the root holes in the upper parts of these layers are lined with lime accumulation. The colors remain about the same as in the upper layers of the soil. The soil is strongly calcareous throughout. Along the borders of natural drainage courses and along road cuts and canal banks the soil material stands in vertical columns.

Billings fine sandy loam occurs in large areas between the river terraces and the uplands, on some of the lower terraces, and along the courses of the smaller streams. Most of the areas occupy broad gently sloping or nearly flat alluvial fans. The parent material of the soil is formed largely from the weathering of the shales and sandstones of the uplands.

The relief renders this soil well suited to irrigation. Winter fat grows on the broad alluvial fans and some sagebrush and grama grow on areas bordering the small streams.

Natural drainage conditions on practically all the Billings fine sandy loam are good, but in most places a system of open drainage ditches is necessary to keep the land from accumulating alkali salts. In small isolated areas of this soil surrounded by deep natural gullies, artificial drainage is unnecessary. The use of tile drains is not successful in most places because the tiles become filled with fine soil material. In some places the soil has a deep substratum of gravel, in which tile drains may be placed.

Probably 75 per cent of the total area of Billings fine sandy loam is under cultivation. The most important crops are alfalfa, grains, sugar beets, and beans. (Pl. 1, A.) Alfalfa produces an average of about 2 tons an acre, sugar beets from 12 to 18 tons, and beans from 1,200 to 2,500 pounds. Wheat averages about 30 bushels and barley about 60 bushels. The soil is low in organic matter, as are all soils of the Basin area, and this is ordinarily supplied by plowing under alfalfa or sweetclover or by using stable manure. The soil is prized very highly by farmers.

Areas of Billings fine sandy loam are widely distributed throughout the Basin area. The land sells at good prices where improved and where there is no appreciable accumulation of alkali, but lower prices prevail where the land is affected by alkali.

Billings fine sandy loam, dark-colored phase.—The dark-colored phase of Billings fine sandy loam is similar to the typical soil in every respect except color. The soil throughout is prevailingly dark olive drab, owing to its occurrence on alluvial fans, the material of which has been washed from dark olive-drab shales and sandstones. Very little of this dark-colored soil is under cultivation, but it is probably slightly less productive than typical Billings fine sandy loam. Small areas occur near Ten Sleep. Winter fat is the principal natural growth.

Billings fine sandy loam, brown phase.—Soil of this phase very closely resembles typical Billings fine sandy loam, the principal difference being its browner color. It is intermediate in color between soils of the Billings and soils of the Meeteetse series. In general, the layer of lime accumulation is fairly well defined.

The 8-inch surface soil consists of light yellowish-brown or pale reddish-brown porous fine sandy loam containing many fine roots. It is slightly laminated in the upper part and is covered with a thin crust of somewhat lighter-colored material when dry. The upper subsoil layer, which is about 12 inches thick, is light yellowish-brown heavy somewhat compact fine sandy loam containing some white spots of lime accumulation. This layer contains many roots and root holes and is rather porous. From a depth of about 20 inches to a depth of several feet interstratified layers of yellowish-brown and of olive-drab fine sandy loam occur. Plant roots extend to a great depth in this material which rests on shales and sandstones at a depth ranging from 5 to 10 or more feet. The soil is calcareous throughout, and it stands in vertical columns where exposed along the intermittent drainage courses and creek banks. In a few places a gravel layer occurs at a depth ranging from 4 to 6 feet.

As mapped, the soil includes small areas which have become marshy under irrigation. These can be reclaimed by drainage and the growing of alkali-resistant crops for a few years. Areas of this character occur just west of Otto and are indicated on the map by marsh symbols.

The topographic features of this soil are similar to those of typical Billings fine sandy loam. This brown soil occurs on broad gently sloping alluvial fans, along the lower terraces of the larger creeks and rivers, and in some places along the smaller drainage courses. It is admirably suited to irrigation but must have a network of drainage ditches to take care of the waste waters and prevent the accumulation of alkali. The natural vegetation is winter fat, grama, and in places sagebrush. About 75 per cent of the land is now under cultivation, and a large part of the remainder could be irrigated by the present system of ditches. Much of the uncultivated land contains too much alkali and must be drained and washed free from alkali in order to render it productive.

The soil is adapted to the same crops as are grown on typical Billings fine sandy loam, and slightly higher yields are produced on the alkali-free areas. It is especially well adapted to the production of beans and is being increasingly used for that purpose. Since much of the land lies a long distance from the railroad, beet growing is not practiced to great extent.

The largest areas of this brown soil are along the Greybull River Valley near Otto, along Dry Creek, and southeast of Emblem, and smaller areas are scattered along the alluvial fans bordering Big Horn River and Paint Rock Creek Valleys.

This soil is valued at about the same prices as typical Billings fine sandy loam where distances to markets, alkali conditions, and other factors are the same.

BILLINGS LOAM

To a depth of 7 inches Billings loam consists of light olive-drab laminated rather friable loam which becomes light grayish brown or brownish gray when dry. It has a thin surface crust of very fine sandy loam underlain by a fine-granular mulch. Between depths of 7 and 20 inches is very pale olive-drab or brownish-gray compact cloddy fine sandy loam or loam. Below this and continuing to a depth of several feet is a series of stratified materials consisting mainly of fine sandy loam and loam. The soil is strongly calcareous throughout, and in places the numerous root holes which penetrate to considerable depths are lined with lime. Except in a few poorly drained areas, no layer shows visible accumulation of organic matter. Where this soil is exposed in road cuts and along stream courses it stands in vertical columns.

Billings loam occupies positions similar to those in which Billings fine sandy loam occurs, between the uplands and the river terraces, along the smaller stream courses, and on the lower terraces of the larger creeks and rivers. In most places the slope is long and gentle, and most of the land is admirably suited to irrigation. Natural vegetation is mainly winter fat, with greasewood covering spots in which appreciable amounts of alkali occur.

Natural drainage of this soil is good in most places but not so thorough as in the fine sandy loam. It is usually necessary to install a system of open drains, however, when the land is irrigated, as areas consisting mainly of this soil are almost sure to become affected by alkali if the land is not ditched. Where the soil occurs on alluvial fans of moderate slope less trouble is experienced from this source, but locally poorly drained alkali-affected areas have developed in the flatter situations.

About 60 per cent of the Billings loam mapped in the Basin area is under cultivation. Some of the remaining 40 per cent is above the levels of the present canals, and there are many areas which contain too much alkali for the production of crops. Many of these areas will doubtless be reclaimed in the future The soil is very productive and is suited to practically all crops which can be grown in this part of the country. It produces higher average yields of grains and beets than does Billings fine sandy loam and gives similar yields of beans and alfalfa.

Land of this kind sells at about the same prices as Billings fine sandy loam or a trifle higher. Some farmers on this type of soil have averaged about $20 profit an acre a year over a period of 20 years by growing alfalfa, barley, beets, and beans, where manure has been applied to the land and where alfalfa has occasionally been plowed under.

Billings loam, dark-colored phase.—The surface layer of Billings loam, dark-colored phase, consists of a 3-inch layer of dark olive-drab loam in the form of a fine-granular mulch. A gray crust about one-fourth inch thick covers the surface. Below the surface layer and continuing to a depth of about 10 inches is dark-gray heavy-textured laminated material which contains a few splotches of white lime accumulation. This layer is rather compact. It is underlain by strata of dark-gray clay loam and clay which have been washed out from the adjacent gray shale hills. In most places this material contains a rather large accumulation of gypsum. The soil is calcareous throughout. It is columnar in structure.

This soil supports a winter fat and greasewood vegetation. A large proportion of the land is affected by accumulations of alkali. The land is very difficult to drain, and only a few farmers have been able to successfully cultivate it on this account. In some places the textures of the substrata are not so heavy as those described, and in such places less trouble from alkali is experienced. The same crops are produced on this soil as on typical Billings loam, but average yields are much lower, though in a few places the dark-colored soil is very productive. Only a very small acreage is under cultivation.

Most of this soil is on the east side of Big Horn River. Scattered areas occur between Shell Creek and Basin and along Shell Creek between Greybull and Shell, and a few areas are near Bonanza and Ten Sleep on Nowood Creek.

Billings loam, brown phase.—The upper 4 inches of the brown phase of Billings loam consists of pale reddish-brown or yellowish-brown laminated loam, with a thin surface crust and mulch where the soil is in a virgin condition. The next 6-inch layer is slightly compact light yellowish-brown loam which breaks into small imperfectly prismatic clods which in some places are very thinly covered with reddish-brown colloidal material. The presence of many root holes makes this layer rather porous. Between depths of 10 and 15 inches the soil is about the same as in the layer above except that it is more friable and contains a few mottlings of white lime accumulation. From a depth of 15 inches and continuing to a depth of several feet are alternating strata of light yellowish-brown loam and fine sandy loam, the loam predominating. Roots extend into these strata to a depth of several feet. The soil is rather strongly calcareous throughout and holds up in vertical columns in road cuts and along stream courses. In a very few places this soil is underlain by a thin gravel layer at a depth ranging from 4 to 6 feet.

Soil of this phase occurs on gently sloping alluvial fans which border the river terraces next to the uplands and along the courses of the creeks, well above the first bottoms. Drainage conditions are practically the same as on the brown phase of Billings fine sandy loam. Artificial drainage is necessary to insure against the accumulation of alkali. Sagebrush and winter fat constitute the principal vegetation on the virgin soil.

All external factors being equal, this soil is perhaps slightly stronger than typical Billings loam. It is adapted to the same crops and will produce slightly better yields where no alkali interferes. The land sells for prices approximately equal to those of typical Billings loam.

The larger areas of this soil occur in the valley of Greybull River in the vicinity of Otto and westward from that place. Areas are southeast of Emblem and widely scattered over the Basin area in association with soils of the Meeteetse, Billings, and Greybull series. Some bodies of this soil west of Otto have become marshy and badly affected with alkali and in their present condition are useless except for pasture.

BILLINGS CLAY LOAM

The topmost 1½-inch layer of Billings clay loam is a mulch of pale olive-drab very fine granular clay loam covered by a thin crust of silt loam of lighter color. Below this and continuing to a depth of about 10 inches the soil is light olive-drab laminated clay loam. A few fine roots occur in this layer, but the soil is too impervious for many roots to pierce. From a depth of 10 inches to a depth of several feet the soil is heavy cloddy clay loam or clay which is very compact and slowly permeable by water. A few spots of gypsum crystals occur in this layer. The soil, as a whole, is more or less calcareous, but there is no visible accumulation of lime in any layer. The subsoil contains somewhat more lime than the upper layers, as is indicated by the reaction with hydrochloric acid. In a very few places the lowest layer contains interstratified materials of lighter texture. Most areas are slightly affected by alkali, the removal of which is very difficult.

Most of this soil occupies gently sloping alluvial fans and slight depressions. Natural drainage conditions range from good to fair, but where irrigated the land very frequently accumulates alkali. Open drainage ditches are used in some places with good results, but on much of the soil no practical way has yet been found to prevent the accumulation of alkali. The natural vegetation, consisting of winter fat and greasewood, makes only a sparse growth.

Where the soil is well drained and free from alkali, excellent crops of alfalfa, grains, sugar beets, and even beans are produced. The soil is well suited to the first three crops and will produce fully as good yields as Billings loam. Beans sometimes do very well on this land but they are better adapted to the fine sandy loam and loam of the Billings series. There is often much difficulty in getting a stand of beans on this soil because of the hard crust which forms on the surface after the soil has been moistened by rain or by irrigation water.

For soil improvement, the land is given applications of barnyard manure and alfalfa and sweetclover are plowed under.

Land of this kind in a good state of productivity has a fair market value, but unimproved land has a very low value and is used only for sheep pasture during the winter.

The largest areas of this soil are east of Big Horn River between the Rairden and Randall beet dumps. Other areas are south and southwest of Worland, just north of the State industrial school, and scattered in other localities. The soil is associated with other members of the Billings series.

Billings clay loam, poorly drained phase.—Billings clay loam, poorly drained phase, occurs in natural depressions where the soil becomes wet as soon as the land is put under irrigation and the soil materials puddle or run together and become very sticky. Alkali accumulates in large quantities, and the land becomes worthless for any purpose except as very poor pasture for cattle. This soil has fundamentally the same profile characteristics as typical Billings clay loam, except that it contains a few mottlings of reddish-brown iron stains and in places a thin accumulation of organic matter occurs on the surface. This soil is very difficult to drain, owing to its heavy texture and plastic consistence, but drainage has been successfully accomplished in a few places. The vegetation on this soil is the same as that on the poorly drained phase of Billings fine sandy loam.

Areas of this soil occur south and east of Manderson, northeast of Bonanza, at various points between the Rairden and Mott beet dumps, in small areas between Table Mountain and Emblem and Lower Emblem Schools, and elsewhere in widely scattered areas.

Billings clay loam, brown phase.—To a depth of about 9 inches the brown phase of Billings clay loam is typically reddish-brown, yellowish-brown, or dull-brown clay loam. A thin crust covers the surface, and about a 1-inch layer of very fine granular mulch is beneath the crust. The surface soil breaks fairly readily into coarse flat grains and is easy to cultivate when not too wet. Between depths of 9 and 15 inches the soil is light olive-drab fine sandy loam interstratified with reddish-brown fine sandy loam, which when crushed together become olive-drab in color. Below this, and continuing to a depth of 36 or more inches, is mottled olive-drab and reddish-brown clay loam containing splotches and streaks of white gypsum crystals. Stratified alluvial-fan materials underlie this material at varying depths. In some places the predominating color of the soil is yellowish brown instead of reddish brown. Although no fixed sequence of layers occurs, the profile described is fairly typical of this soil. The reddish-brown color seems to be caused by a thin coat of red clay particles on the surfaces of the soil grains and clods. When the soil in any layer is crumbled in the fingers the color becomes typical of soils of the Billings series.

This phase of Billings clay loam occurs mainly on alluvial fans in association with other members of the Billings series. The principal vegetation is winter fat, and greasewood flourishes where the soil contains harmful quantities of alkali.

This soil is similar to typical Billings clay loam, but it generally has lighter-textured substrata and hence can be drained more effectively, and for this reason it is much more productive than the typical soil. It is especially well suited to the growing of sugar beets, and areas near enough to the railroads to make beet growing profitable are used to large extent for that purpose. Where sold alone this soil has a value similar to or slightly lower than that of Billings loam.

This is not an extensive soil. One large area, more than half of which is affected by alkali, occurs north and west of Eccles beet dump. Other areas are northwest of Burlington and northwest of Manderson.

Billings clay loam, dark-colored phase.—The dark-colored phase of Billings clay loam is derived from materials washed out from the dark-gray shales of the Basin area. The profile is essentially the same as that of typical Billings clay loam, except that the dark-colored phase is very dark olive drab or dark gray. This soil contains more gypsum than the typical soil. The topmost 3 inches is a mulch of dark olive-drab very fine granular clay loam covered with a thin crust of pale grayish-brown very fine sandy loam. Between depths of 3 and 8 inches is dark-gray or dark olive-drab clay containing much gypsum. Between depths of 8 and 24 inches is dark olive-drab clay which breaks into small angular clods and contains a large quantity of gypsum. Below this and continuing to a depth of several feet are alternating layers of dark-gray silty clay and dark olive-drab loam spotted with alkali and gypsum crystals. The soil is calcareous throughout and in most places contains more or less alkali.

Greasewood is the principal vegetation on this soil. Very little of the land is under cultivation, and where cultivated great difficulty is experienced in trying to overcome alkali. A few spots of land in the cultivated areas, which do not contain alkali, produce excellent crops, but on most of this land nothing will grow because of the excessive amount of alkali. No method has yet been devised for washing out the alkali in soils as heavy as this.

Rather large areas of this soil occur east and northeast of Basin, and along Shell and Paint Rock Creeks. Land values are in general very low.

WORLAND FINE SANDY LOAM

The topsoil of Worland fine sandy loam is pale grayish-brown laminated loamy fine sand containing many grass roots and a very small amount of organic matter. In many places this layer is absent, owing to wind erosion. Between depths of 6 and 10 inches the soil is heavy somewhat compacted friable fine sandy loam which breaks up into small prisms, the surfaces of which are reddish brown and the insides reddish yellow. The many roots and root holes in this layer make it rather porous. Below this, and continuing to a depth of 22 inches, is light olive-drab friable fine sandy loam mottled with reddish brown and grayish white, the last-named color being due to the presence of accumulated lime. This layer is very friable and contains many roots. Between depths of 22 and 34 inches the soil is similar to that of the layer above except that the reddish-brown mottling is lacking. At a depth of about 34 or 36 inches the parent material is reached. This consists of rotten fine-grained olive-drab sandstone which in the upper part is sufficiently soft to allow the passage of roots. Lime accumulation extends well into this layer. This soil is calcareous throughout, but the upper three layers are only slightly so. The soil stands in vertical columns where exposed.

Worland fine sandy loam occurs on gently sloping or slightly hilly uplands. Most of it would be well suited to irrigation, but it would probably need draining to insure against accumulation of alkali. It supports a fairly thick growth of sagebrush, grama, and needle grass. A little winter fat may be found here and there, as well as occasional clumps of rabbit brush. Natural drainage is good.

Most of the Worland fine sandy loam lies outside of present irrigation projects, but very good stands of beans, alfalfa, and beets were observed where the land is under cultivation. If the larger areas of this soil are ever irrigated it will probably be necessary to pump water to them because of their high position. This would probably not be economical at present crop prices, but it may be feasible in the future. This land should be especially well suited to the growing of beans, alfalfa, and beets, and for these crops it would probably be equal or superior to any other soil in the area.

Only a few square miles of Worland fine sandy loam are mapped. Most of the larger areas occur northeast, east, and southeast of Worland at distances ranging from 3 to 8 miles. None of this land is changing hands at present. It is being used as winter pasture for sheep.

WORLAND LOAMY FINE SAND

To a depth of 3 inches Worland loamy fine sand consists of pale brownish-gray fine sand. It is underlain by a 9-inch layer of yellowish-brown or pale reddish-brown loamy fine sand which is very slightly compacted. The next 8 inches of soil is yellowish-brown loamy fine sand somewhat streaked with lime accumulation and fairly compact. The lime accumulation increases below this layer to a depth of 30 inches, where it begins to decrease. At a depth of 40 inches no visible lime remains and the soil is pale-gray loamy fine sand which appears to be made up of a large variety of minerals. The soil is calcareous throughout, with lime concentrated in the middle layers. Where exposed along road cuts it stands in vertical columns.

This soil lies in positions similar to those occupied by Worland fine sandy loam. In some places, however, it is more hilly. Large areas should be easy to irrigate if water could be obtained for the purpose, but practically all the soil lies above the present canals and it is unlikely that water can be put on the land by gravity. Natural vegetation consists mainly of sagebrush, rabbitbrush, grama, and needle grass.

Natural drainage ranges from good to excessive, and the soil is rather leachy in many places. It would probably require a large amount of water for irrigation.

Where cultivated the soil is very productive and is well adapted to alfalfa, beans, and sugar beets. It occurs in the same general localities as Worland fine sandy loam, with which it is intimately associated. It is slightly more extensive than the fine sandy loam.

MEETEETSE FINE SANDY LOAM

To a depth of 8 inches Meeteetse fine sandy loam consists of pale reddish-brown or pinkish-brown laminated and very friable fine sandy loam. A large number of grass roots permeate this layer, and there is a very slight accumulation of organic matter. The next 3 inches of soil is pale reddish-brown slightly compact fine sandy loam which is rendered rather porous by the presence of many grass roots and cavities left by dead roots. Below this, and continuing to a depth of 17 inches, is very pale grayish-brown very fine sandy loam with a somewhat pink cast. The material of this layer is interbedded with fine sandy loam of the same color, and a few streaks of lime accumulation occur along the planes of stratification. In some places this layer has a more pronounced zone of lime accumulation at approximately the same depth. Extending from a depth of 17 inches to a depth of several feet the soil material consists of red or pink alluvial-fan materials In many places remains of sagebrush occur at various depths, showing that the surface of the land is being gradually built up. The soil is strongly calcareous throughout, and where exposed in deep cuts it stands in vertical columns.

Meeteetse fine sandy loam occurs in positions similar to those in which the soils of the Billings series occur, that is, on gently sloping alluvial fans adjacent to the uplands from which the soil material is derived. The uplands from which the Meeteetse soil materials are derived are composed of red shales interstratified with pale-gray sands.

This soil is admirably suited to irrigation. In a virgin state it supports a growth of sagebrush, grama, and pricklypear. Natural drainage on most of the land is good, but in some places imperfect drainage has caused an accumulation of alkali. As with the Billings soils, it is advisable to plan for artificial drainage when the land is first irrigated.

Very little of this soil in the Basin area is under cultivation, but it has proved a very productive soil in other areas. It is well suited to the production of all crops of the region, especially beans, alfalfa, potatoes, and grains. It should be fully as productive as the brown phase of Billings fine sandy loam and should be just as valuable when put under cultivation.

This soil is very inextensive. A number of small areas occur near the point at which Dry Creek enters the western end of the area surveyed, and several areas are east and northeast of Burlington.

Meeteetse fine sandy loam, gravelly subsoil phase.—The surface layer of the gravelly subsoil phase of Meeteetse fine sandy loam is like that of the typical soil. It is underlain by a reddish-brown somewhat compact and cloddy layer of fine sandy loam showing some lime accumulation. From a depth of about 10 or 12 inches and extending into the underlying gravel layer is a zone which is very rich in accumulated lime. At a depth ranging from about 18 to 30 inches a layer of gravel, consisting mainly of limestone, occurs. This layer contains lime in the interstices and much soil material of various light textures intimately mixed with the gravel.

Soil of this phase occurs in association with typical Meeteetse fine sandy loam and is about equal to that soil in value. It can be successfully drained with tile.

MEETEETSE LOAM

Where typically developed, about 3 inches of light reddish-brown platy loam covered with a thin crust of very fine sandy loam constitutes the topsoil of Meeteetse loam. In many places, however, the topsoil is as much as 8 inches in thickness. Below this layer and extending to a depth of about 11 inches the soil is compact cloddy light reddish-brown loam, mottled more or less with white accumulated lime. The clods of this layer are thinly coated with reddish-brown colloidal material. Between depths of 11 and 35 inches is light grayish-yellow very fine sandy loam which forms clods that can be easily crushed in the fingers. This layer contains a small amount of lime accumulation which resembles mold. Below this the soil consists of stratified alluvial-fan materials. In many places the soil color from a depth of 11 inches to a depth of several feet is red or pink instead of prevailingly yellow. The soil is calcareous throughout, but the lime is concentrated in the upper part of the subsoil.

In conjunction with other members of the Meeteetse series this soil occupies the alluvial fans, which are underlain by interstratified red shales and pale-gray sands, adjacent to the uplands.

Natural vegetation consists of winter fat, grama, pricklypear, and some sagebrush. The soil is well suited to irrigation, provided drainage ditches are installed to take care of the excess water. On most of the soil natural drainage is good, but undoubtedly more or less trouble would be experienced from alkali if irrigation were attempted without artificial drainage.

The soil is not cultivated to a great extent, but the few cultivated areas are fairly productive, being fully equal to Billings loam in this respect. The cultivated land is used chiefly for alfalfa but would doubtless be well suited to potatoes, grains, beans, and sugar beets. None of the soil occurs near enough to the railroad for the production of sugar beets to be profitable.

Only a small total area of Meeteetse loam is mapped in the Basin area. The largest bodies are in the extreme western end of the area along the Yellowstone Highway. Several small bodies surround Table Mountain northeast of Burlington, and a few small areas are along Shell Creek in the extreme northeastern part of the area surveyed.

As mapped this soil includes one small area on the western boundary, adjoining the Shoshone area, which has a gravelly subsoil similar to that of the gravelly subsoil phase of Meeteetse fine sandy loam. It also includes small areas of Meeteetse silt loam which join with Meeteetse silt loam areas of the Shoshone area, the silt loam being too inextensive in the Basin area to warrant recognition as a distinct soil type.

MEETEETSE CLAY LOAM

The surface soil of Meeteetse clay loam consists of a 2 or 3 inch layer of reddish-brown cloddy clay loam, with a thin crust, underlain by about a 6-inch layer of similar soil mottled with limy material. Beneath this, where the soil is typically developed, is a 4-inch layer of light reddish-brown loam mottled with lime, and another layer, 8 inches thick, of reddish-brown silty clay loam or clay loam, mottled with white gypsum crystals. Between depths of 20 inches and several feet are stratified somewhat red alluvial-fan materials. The soil is calcareous throughout, and the structure is columnar.

This soil lies in positions similar to those occupied by other members of the Meeteetse series. None of the land is at present under cultivation. It occupies only 1.2 square miles in the area, occurring in small bodies in the northern and western parts of T. 52 N., R. 97 W., and along the Yellowstone Highway near the western boundary of the area.

Under cultivation this soil would probably be inferior to other members of the Meeteetse series and would doubtless be more or less affected by alkali accumulation. In its virgin condition it affords pasturage of winter fat which makes a good winter feed for sheep.

CHIPETA FINE SANDY LOAM

The soils of the Chipeta series are, with the exception of the gravelly subsoil phases, largely residual from the underlying rocks. The topsoils consist locally of transported alluvial wash material, but the subsoils are derived from underlying pale yellowish-gray sandstones and shales.

The topmost 3 inches of Chipeta fine sandy loam is pale yellowish-gray strongly calcareous laminated loamy fine sand covered by a thin crust of pale brownish-gray fine sandy loam. This layer is underlain by a 2-inch layer consisting of yellowish-brown platy and slightly compact somewhat granular fine sandy loam which contains some accumulation of lime in the form of white mottlings. The next 3-inch layer is olive-drab very fine sandy loam, in many places mottled with reddish-yellow iron stains and white gypsum crystals. This layer is strongly calcareous, but there is no visible segregation of lime. Between depths of 8 and 12 inches the soil has the same appearance as the layer above, but the acid test shows no evidence of lime. The olive-drab color becomes more pronounced with depth, and at a depth of 36 inches or less olive-drab fine sandy loam or very fine sandy loam derived from weathered sandstone occurs. At a slight increase in depth this material merges with bedrock of loosely cemented sandstone. In many parts of the area harder sandstone is reached at a depth ranging from 18 to 36 inches, and in such places the other layers are correspondingly thinner than those described. In other places the sandstone rock is replaced by somewhat sandy weathered shale material. In a very few places the parent rock is calcareous.

As mapped, this soil includes small undifferentiated areas of Chipeta very fine sandy loam which join with that soil in the Shoshone area.

Areas of Chipeta fine sandy loam range from gently sloping to hilly, most of the land having a moderate slope, and for this reason the soil is well suited for irrigation.

Natural vegetation consists of scattered sagebrush and a fairly thick growth of winter fat. In some places a fair stand of grama grows, and in others shadscale is common.

Natural surface drainage ranges from good to excessive. Under irrigation, however, most of the depressed areas and lower slopes become seepy and accumulate large quantities of alkali salts which come from the parent rocks. Drainage is not usually practical in such localities because of the shallowness of the soil and the imperviousness of the parent rocks. In other areas fair crops of alfalfa and grains are produced on the hillsides, but large areas of the soil become affected with alkali in a short time after irrigation is started. Very little of this soil is under irrigation in the Basin area.

The soil is fairly extensive in the northern part of the area, large bodies having been mapped a few miles west of Basin, northeast of Otto, between Greybull River and Dry Creek, and in the northeastern part of T. 52 N., R. 98 W. Small areas are east of Greybull along the edges of Shell Creek Valley.

Chipeta fine sandy loam, gravelly subsoil phase.—The surface soil of of the gravelly subsoil phase of Chipeta fine sandy loam to a depth ranging from 7 to 9 inches consists of light grayish-brown mellow fine sandy loam which is only slightly calcareous. In most places it contains some gravel, though nowhere in sufficient quantity to interfere with cultural operations or to greatly modify the physical character of the soil. Small gravelly mounds at the mouths of prairie-dog holes dot the surface of this soil in most places. The upper subsoil layer consists of light grayish-brown or brownish-gray moderately calcareous and slightly compacted fine sandy loam or loam. This material contains some gravel, which increase in quantity with depth until at an average depth of about 20 inches the subsoil is compact brownish-gray gravelly loam or gravelly fine sandy loam. This material is very calcareous, and the gravel are more or less completely incrusted with lime. At a depth ranging from 36 to 48 inches the gravelly layer rests on partly weathered shale or sandstone material, which grades into the parent rock at a slightly greater depth.

The surface is smooth except on locally eroded areas, and the soil is well suited to irrigation practices except for the danger of alkali accumulation. Drainage is good under natural conditions but would probably not be sufficient under irrigation.

Soil of this phase is developed from transported materials derived largely from shales and sandstones. It is well weathered and in the deeper part contains a slight amount of soil of residual character. The gravel in the soil are largely of limestone origin, with less quantities of quartzite and basic and acid igneous rocks.

This soil is associated with typical Chipeta fine sandy loam, and a small area joins with an area of that soil in the Shoshone area.

CHIPETA GRAVELLY FINE SANDY LOAM

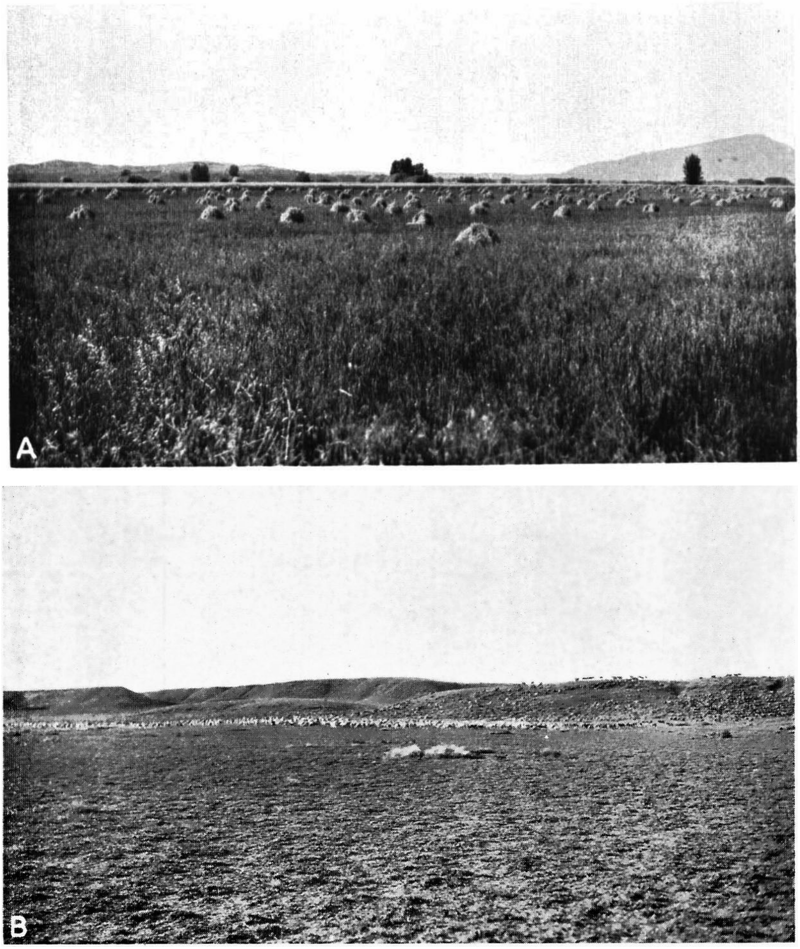
The surface soil of Chipeta gravelly fine sandy loam to a depth ranging from 6 to 9 inches consists of light grayish-brown gravelly fine sandy loam which, as a rule, contains a slight organic-matter accumulation in the upper 1 or 2 inch layer. The material in this layer is only slightly calcareous, is granular and friable, absorbs moisture readily, and works up to a fine-granular structure under cultivation. The subsoil to a depth ranging from 12 to 15 inches consists of slightly calcareous and moderately compact light grayish-brown or brownish-gray loam which, when disturbed, breaks to a small cloddy structure. The clods can be readily pulverized in the hand. The lower subsoil layer consists of grayish-brown or brownish-gray compact very calcareous gravelly clay loam or loam. At a depth ranging from 30 to 48 inches this material gives way to partly weathered shale or sandstone which grades into the unweathered bedrock at a slightly greater depth. In most places the parent shales and the weathered soil material directly overlying them contain appreciable quantities of alkali salts.

This soil occurs in association with other members of the Chipeta series and is not extensive in the Basin area.

The relief ranges from smooth, gently sloping, and terracelike to rolling or hilly. Most of the soil has a smooth surface well suited to irrigation practices. However, erosion has resulted in local areas of irregular or broken relief. Drainage courses are deeply intrenched between steep banks, and most areas of this soil are separated from areas of associated soils by steep slopes or bluffs, ranging from 10 to 50 feet in height, which have been formed by erosion.

The stone and gravel in this soil are angular or subangular and are of limestone and ironstone origin. They differ in character from those occurring in soils along the larger stream ways of the area. As mapped this soil includes some residual materials, but the surface soil is derived mainly from weathered old alluvial deposits transported by surface wash and by the present or former streams and superimposed over the shales and sandstone underlying the region.

The vegetation consists of sagebrush and native grasses. The soil is not farmed, as water for irrigation is not easily available. Most of the areas are open range country which is pastured to sheep or cattle. Under irrigation the soil should prove fairly productive, though it would require more frequent irrigation than the heavier-textured soils. Drainage would also be necessary to insure against alkali accumulation. Areas of this soil within the proposed Oregon Basin division of the Shoshone project are in Government ownership



A, Oats growing on Billings fine sandy loam in foreground, alfalfa stacks in background, B, virgin Chipeta loam in foreground, used as grazing land for sheep

and have not yet been declared open to entry and settlement. Soil areas not in the project can be purchased for a few dollars an acre.

CHIPETA LOAM

To a depth of 4 inches Chipeta loam consists of light yellowish-brown calcareous fine granular loam, covered by a thin crust of very pale brownish-gray loam. This layer is underlain by a 2-inch layer of heavy compact cloddy loam slightly mottled with white lime accumulation. It is somewhat porous, owing to the presence of roots and root holes. The next lower 8-inch layer consists of light olive-drab cloddy loam which is slightly calcareous and contains many clumps of white gypsum crystals. Below a depth of 14 inches is dark-gray decomposed shale containing gypsum crystals as in the layer above. At a depth of about 20 inches this material rests on dark-gray soft shale rock. In many places, the layers are somewhat thicker than those described and the depth to the unaltered parent material may be as much as 3 feet.

Most areas of Chipeta loam are gently undulating, nearly flat, or slightly depressed. This renders irrigation mechanically easy but introduces the factor of imperfect drainage. The land is partly covered with a growth of winter fat.

Natural drainage is sufficiently favorable to take care of the regional precipitation, but under irrigation much trouble is experienced in trying to remove waste water. Ditching has very little effect in removing water from the soil, because the parent rock is too impervious to allow the passage of water and it lies so close to the surface that it prevents downward percolation. The presence of alkali salts in the parent rock makes the accumulation of alkali on the surface practically a certainty if the land is irrigated.

Very little of the land is under irrigation at present and it is strongly recommended that this land be left in a virgin state. (Pl. 1, B.) Although fair yields of the crops common to the region are produced on very small areas of this soil, it is unlikely that irrigation and cropping of large tracts would prove successful.

Chipeta loam is associated with Chipeta fine sandy loam and has about the same distribution in the Basin area. The largest bodies are a few miles west of Basin and on the uplands between Greybull River and Dry Creek northeast of Otto.

CHIPETA LOAMY FINE SAND

The surface soil of Chipeta loamy fine sand consists of a layer of light grayish-brown or grayish-yellow fine sand about 12 inches thick. This layer is subject to shifting by the wind. Beneath this is a 2-inch layer of similar-colored loamy fine sand containing numerous roots. Between depths of 14 and 24 inches the soil is very pale brownish-gray or grayish-brown very fine sandy loam mottled with white accumulations of lime. This layer contains more roots than any other layer in the profile. The soil below this depth is pale grayish-yellow oı light yellowish-brown calcareous loamy fine sand which lies, at varying depths, on sandstone. In places the thicknesses of the different layers vary somewhat from those described. The soil is calcareous throughout, but the lime is concentrated in the upper part of the subsoil.

Practically none of this soil is being farmed as it is too light in texture to be of great agricultural value. Large quantities of water would be necessary to keep it moist, and it is likely that the winds would carry much of the soil away if the natural cover of rabbitbrush, sagebrush, and scattered grasses were removed. The land affords fair winter pasture for sheep.

The largest areas of this soil occur just southeast of Greybull bordering Big Horn River, northeast of Winchester, and south of Otto. A few small bodies are scattered elsewhere over the area.

GREYBULL FINE SANDY LOAM

The soils of the Greybull series resemble those of the Chipeta series in that they are shallow residual soils in which the upper part of the surface soil has been modified by alluvial wash. These soils are derived from interbedded red shales and light-gray sandstones.

The topsoil of Greybull fine sandy loam is about 7 inches thick and consists of light reddish-brown or yellowish-brown laminated and fine-granular fine sandy loam which is full of grass roots. When dry this layer is covered by pale pinkish-brown fine sandy loam. The next 4-inch layer consists of dark reddish-brown heavy compact clay loam which contains many splotches of white lime accumulation. Roots and root holes render this layer rather porous. It breaks into irregularly prismatic clods. Between depths of 11 and 17 inches the soil is similar to that above but is slightly paler red or yellowish brown. This layer rests on weathered shales which are alternately dark red and olive drab in color every few feet. The shales are in general noncalcareous, and they contain little if any alkali salts. The lower part of the soil contains gypsum accumulation in places.

Areas of Greybull fine sandy loam are gently sloping or hilly. It is estimated that perhaps one-half the soil could be conveniently irrigated. Natural vegetation is mainly grama, sagebrush, and winter fat.

Natural drainage is good on most of the soil, but some trouble from seepage has been experienced where the land has been irrigated. The soil is too shallow to allow the effective use of tile or open drainage ditches, so there is no practical way in which the land can be artificially drained. The accumulation of alkali in the soil is not rapid, owing to the absence of appreciable quantities of salts in the parent rock, but some accumulation results from the presence of salts in solution in the irrigation waters.

Fair crops of alfalfa, grains, and beans are produced on this soil, and a fairly large acreage is devoted to sweetclover. Alfalfa yields about 1½ tons to the acre, wheat 25 bushels, and beans 1,000 pounds or less. Improved land that has not become too wet to farm brings a fair price, but much of the land now under cultivation is of very low value.

Large areas of this soil occur in the northern parts of T. 52 N., Rs. 97 and 98 W. Other fair-sized bodies are distributed along the uplands south of Greybull River southward from Burlington and Otto.

GREYBULL LOAM

Greybull loam is a very shallow residual soil which lies on fine-grained gray sandstones interstratified with red shales. It consists typically of a thin gray surface crust, below which is about 7 inches of fine-granular reddish-brown loam, underlain by 5 inches of light reddish-brown, compact, cloddy loam, and, in turn, by 6 inches of heavy, cloddy, reddish-brown clay loam which rests on the parent material. The entire soil, as well as the upper part of the parent rock, is calcareous, and the layer occurring between depths of 7 and 12 inches has an accumulation of lime in the form of white mottling. The layer just above the parent rock in many places contains much gypsum.

As mapped this soil includes a few small areas in which the surface soil is of heavier clay loam texture, but these were of insufficient extent to warrant recognition as a distinct soil type. Aside from the heavier texture of the surface soil, the soil in these areas conforms in profile and in other characteristics to typical Greybull loam. The largest included areas are near the central part of T. 52 N., R. 98 W.

Most areas of this soil occupy gentle slopes or flat areas, therefore the land is easy to irrigate. Natural drainage is only fair, and the land is likely to become seepy when irrigated. No practical method of draining large areas of this soil exists. Vegetation consists mainly of winter fat.

In the few places where the soil is being irrigated it is used mainly for growing alfalfa and sweetclover, of which only fair yields are obtained. Land values are slightly less than of Greybull fine sandy loam.

Small areas occur southeast of Worland, in conjunction with Greybull fine sandy loam south of Greybull River, and in the northern part of the two northwestern townships of the area.

SHOSHONE FINE SANDY LOAM

The soils of the Shoshone series occur on the first bottoms and lower terraces of the rivers and creeks of the Basin area. They do not have pronounced profile characteristics as they consist of unweathered recently deposited alluvial materials.

The 3-inch surface layer of Shoshone fine sandy loam is dark-brown or dark grayish-brown fine sandy loam containing a quantity of semidecayed dark-colored organic matter. Between depths of 3 and 13 inches the soil is light olive-drab or light-brown loamy fine sand or fine sandy loam. The next 11-inch layer is very pale olive-drab or light grayish-brown very fine sandy loam containing some mottling of reddish-yellow iron stains. This layer rests on dark-colored loose igneous river gravel and sands. The soil is calcareous throughout. This description represents a profile of this soil in an area bordering Greybull River. The sequence of the layers described is typical, but much variation occurs in different localities. Along Big Horn River, the general color of the soil is much lighter and the gravel layers are likely to be deeper and in some places are missing.

Most areas of this soil are flat or undulating, and the land is fairly easy to irrigate. It supports a growth of cottonwoods, rosebushes, buffaloberries, sagebrush, and meadow grasses. Along the smaller creeks the vegetation is mainly sagebrush and rabbitbrush.

Natural drainage ranges from fair to poor. Large areas of this soil develop alkali under irrigation because the soil lies so near the level of the rivers and creeks that there is little chance for subdrainage. Those parts of the areas lying near the streams are often overflowed during floods.

Where this soil has not become affected by alkali it produces good crops of grains, alfalfa, beans, and beets. Alfalfa, which occupies the largest acreage, yields from 1½ to 2 tons an acre. Beans are very well adapted to this soil and may produce as high as 2,000 pounds to the acre, but they will not grow on land affected by alkali. Beets produce from 10 to 12 tons an acre.

This soil is rather extensive. Where free from alkali and improved the land commands a fair price, but very little of it is changing hands at present.

Shoshone fine sandy loam, terrace phase.—The terrace phase of Shoshone fine sandy loam is identical with the typical soil except that it lies on slightly elevated terraces. It is never overflowed by streams and can be easily drained by open ditches and tiles. For this reason it is comparatively simple to reclaim when it becomes affected by alkali and is more valuable than the typical soil. The principal areas occur between Avant School and Otto.

Shoshone fine sandy loam, poorly drained phase.—The poorly drained phase is similar to Shoshone fine sandy loam except that it contains some rust-brown mottlings throughout and in some places has a thin layer of black organic material on the surface. The land is very wet at all times and is heavily charged with alkali. In few places can it be drained satisfactorily, owing to its low position. Its only use is for pasture.

SHOSHONE LOAM

The topsoil of Shoshone loam typically consists of 8 inches of olive-drab and reddish-brown stratified loam which becomes dull brown when dry. In many places the reddish-brown material is lacking. Between depths of 8 and 11 inches is olive-drab or dull-brown loam, or in some places reddish-brown silty clay loam. Below this is olive drab loamy fine sand, underlain at a depth of 30 inches by dark-colored igneous river gravel and sands. The soil is calcareous throughout. The thicknesses and colors of different layers vary somewhat according to locality. Along Big Horn River most of the soil material is somewhat lighter colored, except where this soil occurs near the dark-colored phases of the Billings soils.

Natural vegetation is about the same on this soil as on Shoshone fine sandy loam. On areas along the smaller streams the vegetation is mainly sagebrush. The surface of Shoshone loam is favorable to irrigation, but drainage is less favorable than in Shoshone fine sandy loam. The higher-lying areas of this soil are somewhat more productive than the best areas of Shoshone fine sandy loam, and they command slightly higher prices. Where this soil is affected by accumulations of alkali it is generally hard to drain and is used mainly for pasture. The areas near the rivers and larger creeks are often overflowed during high water.

Shoshone loam, terrace phase.—Like the terrace phase of Shoshone fine sandy loam this soil differs from typical Shoshone loam only in being located on areas high enough to allow artificial drainage. For this reason it has a higher value than the lower-lying areas. It is used mainly for the production of alfalfa, grains, and beans, and it returns yields slightly higher than those obtained on the terrace phase of the fine sandy loam.

The principal areas of this soil are between Avant School and Otto.

SHOSHONE CLAY LOAM

The topsoil of Shoshone clay loam consists of an 8-inch layer of heavy olive-drab clay loam matted with grass roots and containing some accumulation of organic matter. Between depths of 8 and 18 inches is olive-drab clay loam mottled with reddish-brown iron stains and containing many grass roots. From a depth of 18 inches to a depth of several feet is a substratum of dark-colored igneous river gravel and sands. In some places this soil is nearly black, owing to the presence of dark-colored decomposed shale which has been washed in from adjoining uplands.

Most areas of this soil are flat or depressed, and most of the land is affected by alkali. It supports a rank growth of meadow grasses where there is not too much alkali. In a few places good crops of alfalfa, grains, and beets are produced, but most of the land is used as pasture for cattle and horses. The agricultural value of the land is very low, and none of it is sold alone.

MOFFAT VERY FINE SANDY LOAM

The soils of the Moffat series are developed from red very fine grained sandstone materials washed out on alluvial fans near outcrops of these rocks adjacent to the Big Horn Mountains. They resemble the soils of the Meeteetse series except that they are much redder.

The topmost 4-inch layer of Moffat very fine sandy loam is highly laminated dark reddish-brown very fine sandy loam. It is underlain by a 6-inch layer of slightly lighter colored and more compact soil material which breaks into irregular, easily crushed clods. Between depths of 10 and 36 inches the soil is light reddish-brown heavy very fine sandy loam, fairly compact and containing faint mottlings of accumulated lime. Below this, and continuing to a depth of 5 or more feet, the soil is slightly lighter, both in color and texture, and contains some whitish gypsum crystals which decrease in number with depth. In many places very fine grained red sandstone is reached at a depth of a little more than 3 feet. The soil is calcareous throughout.

This soil occurs in the form of alluvial fans between the creek bottoms and uplands, and the slope of most areas is gentle or moderate. The land is well suited to irrigation. Natural vegetation is mainly sagebrush.

Natural drainage in most places is good, and artificial drainage is rarely required, except on the large nearly flat areas where alkali accumulates to a harmful extent.

Areas of this soil occur near the towns of Ten Sleep and Hyattville in Nowood, Ten Sleep, and Paint Rock Creek Valleys.

The soil is used chiefly for the production of alfalfa and grains, but some farmers have found it very profitable to grow beans which give excellent yields. Potatoes also do very well. All the Moffat soils mapped in the Basin area are too far from the railroad for sugar beets to be profitable. Average acre yields on areas of this soil not affected by alkali accumulations are 40 bushels of wheat, 3 tons of alfalfa, and 1,800 pounds of beans.

Most of the ranches composed of this soil are owned by cattle or sheep men living near Ten Sleep and Hyattville, and the land is used for producing feed for the livestock.

MOFFAT SILT LOAM

To a depth of 3 inches, Moffat silt loam consists of pronounced reddish-brown or dull-red highly laminated silt loam which is finely porous. Between depths of 3 and 8 inches the color is somewhat lighter and the soil is slightly compacted silt loam which breaks up into medium-sized, easily crushed, irregular clods. The next 22-inch layer consists of yellowish-red silt loam which is streaked and mottled with whitish-gray lime accumulation. The soil in this layer is rather compact and breaks into small irregular clods which are easily crushed in the fingers. The lower part of this layer is lighter textured. At a depth of 30 inches, in the sample here described, a decomposed very fine grained sandstone occurs. In most places bedrock lies at a depth of several feet.

The vegetation is chiefly sagebrush and grasses. Topographic features and drainage are about the same as of Moffat very fine sandy loam. Some of the larger areas under irrigation have become affected by alkali, owing to poor drainage. The value and crop adaptations of the nonalkali areas are the same as those of Moffat very fine sandy loam, with which this soil is associated.

PIERRE LOAM

The soils of the Pierre series are very shallow residual soils which have weathered in place from the dark-gray salty shales of parts of the Basin area.

Pierre loam has a thin pale yellowish-gray surface crust and mulch over a 2 or 3 inch layer of dark grayish-brown or slate-colored loam which in most places is underlain by a 1-inch layer of similar-colored loam containing some spots of lime accumulation. Between depths of 3½ and 10 inches is dark slate-gray or dark olive-drab mottled silty clay loam which is full of white and yellow gypsum crystals. Extending from 10 inches to an indefinite depth is very dark slate-gray rotten shale having a few gypsum crystals and rust-colored iron stains along the root passages.

The surface relief of Pierre loam is gently sloping or hilly. The soil is easy to irrigate but is worthless for agriculture after water is put on it, because it is too shallow to allow downward percolation of water and the underlying shales are very salty so that alkali always accumulates on the land when it is irrigated.

The largest areas occur east of Greybull on the south side of Shell Creek Valley. Other bodies are along the border of Paint Rock Creek Valley.

PIERRE CLAY LOAM

Pierre clay loam is essentially like Pierre loam except that the topsoil is clay loam instead of loam, being dark olive-drab or dark slate-gray very heavy and compact clay loam with a surface crust of somewhat paler gray. At a depth of about 4 inches this material is underlain by a 12-inch layer of similar material mottled with accumulations of gypsum, and this layer in turn rests on weathered shales which contain large amounts of salts.

Relief and drainage are similar to those of Pierre loam. Natural vegetation is chiefly winter fat and a few annual weeds. This soil is of little agricultural worth.

Areas of the soil occur rather widely distributed over the uplands, mainly between Greybull River and Dry Creek northeast of Otto. Small bodies border Shell Creek Valley.

ROUGH BROKEN AND STONY LAND

Rough broken and stony land includes areas that are too hilly, stony, or rough to be of agricultural value. Such areas occur on the uplands and along the steep terrace escarpments, bordering stream courses, and they are characterized by outcrops of sandstone or shale or by steep gravelly slopes which can not be irrigated. This type of land is widely distributed throughout the Basin area, being especially extensive along the borders.

DUNE SAND

Dune sand occurs chiefly in the river valleys. It consists of various grades of sand and loamy sand piled by wind in rough hillocks and hummocks and overgrown by rabbit brush, sagebrush, and greasewood. In some places this land is leveled and cultivated, but it is too leachy to be of practical value. Areas occur along the valleys of Greybull and Big Horn Rivers, most of them in association with soils of the Billings series.

RIVER WASH

River wash consists of areas of cobblestones, gravel, and sands occurring in and adjacent to the larger stream channels which are overflowed when the streams are in flood. This material has no agricultural value. It occurs chiefly along Greybull River and less extensively on Big Horn River.

ALKALI AND DRAINAGE

Under virgin conditions the surface soils of the Basin area were in general free from harmful concentrations of alkali salts. Early settlers established irrigation systems for applying water to soil that had previously been dry. This upset the natural condition of the soil. At first the soils produced abundant crops, under almost all methods of handling, but in a few years crop yields began to decrease and white crusts of alkali salts appeared on the surface of some of the soils. Irrigation water had been added to the soil to such an extent that the water table (level of the ground water) was raised to within a few feet of the surface, and in some places above the surface, forming worthless marshland. This condition first appeared in the shallower soils and soils with restricted subsurface drainage. It still exists in a large part of the area and is becoming more prevalent in some places. The important problem confronting the farmers of the area is how to prevent this trouble and how to profitably reclaim land which is now unproductive because of alkali.

Before prescribing a remedy it is necessary to know the exact nature of the ailment. Soil alkali consists of soluble salts which are present in the soil in quantities sufficient to affect the growth of crops. There are two principal types, namely, black alkali and white alkali. Black alkali, which consists of ordinary washing soda (sodium carbonate), does not exist in an appreciable quantity in the Basin area. White alkali, as it occurs in this area, consists largely of sodium chloride (ordinary table salt), and sodium sulphate (Glauber salt), with some magnesium sulphate (Epsom salt), magnesium chloride, and potassium sulphate. These salts dissolve in the soil water, and if the resulting solution is more concentrated than the sap of the plants, water will pass from the roots into the soil solution. Hence, the plants suffer from lack of water.

The concentration of alkali salts required to adversely affect the growth of crops depends on several factors. Crops will tolerate more alkali in heavy-textured soil than in sandy soil, because of the greater water-holding capacity of the heavy soil. Alkali salts consisting largely of sodium chloride are much more harmful than those which are principally sodium sulphate. Crops are tolerant of higher concentrations of alkali in well-drained soils and those high in organic-matter content. Accumulations of alkali localized in the surface soil will do more harm than deeper-lying accumulations.

Crop plants themselves vary greatly in resistance to alkali. Most crop plants are not affected by concentrations of less than 0.2 per cent of white alkali, but few crops can be successfully grown where the concentration is greater than 0.5 per cent. Barley and sweet-clover are rarely injured to an appreciable extent by concentrations ranging from 0.4 to 0.6 per cent and are sometimes successfully grown on soils with as much as 1 per cent of alkali. Other small grains, vetch, and sugar beets are only slightly less tolerant than barley. Alfalfa in the seedling stage will not tolerate a concentration of more than 0.2 per cent, but once established it will grow where there is as much as 0.4 per cent of alkali. Corn, beans, potatoes, peas, and the orchard crops are very sensitive and should not be grown except on soils with less than 0.1 per cent of alkali. These figures are very general and vary with different conditions, but they give a fair idea of the relative resistance of the crops adapted to the Basin area.

Besides interfering with the growth of plants, alkali salts cause deflocculation or puddling of the soil. This condition is especially noticeable where the black alkali and sodium chloride salts occur.

The accumulation of alkali salts does not occur on irrigated soil unless no provision has been made for removing the drainage water from the soil. Where the water table is within 3 or 4 feet of the surface, capillary attraction brings water to the surface. As the water reaches the surface it evaporates and leaves the dissolved salts as a surface accumulation of alkali. If allowed to continue, this process eventually increases the amount of alkali in the surface soil to such an extent that crops can not be grown. Alkali salts are frequently present in the irrigation waters, and therefore irrigation tends to aggravate the trouble.

Before the agriculture of the Basin area can be considered a permanent asset to its inhabitants, the land must be provided with adequate drainage. Provisions for drainage have been made in several localities, but there are still large areas of poorly drained soil. To be successful, drainage must be intelligently installed. Drainage operations are much more successful where large areas are drained by a unified system. An individual farmer can not lower the water table on his own land to a great extent if it is surrounded by large areas in which the water table is higher. The services of a competent drainage engineer should be procured when installing a drainage system, as poorly constructed drains are a liability rather than an asset.

The soil type should be taken into consideration when drains are installed. Soils with heavy-textured surface soils and subsoils are more difficult to drain and therefore require more drainage lines. In general, soils of the Chipeta, Pierre, and Greybull series can not be drained by any practical method because of the slight depth to impervious sandstone and shale substrata, and even with the most careful handling these soils must eventually become worthless for crop production. The Meeteetse soils and most of the soils of the Billings, Shoshone, and Worland series have restricted subsoil drainage. Owing to the fine texture of the subsoil, these soils require open drainage ditches. Soils of the Ralston series have a very porous gravelly substratum and are easily drained by tiling. Artificial drainage is not needed except in surface depressions and in basins formed by irregularities of the shale or sandstone underlying the gravel. Natural drainage of the alluvial-fan phase of Ralston fine sandy loam is good, and tiling is not needed in most areas. Some areas of the Billings soils, which are underlain by gravel at depths ranging from 4 to 6 feet, are adapted to tile drainage.

Experience of farmers has shown that it is much easier to prevent the accumulation of alkali salts by providing drainage and by careful use of irrigation water than it is to remove the salts after they have accumulated. When drainage has been provided, the reclamation of alkali land is completed by growing alkali-resistant crops, such as sweetclover, barley, and sugar beets.

All important areas of alkali-affected soil in the area have been shown on the soil map by appropriate symbols. Alkali samples of soil were collected in the more extensive areas of alkali soil. The percentage of alkali salts in the air-dried soil was determined, and locations and alkali concentrations of these samples are shown on the accompanying map. With the exception of the Pierre soils, most of the virgin soils of the area are free from harmful quantities of alkali. Soils of this series contain from 0.3 to 0.6 per cent alkali. Soils of the Chipeta series are generally free from surface accumulations of alkali, but the underlying shales and sandstones are high in content of soluble salts. Virgin soils of the Worland series at present contain no injurious concentrations of salts. The quantity of alkali contained in soils of other series depends on thoroughness of drainage and the amount of irrigation they have received. The principal alkali-affected areas occur in the lowland along the courses of Greybull River, Nowood Creek, Big Horn River, Dry Creek, and Shell Creek. Large areas are on the upland south of Shell Creek where soils of the Pierre series predominate, on the higher bench land around Burlington and Emblem, and in the vicinity of Otto where the brown phases of the Billings soils occur.

The locations of areas having poor or restricted drainage coincide with those of alkali accumulation. Alkali concentration and poor drainage are the limiting factors in the productivity of the soils of this area and unless steps are taken to check the growth of this condition, it will eventually put an end to the production of farm crops except where drainage systems are already installed.

The results of the alkali determinations are indicated on the map by a number in the form of a fraction, for example $\frac{0.35}{1.02}$. This denotes that the surface soil contains 0.35 per cent of soluble salt and that a 3-foot section contains an average of 1.02 per cent. Where the denominator of the fraction is larger than the numerator it indicates that the soluble salts increase with depth.

SOILS AND THEIR INTERPRETATION

The following general discussion of the soils of the Big Horn Basin applies to the soils mapped in the Shoshone[3] and Basin areas and is designed for the information of those who are interested in soils mainly from the viewpoint of scientific soil classification. A few of the soil variations discussed occur outside the areas mapped but they are of sufficient scientific interest to be included with this report.

Big Horn Basin is a great basinlike area lying between the main ranges of the Rocky Mountains on the west and the Big Horn Mountains on the east. It is further hemmed in on the south by the Owl Creek Range and on the north by the Pryor Mountains. Big Horn River enters the basin through a gorge in the Owl Creek Range and leaves by a gorge lying between the Big Horn and Pryor Mountains. This river has several large tributaries, the principal ones being Greybull and Shoshone Rivers. The land comprises a series of great alluvial terraces with deposits of gravel of various dark-colored igneous rocks underlain by sandstones and shales of various geologic periods. In places the soils are derived from these shales and sandstones instead of from the alluvial terrace materials. This is especially true in the region adjacent to the McCullough Peaks which are a series of badland mountains in the north-central part of the basin. There are also large areas of residual soil in the south-central part of the basin, on both sides of Big Horn River.

The climate of the Big Horn Basin is that of a cool temperate desert with an average rainfall, over the region as a whole, of about 6.5 inches. The mean annual temperature is about 44° F., with extremes of 114° above and 51° below zero having been officially reported. Outside the basin, in every direction, the precipitation increases and the mean annual temperature decreases. The altitude of the basin ranges from about 3,800 feet to more than 5,000 feet above sea level.

The distribution of vegetation seems to vary somewhat with the soils and somewhat with the slight variations in climate which obtain in the Big Horn Basin. However, in general, the vegetation is largely of the same type throughout the basin. The principal upland and alluvial-fan plants are sagebrush (*Artemisia tridentata*), winter fat (*Eurotia lanata*), greasewood (*Sarcobatus vermiculatus*), shadscale (*Atriplex confertifolia*), rabbit brush (*Chrysothamnus* sp.), grama (*Bouteloua oligostachya*), and needle grass (*Stipa comata*). Of the smaller flowering plants various Pentstemons, Indian paintbrush (*Castilleja* sp.), evening primrose (*Onagraceae* sp.), pricklypear (Opuntia), and some larkspur (Delphinium) along the edges of the mountains, are common. Rabbit brush is common on the very sandy soils, sagebrush grows largely on soils with gravelly or sandy subsoils,

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[3] See footnote 1, p. 1.

winter fat on soils with very small quantities of alkali salts, and greasewood on moist soils which generally contain some soluble salts. Shadscale grows on soils in slight depressions which are fairly well drained but which are underlain by excessive accumulations of lime and gypsum. Grama and needle grass are commonly found on the same kinds of soil as those supporting sagebrush, and in some places they grow in association with sagebrush as do most of the smaller flowering plants. Pricklypear is commonly associated with grama and needle grass on sandy soils underlain with gravel. The vegetation along the rivers and creeks differs to some extent from that just described, because the soil in such places is moister than that in most of the basin.

As far as may be determined, the soils of the Big Horn Basin have never supported a forest growth since the land surface reached its present general configuration, and it has never supported a sufficiently heavy growth of grasses for an appreciable quantity of organic matter to accumulate. Consequently the soils are all very light colored on the surface. Toward the foothills in the western part of the Shoshone area the grass vegetation increases and there is a corresponding darkening of the surface soil. Just outside the boundary of that area, in the foothills of Heart Mountain, the soils become very dark colored and have a decided tendency to granulation in the A horizon, and the angular grains are rather thickly covered with dark-colored organic material. In the eastern part of the Basin area the soils retain their desert characteristics, and there is no noticeable change in the soil in this region until a height of 1,000 feet up the mountain side is reached, where conditions are rather similar to those at the foot of Heart Mountain. This difference seems to be due to the fact that summer storms drifting almost daily from the western mountains keep the soils rather moist for a large part of each summer, whereas on the eastern side of the area the precipitation does not begin until the eastward-blowing winds have been cooled on the higher slopes.

Observed from almost any hilltop in Big Horn Basin, the prevailing color of the soil appears pale brownish gray. On the few days that the soils are moist on the surface the color appears browner and slightly darker. Where erosion has exposed the underlying horizons, various colors are noticeable, but the predominating color is very light brown. In some places the red color of the parent red shales persist more or less in the soil, and in others the dark-gray shales give their color to the soils.

For convenience in describing their broad characteristics the soils of the Big Horn Basin are classified as follows:

Maturely weathered soils, soils of the Ralston, Gilcrest (in Shoshone area only), and Worland series; moderately weathered soils, soils of the Chipeta series, the alluvial-fan phase of Ralston fine sandy loam, and the gravelly subsoil phases of the Meeteetse and Billings soils; slightly weathered soils, normal types of the Meeteetse and Billings series and soils of the Moffat series; unweathered soils, soils of the Shoshone series; and shallow soils developed in place on impervious shales and sandstones, soils of the Pierre and Greybull series.

Detailed descriptions will be given of members of the two series of mature soils of the Basin area, and the soils that have not reached such an advanced stage in weathering will be dealt with in less detail. The fine sandy loams of the Ralston and the Worland series are representative not only of the maturely weathered soils of the region but also of the prevailing soil texture.

The sample of Ralston fine sandy loam herewith described was taken from a high bench or terrace bordering Dry Creek known as the Emblem bench, and it represents virgin land adjacent to cultivated land. The descriptions will be taken up by horizons.

Horizon A, from the surface to a depth of one-eighth inch, is a crust of very pale brownish-gray slightly calcareous fine sandy loam. From a depth of one-eighth inch to a depth of 1½ inches is a mulch of very pale brownish-gray loose loamy fine sand which has a single-grain structure and is slightly calcareous. On the loams and clay loams of the soils of this region the crust is slightly thicker than in this sample and is filled with small spherical pores, or vesicles, from one-sixteenth to one thirty-second of an inch in diameter. By actual experiment these were found to be made by imprisoned air which takes the form of small spheres when the soil becomes puddled on the surface during the beating summer rains. On these heavier types of soil, the mulch is in the form of very fine angular grains which make a loose mulch when dry. Between depths of 1½ and 5 inches is light yellowish-brown laminated fine sandy loam containing many grass and sage roots. This material tends to break up into thin flakes, and this tendency is much more pronounced in the heavier soils. This layer is strongly calcareous.

Horizon B, from a depth of 5 inches to a depth of 12 inches, is light yellowish-brown slightly compact fine sandy loam which breaks into irregular friable clods. It contains many roots and root cavities, and the dead roots and rootlets are incased in a white lime accumulation resembling mold mycelia. The soil material is faintly columnar and strongly calcareous. Between depths of 12 and 22 inches is grayish-white or yellowish-white loam with irregular vertical streamers of yellowish-brown lighter-textured materials following the larger masses of roots. This layer contains more lime than any other layer in the profile. Between depths of 22 and 32 inches is a layer which might be considered as belonging to the lower B or upper C horizon, according to the viewpoint. The main mass of material is C material, but there is some concentration of lime. The layer consists of dark-colored igneous alluvial gravel and sands, the interstices being filled with grayish-white or yellowish-white lime accumulation. Few plant roots extend below this depth. In many places, especially in the heavier types of soil, this layer contains some white or pink gypsum deposit.

Horizon C, from 32 inches to a depth of several feet, the material consists of dark-colored igneous alluvial gravel and sands. On the higher terraces, such as the Polecat bench in the Shoshone area, the gravel in the upper part of the layer are rather well weathered and when cracked with a hammer are found to have a thin film of white lime along the broken surfaces. On the lower terraces the gravel and cobblestones are hard and unweathered.

Scattered gravel occur throughout the soil, and most of the gravel are coated on the undersides with a white lime accumulation resembling thick whitewash. The interstitial limy material is soft and cryptocrystalline in character.

Where the Ralston soils are exposed in road cuts or along steep declivities along the edges of the terraces, they stand in a vertical plane with faintly defined columnar structure. The alluvial gravel, which constitute the substratum, lie, at a depth ranging from 4 feet to as much as 20 feet, on sandstones and shales, which have been unequally eroded.

The natural vegetation on the Ralston soils is mainly sagebrush, grama, rabbit brush, pricklypear, and winter fat. The first three are common on the lighter-textured soils, and the last two are common on the heavier soils.

Worland fine sandy loam resembles the Ralston soil very closely, except that its parent material is entirely different and the color of the upper part of the B horizon is reddish brown instead of light yellowish brown as in Ralston fine sandy loam. This difference of color is probably due to the fact that the Worland soil is derived from dark-red shales interstratified with pale-gray fine sands. The lime accumulation extends into the rotten upper layers of sandstone in Worland fine sandy loam in a way similar to the extension of this material into the alluvial gravel of the Ralston soil. Vegetation on this soil is the same as that on Ralston fine sandy loam.

In these two maturely weathered soils several striking points of interest may be noted. First among these is that although, as a rule, the parent materials of these soils are noncalcareous rocks, the soils are calcareous from the surface well into the parent material. This is because the carbon dioxide from the air and from the decomposition of organic matter reacts with the silicates and other compounds of calcium and magnesium to form carbonates. This process is active in all soils, but only in those which occur where the rainfall is light do the carbonates remain. Although there is some lime in the A horizon, the greater part of it has been translocated by the process of leaching to the B horizon where it has accumulated in large quantities. In a somewhat similar manner gypsum has accumulated in the lower part of the B horizon and in the upper part of the C horizon. Where the soil contains appreciable quantities of soluble salts, these salts are more concentrated below the gypsum. Another very noticeable characteristic is that the soils at the immediate surface have very little real color, being nearly neutral gray. The lower part of the A and upper part of the B horizons, on the other hand, in most places show a decided yellow, brown, or red tint according, apparently, to the color of the parent materials. There is invariably a layer of moderate compaction, which is generally the most highly colored layer of the profile, just above the layer of maximum lime accumulation, indicating a translocation of fine materials from the upper layers. In the Worland soils the material of this layer is thinly coated with reddish-brown colloidal material. This tendency is noticeable to a less degree in the Ralston soils.

The alluvial-fan phases of the Ralston and Chipeta soils are both recognized as moderately weathered soils. They show the same general type of profile as the Ralston and Worland soils, but they have not had time to develop quite so far and their lime horizon is in most places much thinner. The gravelly subsoil phases of the Billings and Meeteetse soils also belong to this group.

Soils which are in the process of formation on the broad alluvial fans of the area have been classified as slightly weathered soils. They include the various members of the Meeteetse, Billings, and Moffat series, with the exception of the gravelly subsoil phases of the Meeteetse and Billings soils. Soils of these series are essentially the same in every respect except in color. The differences in color are due primarily to the differences in the colors of the upland materials from which the alluvial fans were built up. The Meeteetse soil materials are derived from red shales, the materials of the typical Billings soils are from gray shales and sandstones, and the materials of the brown phases of the Billings soils seem to be a mixture of Meeteetse and Billings materials. Moffat soil materials are derived from brick-red sandstones. All these soils have the prevailing pale-gray crust and mulch, are laminated in the upper layers, and most of them have a very slightly compact layer. In places they all show a very slight accumulation of lime under the compact layer, but in many places this is not noticeable to the naked eye. They are mainly stratified soil materials, and in many places, where the soil is exposed on creek banks or road cuts, old soil levels are discernible. All these soils are strongly calcareous throughout and all stand in vertical columns where exposed. Detailed descriptions of these soils are given in the section on Soil Series and Types.

The only soils included in the unweathered group are those of the Shoshone series. They consist of recently deposited soil material and in the scientific sense are not true soils. Detailed descriptions are given under Soil Series and Types.

The soils of the Greybull and Pierre series are grouped together because they are shallow immature soils of a residual character. Their shallowness and immaturity are due to the impervious character of the parent rocks rather than to erosion or any other cause. They show practically the same sequence of layers as the Ralston and Worland soils, the chief difference being that in the Pierre and Greybull soils the layers are exceedingly thin. A detailed profile description of Pierre loam follows:

Horizon A, from the surface to a depth of one-half inch, is a crust of very pale yellowish-gray calcareous very fine sandy loam full of spherical vesicles. This is underlain to a depth of 2½ inches by a mulch of dark yellowish-brown fine granular loam which is calcareous and somewhat laminated.

Horizon B, between depths of 2½ and 3½ inches, is dark grayish-brown or yellowish-brown loam containing some spots of accumulated lime. The soil is highly effervescent with dilute hydrochloric acid. Some gypsum and a few fragments of shale occur in this layer. Below this, and continuing to a depth of 10 inches, is dark-gray or dark olive-drab mottled silty clay loam filled with fine white and yellow gypsum crystals. This material does not effervesce noticeably with acid. Roots are most numerous in this layer.

Horizon C, from a depth of 10 inches and extending to a depth of 36 and more inches, is very dark slate-gray rotten shale which turns a lighter color when crushed. The crushed material has a silty clay loam or clay texture. A few gypsum crystals occur in the upper part of the layer, and some rust-brown iron stains are noticeable along the cleavage planes. This layer contains no lime that can be detected by acid. It generally contains from 0.3 to 0.5 per cent of soluble salts.

It will be noted from the foregoing description that the solum is fairly complete as expressed in horizons but that it extends to a depth of only 10 inches. Horizons in the Greybull soils are less distinct, but the solum averages thicker.

On the slopes of the Big Horn Mountains it is possible to trace soil differences which corresponded roughly with those to be observed in progressing from the Big Horn Basin, Wyo., to northern Minnesota.[4] Up the western slopes of the Big Horn Mountains, accumulation of organic matter in the A horizon begins to be noticeable about 1,000 feet above the general level of the basin. This soil corresponds to the light-brown soils of the Great Plains. Somewhat higher the soil becomes darker brown, until at an altitude of about 7,500 feet a soil resembling the black earths occurs. A short distance above this the soil loses its layer of lime accumulation and becomes acid in character. On the grass and sagebrush lands this soil resembles the black prairie soils except that it is much shallower. The soils covered by lodgepole pine, spruce, and fir forests resemble those in the forested region of northern Minnesota. They are strongly acid, and the upper layers are highly leached and show very little accumulation of organic material. In general, the parent materials on the west slope of the Big Horn Mountains are similar to the parent materials in the basin, so it may be reasonably assumed that the soil differences in this region are due fundamentally to differences in climate and vegetation similar to those which are known to exist at different atitudes on the mountains.

SUMMARY

The Basin area is in northwestern Wyoming, in a part of the Big Horn Basin. It includes the irrigated and irrigable lands bordering Big Horn River and its main tributaries between Winchester and Greybull. Large parts of Big Horn and Washakie Counties and a small part of Park County are included in the area. A large part of the area lies along the courses of Greybull River and Dry Creek, both of which enter Big Horn River from the west. The altitude of the land ranges from somewhat less than 4,000 feet to about 5,000 feet above sea level. The climate is arid, with cold winters and warm summers, and the frost-free season averages about 130 days.

Local markets are afforded by the small towns of the region, and most of the cash crops are shipped by rail to larger markets north, south, and east of the area. The most important crop grown is alfalfa hay which is used as feed for cattle and sheep. The important cash crops are sugar beets, dry beans, potatoes, and grains. Large shipments of cattle, lambs, and wool are made, and the raising and shipping of turkeys has become an important industry. Several flour mills are located in the area, and a sugar mill at Worland handles the beet crop. The Big Horn Cooperative Marketing Association handles the other principal crops.

Most of the agricultural soils occupy the alluvial terraces and fans of the river and creek valleys. The most important agricultural soils of the area are those of the Ralston and Billings series. The Ralston soils are underlain by gravel and occupy the river terraces,

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

and the soils of the Billings series lie on alluvial fans. Meeteetse soils are equal in value to those of the Billings series but are much less extensive. The value of soils of the Shoshone series, which occupy the first bottoms of the rivers and creeks, is limited because of the danger of alkali accumulation. Soils of the Chipeta, Greybull, and Pierre series, which are derived from shales and sandstones, are of low value because they are too shallow to allow the downward percolation of water.

Natural drainage is good throughout most of the area, but when the lands are put under irrigation it is necessary to use artificial drainage in almost all places, in order to prevent the accumulation of alkali salts in harmful quantities. The supply of irrigation water is ample for the entire area.

No important new irrigation projects are being opened at this time (1928), but there are many opportunities to purchase productive lands at reasonable prices. Care must be exercised in choosing land to avoid areas badly affected with alkali or consisting of soils of extremely heavy texture, unless they are productive at the time the land is bought. Drainage, under irrigation practices, should be carefully observed, and land where drainage is poor should be avoided.

Good land may be purchased at reasonable prices. Dwelling houses on the farms range from fair to good, but most of the barns are poorly constructed and inadequate. Many districts are accommodated with a thorough system of open drains and tiles to insure good drainage. The country roads are fairly good, and good State highways pass through the area.

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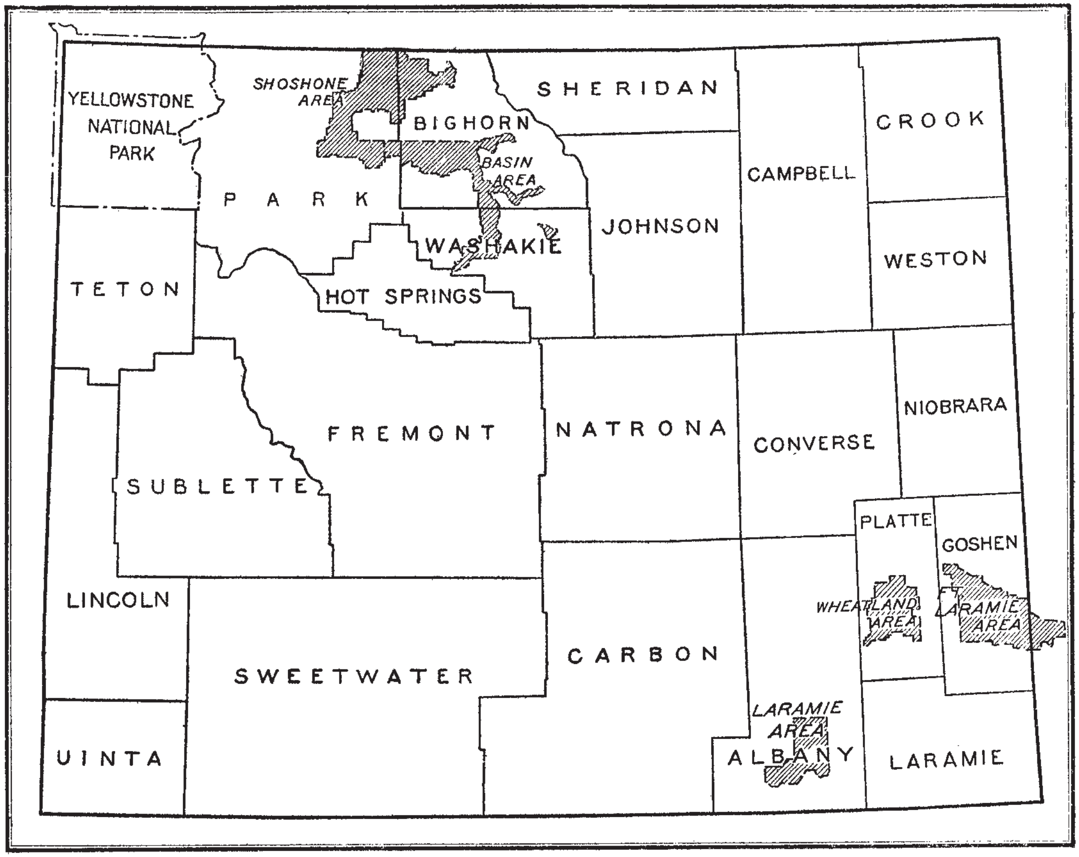

Areas surveyed in Wyoming, shown by shading. Detailed surveys shown by northeast-southwest hatchings.

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