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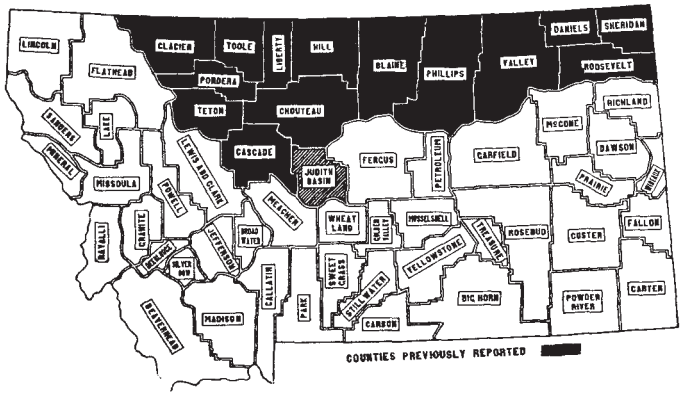
Soils of Judith Basin County



Soil Reconnoissance of Montana

PRELIMINARY REPORT

BY

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IN CHARGE OF SOIL SURVEY

COOPERATING WITH THE BUREAU OF CHEMISTRY AND SOILS

UNITED STATES DEPARTMENT OF AGRICULTURE

MONTANA STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
BOZEMAN, MONTANA

2

CONTENTS

TABLES

Soils Of Judith Basin County

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LOCATION

Judith Basin County, located in Central Montana occupies the western two-thirds of a high tableland area known locally as the Judith Basin. It covers 1894 square miles between Townships 10 and 20 North of the Base Line Montana and Ranges 7 and 16 East of the Principal Meridian Montana. Its maximum width is 48 miles (east and west) and maximum length 52 miles. The county was created in 1920 from parts of Cascade and Fergus counties and includes some of the more important farming and stock raising districts in the state.

PHYSIOGRAPHIC FEATURES*

Isolated mountain ranges, separated by low divides and high tablelands are the more prominent physiographic features of several counties in Central Montana. The mountain uplifts rise 2000 to 4000 feet or more above the tablelands and rolling plains to the north and east and are capped with ancient crystalline rocks, in which igneous intrusions often occur. The tablelands cover transitional areas, having many of the features of the plains. The principal physical features of Judith Basin County are: (1) the Little Belt and Highwood Mountains; (2) the mountain foothills; (3) the badlands along Arrow Creek; and (4) the Judith Basin. The basin is characterized by gravel-capped tablelands or benches extending out 50 miles or more from the mountains. These benches lie at different erosional levels and are separated by broad stream valleys.

The Little Belt Mountains, the crest of which forms the southern boundary, cover the southwestern part of the county. These mountains rise in Cascade and Meagher counties and extend east for about 60 miles. The mountains were formed by a folded, arched uplift, which has been eroded to produce the rounded peaks and ridges and relatively deep and narrow intervening stream valleys. Ancient crystalline rocks ranging in age from Archean to Jurassic, and local igneous intrusions which form the higher peaks, are the more conspicuous outcrops in the mountains. The rocks are mineralized highly in the vicinity of Yogo, Barker and Neihart. The Little Belt Mountains have an average elevation above sea level of approximately 7000 feet with some

*See discussion of maps on page 15.

of the higher peaks, such as Mount Baldy, rising to 9000 feet. Some of the outlying buttes and peaks in Judith Basin County, such as Wolf, Woodhurst, Twin, and Barker are between 6600 and 8100 feet in elevation. The crests of the mountains rise to the west and northwest and lie 1800 to 3900 feet above the gravel-capped tablelands. The outcrops on the northern slopes of the mountains consist largely of resistant limestones, through which the mountain streams have eroded deep box-like canyons. The higher peaks are serrated locally, but most of them are well rounded. The mountains are covered with lodge pole pine with numerous tracts of grass land on the broader ridges and on their southern slopes.

The Highwood Mountains extend into the northwestern part of the county. These mountains, a group of volcanic peaks rising several thousand feet above the Judith Basin, protrude through rocks of Cretacious Age, which have not been uplifted greatly by the volcanic forces. This mountainous area lies chiefly between 4000 and 6000 feet in elevation with the higher peaks, such as South, Middle and Highwood (located across the county line) having altitudes of 7000 feet. The southern slopes of the mountains rise 2000 feet or more above the foothills and dissected tablelands. The mountains have a fair cover of timber at the higher elevations.

Foothills.—The rock exposures on the lower slopes of the Little Belt Mountains are chiefly sedimentary crystalline sandstones, which are eroded into rounded ridges, steeply sloping benchlands and buttes in Judith Basin County. The broken foothill area, capped with these sandstones, is separated locally from the mountains by gaps and basins resulting from the erosion of the less resistant shaly formations. The ridges and higher benchland areas in the foothills lie between 5000 and 6000 feet in elevation and often have steep, uniform slopes below the mountains. The foothills of the Little Belt Mountains cover an irregular shaped area in Judith Basin County. The higher foothill ridges, forming the divides between such streams as Sage, Skull, Wolf and Antelope Creeks, extend out from the mountains from 6 to 8 miles. East of Antelope Creek, the average width of the foothill zone is less than 3 miles and locally, the gravel-capped tablelands lie directly below the mountains. West of Wolf Creek, the ridges extend out 3 to 6 miles. Skull butte, southwest of Stanford has an elevation of 5200 feet and on its broken slopes, sandstones outcrop. The streams flowing through the foothills have eroded deep, narrow valleys, bordered by steep sandstone bluffs rising 300 to 500 feet or more. A light stand of timber occurs on the higher ridges and along the more broken stream courses.

The foothills of the Highwood Mountains have approximately the same elevation as the Little Belt Mountains. These foothills

extend out from the mountains from 2 to 6 miles and consist largely of shaly ridges, capped with stony outwash. A few igneous dikes also occur in the foothill area. The higher ridges are covered lightly with timber.

Divides.—Separating the drainage basins of Belt and Arrow Creeks between South Peak of the Highwood Mountains and a portion of the Little Belt Mountains known as the Otter Range is a divide approximately 15 miles long which varies in elevation from 4500 feet in a gap west of Spion Kop to over 5000 feet on the mountain slopes. A broken sandstone-capped ridge rises toward the mountains south of the gap, and sandstone ridges and escarpments through which the streams have eroded small open valleys, lie to the north.

The divide between the Little Belt and Big Snowy Mountains is about 12 miles long and ranges in elevation from 4800 feet in a depression known as "Judith Gap" to 5500 feet on the slopes of the mountains. The ridges rising above the gap are capped chiefly with sandstone.

The Judith Basin, surrounded by such mountain ranges as the Big Snowy, Little Belt, Highwood, Moccasin and Judith, covers a tableland approximately 30 miles long and 40 miles or more in width. It is characterized by high, gravel-capped benches which extend north beyond the limits of the basin almost to the breaks of the Missouri River. The tablelands separated by wide stream valleys have smooth surfaces, grades of 30 to 40 feet to the mile and elevations ranging from 3500 feet above the breaks of the Judith River and Arrow Creek to 4900 feet below the foothills and mountains. The stream valleys are intrenched 50 to 100 feet in the higher part of the basin and from 300 to 500 feet in the lower part. The protective covering on the benchlands consists of outwash gravel and rock from the different mountain ranges, and on some of the larger and higher benches the gravel deposit is 80 feet or more in depth.

The Gravel-capped Benches in Judith Basin County are known locally by their location with reference to towns and streams. The area known as "Geyser Bench" lies betweeen the foothills and Arrow Creek west of Surprise Creek in the vicinity of Geyser and Merino. It is about 10 miles long and 8 miles wide and its protective covering consists of igneous and ancient sedimentary rock and gravel which is quite shallow and stony below the foothills and very gravelly above Arrow Creek. This bench is dissected with coulees which become deeply intrenched above their entrance into Arrow Creek. The Merino Bench lies west of Surprise Creek, north of Merino. It is 10 miles long and one-half to one mile wide and occupies an elevated area lying 300 feet or more above Surprise Creek. It is capped with rock and gravel similar to that found on the Geyser Bench. The Sur-

prise Creek Bench, east of Surprise Creek is approximately 11 miles long and one to 3 miles wide. It has about the same elevation as the Merino Bench and grades into the Arrow Creek Bench to the north. Its protective covering consists largely of limestone gravel, which contains a fair amount of stone southeast of Dover. The Stanford Bench east of Wolf Creek occupies a lower erosional level. It is about 11 miles long and one to 3 miles wide and is capped with limestone gravel which contains some stone southeast of Stanford. The Coyote Bench, also capped with limestone gravel, rises east of Coyote Creek. It lies several hundred feet above the creek and covers a V-shaped area having its apex east of Stanford. It extends along Coyote Creek for 9 miles and is 5 miles wide along the county line. The large limestone gravel-capped area between Sage Creek and the Judith River in the east central part of the county is known as the "Benchland Bench" although the northern part sometimes is referred to as the Indian Creek Bench. This gravel-capped area extends northeast from Utica for over 20 miles and averages 6 miles wide. The bench has good surface drainage, except at the head of some of the intermittent streams. It is dissected with coulees which are locally intrenched in the western part. The area lying between Utica, Hobson, and Buffalo, south of the Judith River, usually referred to as the "Triangle" also is capped with limestone gravel. This bench, dissected with deep coulees in the eastern part, is 10 miles long and 7 miles wide. Several secondary benches also are included in the Triangle. One occupying a lower erosional level along the Judith River is known locally as the "Hobson Bench" and another, north of Buffalo Creek, as the "Shaw or Buffalo Bench." Irregular shaped, gravel-capped benches, separated by deep coulees, extend out from the foothills of the Highwood Mountains for 10 to 12 miles. The foothills and benchland areas north of Arrow Creek are known as the south slope of the Highwood Mountains. Secondary benches occur east of Ross Creek in Township 14 North, Range 15 East and other isolated benches, capped with limestone gravel and rock are found in the foothills of the Little Belt Mountains between the smaller stream courses.

Pig Eye and Other Basins.—The forks of the Judith River unite below the mountains in a basin known as Pig Eye. This basin is approximately 4 miles long and 2 miles wide and is bordered by high limestone and sandstone escarpments lightly covered with timber. Other gaps or depressions occur between the mountains and foothills. The larger gaps connect the valleys of Sage, Running Wolf, and Dry Running Wolf creeks.

Badlands.—The valleys of Arrow Creek and its branches in the north central part of the county are intrenched 300 to 500 feet and bordered by shaly slopes and gullied clay ridges,

which are timbered lightly with yellow pine along their crests. The shale exposures on the steep slopes of some of the gravel-capped benches, along such streams as Sage and Coyote Creeks are eroded locally into barren shaly ridges.

Rock Outcrops and Outwash Gravels.—Limestones, locally covered lightly with vegetation, outcrop on the slopes of the Little Belt Mountains and occasionally in the foothills. The more barren phases are classed as rock outcrops. Outwash gravel deposits which are quite barren also occur below the mountains along such streams as Lone Tree, Dry Running Wolf, Yogo, and the Middle Fork of the Judith River.

DRAINAGE

Judith Basin County lies in the drainage basins of the Judith River and the Arrow and Belt Creeks. The Judith River and its branches—Ross, Sage, Coyote, and Wolf Creek drain the southern and eastern parts; Arrow Creek and its branches—Surprise, Lone Tree, and Cottonwood, the northern part; and Otter Creek, a branch of Belt Creek, the extreme western part. These streams are at flood stage during the spring runoff, which occurs usually in March and early April and again in May and June when the streams are swollen by the seasonal rains and by the melting snow in the mountains. Most of the streams have a perennial flow in the mountains and foothills, but at lower levels the waters of many of the smaller streams sink into the gravels and disappear during the late summer and fall.

Judith River.—The South, Middle and North Forks of the Judith River (the latter fork also known as Yogo Creek) rise on the crest of the Little Belt Mountains in the southwestern part of the county and unite in Pig Eye Basin to form the Judith River. These streams flow through deep, narrow valleys, bordered by steep wooded slopes and emerge from the mountains in limestone canyons. Below Pig Eye Basin, the river flows through a limestone and sandstone gorge which gives way to a valley 2 to 2 and one-half miles wide. The valley is bordered on the north by the shaly slopes of the Benchland Bench and on the south by the gravelly slopes of the Triangular Area. The upper part of this valley is in need of drainage, but lower down terraces rise above the stony first bottom and form the secondary benches along the intrenched stream valley in the eastern part of the county. The Judith River carries a large volume of water during the spring and early summer months, but later on in the year a large portion of its flow sinks into the stream gravels.

Ross Creek and Its Branches.—Ross Creek heads in the Judith Gap and flows north entering the Judith Basin in Fergus County. The upper part of this stream has an intermittent flow; but below Buffalo Creek it has a continuous flow the greater part of the year.

The upper course of this stream is through a small, poorly drained, alkali impregnated valley averaging less than one-half mile wide. Just above the entrance of Buffalo Creek, the valley expands to about one mile wide and is bordered on the east by sandy secondary benches and on the west by a heavy flat below the shaly escarpments of the Triangular Area. In the vicinity of Hauck, the stream drains a scabby basin north of which its narrow valley is intrenched between the secondary benches along the Judith River. Muddy Creek is a small perennial stream, heading on a limestone ridge and flowing northeast, entering Ross Creek south of Buffalo. Its poorly drained valley, averaging one quarter of a mile wide, lies below a broken sandstone-capped foothill and gravel-capped area west of Ross Creek. Buffalo Creek is another small perennial stream entering Ross Creek south of Straw. It flows through a small poorly drained valley and receives the drainage from a broken foothill and gravel-capped area. Big Coulee, entering Ross Creek south of Mindon, is an intrenched intermittent stream heading in the western part of the Triangular Area.

Antelope and Waite Creeks.—Antelope Creek, rising in the Little Belt Mountains is a small perennial stream flowing north and entering the Judith River 6 miles west of Hobson. Below the foothills it flows through a small valley bordered on the east by secondary benches above which rises the Triangular Area, and on the west by a broken sandstone-capped area. Waite Creek, another small perennial stream, rises in the mountains and flows north entering the river south of Utica. This stream and its branches are deeply intrenched in the broken sandstone-capped area below the mountains.

Sage Creek, heading in Bear Park, is one of the larger perennial streams rising in the Little Belt Mountains and flowing northeast through the county. Below the foothills its valley varies from one-half to one and one-half miles wide and is bordered by high sandstone-capped benches and hills. Five to 6 miles northeast of Windham the stream enters a broad basin lying between the Benchland and Coyote Benches. The lower part of this basin is scabby and in need of drainage. Willow Creek entering Sage Creek north of Benchland, is a small perennial stream also heading in the mountains. Below the foothills its valley averages one-half mile wide and is bordered by rolling land, locally capped with gravel.

Wolf Creek.—The Dry Fork of Wolf Creek heads on the crest of the Little Belt Mountains south of Big Baldy and flows northeast through a deep narrow valley. It emerges from the mountains through a limestone canyon into a small enclosed basin. The Running Fork of Wolf Creek, heading on the slopes of Bandbox Mountain flows north also through a deep wooded valley and unites with the Dry Fork southwest of Stanford to form Wolf Creek. These

streams carry a fair volume of water in the mountains but during the summer and fall the flow of Dry Fork sinks into the stream gravels and its bed often is dry through the foothills. Wolf Creek flows northeast through a broad poorly drained terraced basin between the Stanford and Surprise Creek benches. Meadow Creek, heading on the shaly buttes south of Dover, flows southeast and enters Wolf Creek across the county line. It flows below the gravelly slopes of the Surprise Creek Bench in the poorly drained basin of Wolf Creek.

Coyote Creek and its branch, *Skull Creek* are small perennial streams, heading on Skull Butte south of Stanford. Coyote Creek, flowing northeast through a small poorly drained valley intrenched between Coyote and Stanford Benches, enters Wolf Creek across the county line.

Arrow Creek, heading in the south central part of the Highwood Mountains, follows a circuitous route through the northern part of the county. The stream carries a fair volume of water during the spring months, but after the snow melts in the mountains its volume shrinks, and during the late summer and fall its lower course often consists of a number of stagnant water holes. Below the foothills the stream flows through an intrenched valley, which becomes more open to the east and northeast and is bordered by shaly breaks, rising more than 300 feet. Its northern branches—Davis and Cottonwood, which flow through small poorly drained valleys below the mountains, are deeply intrenched in the shaly badlands above their entrance into Arrow Creek.

Surprise Creek, heading in the foothills east of Wolf Butte, is a small perennial stream flowing northeast and entering Arrow Creek in Fergus County. Below the foothills its valley widens out for a few miles, but to the north it is intrenched 300 feet or more below the Merino and Surprise Creek benches. The shaly slopes of the benches rise steeply above the narrow stream course.

Lone Tree Coulee is another small perennial stream heading in the foothills and uniting with Arrow Creek north of Geyser. Its valley is deeply intrenched in the foothills and in the gravel-capped area north of the foothills. Dipping Vat Coulee is an intermittent stream rising in the foothills and entering Arrow Creek east of the mouth of Lone Tree Coulee. Its small valley also is intrenched above Arrow Creek

Hay Coulee is an intermittent stream heading in a gap west of Spion Kop and entering Arrow Creek north of Geyser. West of Geyser it flows through a small poorly drained valley, bordered on the north by a shaly escarpment and on the south by the gravelly slopes of the Geyser Bench.

Geyser, Crow and McCarthy creeks, entering Hay Creek from the south, are intermittent streams with a few perennial springs

along their courses. These streams flow through intrenched valleys which locally are in need of drainage.

Otter Creek rises in the Otter Range of mountains, flows north and joins Belt Creek in Cascade County. This stream and its branch, Little Otter, are small perennial streams flowing through enclosed valleys in the foothills and in the sandstone-capped tablelands north of the mountains.

Williams, Bear, and Cora creeks, heading on the southwestern slopes of the Highwood mountains, are also small perennial streams entering Otter Creek from the north. These streams flow through deep narrow valleys below sandstone-capped benches and ridges.

SETTLEMENT AND DEVELOPMENT

The Missouri and Yellowstone rivers were the two main routes of travel through eastern Montana for a number of years after the discovery of gold in western Montana. The large area between these streams was seldom visited by white men and remained the land of Buffalo and Indians long after western Montana was settled. After the Custer Massacre, military forts were established in eastern Montana and an attempt was made to confine the Indians to reservations. Mining and stock raising grew rapidly after the Indian depredations were brought to a close and were the chief industries in central Montana until the beginning of dry land farming in about 1906. The foothills and benchlands in Judith Basin County were sectionized largely during the 80's and 90's.

History.—The Judith Basin was the hunting grounds of such Indian tribes as the Blackfeet, Gros Ventres and Crows. Trapping and trading with the Indians were the chief industries for a number of years after the Lewis and Clark Expedition passed through the state in 1804-1806. Other expeditions such as Hayden's were organized during the 50's and 60's to investigate the natural resources of the Northwest Territory and several passed through the Judith Basin. The Little Belt Mountains were prospected in the late 70's, and in 1879 and 1880 rich deposits of silver and lead ores were discovered at Barker, Neihart and other places in the Little Belts. Sapphires were discovered at Yogo during the late 90's but the deposits were not worked extensively until after 1900. A fair quality of coal underlies a portion of the county and after completion of the Great Falls-Billings Branch of the Great Northern Railway, coal mining was one of the more important industries for a few years. The mining districts developed rapidly and thrived until shortly after 1890, when silver was demonetized. Mining was followed by stock raising, which gave way to dry land farming in the more desirable agricultural districts.

Time of Settlement.—The first permanent settlements in the Judith Basin were made at such mining camps as Barker and at the stage stations located on routes through the basin. Utica, settled in 1881; Kirby, in 1883; and Stanford, in 1884, served mining centers and stock raising sections. Much of the desirable grazing lands were owned privately at the time of the so-called "dry land movement" in the state. Many of the large ranch holdings on the benches were subdivided into tracts of 160 and 320 acres or more and sold for farm lands soon after the railway built through the county.

Settlers.—Many of the early miners and stockmen were of English and Scotch descent. Most of the people attracted to the Judith Basin during the dry land movement were native born Americans, who migrated largely from the agricultural districts and industrial centers in the central and northcentral states. These settlers probably had more available capital for the development of the area than in many other sections of the state. A few Japanese, Chinese and negroes are found in the larger towns.

Population.—The basin was sparsely settled while stock raising was the leading industry. However, after the large stock ranches were divided into farming units, the farm and urban populations increased rapidly. The census report for the year 1930 gives Judith Basin County a total population of 9541 of which 35 were colored. The present farm population is reported at 2808.

Towns.—Stanford, the county seat and largest town, is located in the north central part of the county on a branch line of the Great Northern Railway. It has a population of 509 and serves a large farming and stock raising section. Moccasin, the second largest town with 306 inhabitants, is the junction of the Moccasin-Lewistown Branch of the Great Northern Railway. The Judith Basin Branch of the Montana Agricultural Experiment Station is located on Highway 87E, two miles east of Moccasin. Other towns located on the railway, such as Hobson, Geyser, Benchland and Raynesford with populations ranging from 105 to 240, also serve farming and stock raising sections. Spion Kop, Windham, and Kolin are small distributing points, while Mindon, Hauck and Merino are chiefly loading and receiving stations of the railway. Arrow Creek, located on a branch of the Milwaukee Railway in the northern part of the county, serves a large farming section. Yogo and Barker are mining centers in the Little Belt Mountains. Utica is an inland trading point, located in the valley of the Judith River. The larger towns have many of the modern municipal improvements such as electric lights, water and sewerage systems. The educational facilities in the larger towns and in the more prosperous farming districts meet state standards. All towns are served by power and telephone companies.

Transportation and Markets.—The Great Falls-Billings branch

of the Great Northern Railway completed about 1907 runs through the central part of the county and makes connection with the Lewistown Branch at Moccasin. The Great Falls-Lewistown Branch of the Chicago, Milwaukee, St. Paul and Pacific Railway, constructed in 1912, passes through the northeast corner of the county; while the branch from Lewistown to Harlowtown crosses the southeast corner. These railways provide facilities for the shipment of freight to eastern and western markets such as Chicago, St. Paul, St. Louis, Portland and Spokane. Great Falls and Butte are the chief state markets for the more perishable farm products.

U. S. Highway 87E, also known as the Custer Battlefield Highway, parallels the Great Northern Railway through the county. It is an oil surfaced highway with a branch to Lewistown. The main roads between the larger towns in the Judith Basin are improved and many of them have surfaces of crushed gravel. The rural roads in the farming districts are improved dirt roads, which often become rutty and dusty during the late summer and fall. Other upland trails are open to traffic the greater part of the year.

JEFFERSON NATIONAL FOREST

The Jefferson National Forest includes the greater part of the area covered by the Little Belt and Highwood Mountains. The grazing season in the mountains usually opens in June and closes in September. Grazing permits are obtained from the forest supervisor, located in Great Falls.

STATE LANDS

There are approximately 57,000 acres of state land in Judith Basin County. The sale and lease of these lands are in charge of the Registrar of state lands, located in the Capitol Building, Helena. A minimum price of ten dollars ($10.00) per acre has been placed on these lands by legislative enactment.

CLIMATE

The climate of Judith Basin County ranges from semi-arid on the lower tablelands to sub-humid in the foothills and mountains. The Judith Basin is characterized by a moderate rainfall, a comparatively low relative humidity, great temperature extremes and a large number of sunny days. The mid-summer temperatures are not oppressive because of the low humidity and cool nights, and the winter extremes are not especially disagreeable as the cold waves are not often accompanied by strong winds.

The following tables 1 and 2 give the normal, monthly and annual temperature and precipitation at Utica and Moccasin in Judith Basin County and at Denton and Lewistown located in

Fergus County. The stations range in elevation from approximately 3800 feet at Denton in the northeastern part of the Judith Basin to 4400 feet at Utica in the upper part of the valley of the Judith River. Lewistown and Moccasin have elevations of 3900 and 4167 feet respectively.

Temperature.—The average annual temperature for the different stations ranges from 41.8° F. at Moccasin to 43.7° F. at Denton. January with averages of 20.0° to 22.9° is the coldest month, and July with averages of 63.9° to 66.8° is the warmest. Mid-summer temperatures of 105° to 108° have been recorded at

TABLE 1.—AVERAGE MONTHLY, SEASONAL, AND ANNUAL TEMPERATURES WITH ABSOLUTE MAXIMUM AND ABSOLUTE MINIMUM TEMPERATURES FOR SELECTED STATIONS IN AND NEAR JUDITH BASIN COUNTY

	Mean				Absolute Maximum			Absolute Minimum		
Months	Denton	Lewistown	Moccasin	Utica	Denton	Lewistown	Utica	Denton	Lewistown	Utica
December	23.0	24.3	23.0	28.4	63	71	64	-27	-36	-31
January	20.0	21.7	20.0	22.9	60	60	62	-46	-41	-36
February	21.9	24.1	24.0	23.1	62	66	66	-30	-36	-34
WINTER	22.0	23.3	22.3	24.8	63	71	66	-46	-41	-36
March	31.3	31.5	29.0	29.6	72	77	73	-19	-26	-25
April	43.6	42.2	41.0	42.3	86	86	85	5	-12	- 8
May	51.2	50.5	49.0	49.1	96	93	91	19	19	10
SPRING	42.0	41.4	40.0	40.3	96	93	91	-19	-26	-25
June	61.0	58.8	58.0	57.5	100	105	108	32	25	24
July	66.8	65.4	65.0	63.9	102	105	102	37	30	33
August	64.7	63.6	64.0	63.7	106	98	100	28	27	32
SUMMER	64.0	62.6	63.1	61.7	106	105	108	28	25	24
September	56.1	53.5	53.0	53.5	94	98	93	24	9	13
October	49.8	44.4	43.0	45.1	88	92	81	- 2	- 4	2
November	34.3	32.7	33.0	36.8	72	81	79	-22	-25	-27
FALL	46.7	43.5	43.0	45.1	94	98	93	-22	-25	-27
ANNUAL	43.7	42.7	41.8	43.0	106	105	108	-46	-41	-36

all the stations. The minimum winter temperatures range from —36° at Utica to —46° at Denton. The average frost free period varying with the location and elevation, dates from May and early June to the middle of September. Temperatures of 32° or lower have been reported at all the stations for every month in the year except for the month of July at Utica, Denton and Moccasin. Small grains are seeded usually the last of April on the lower tablelands and early in May on the higher. These small grains are injured rarely by late spring frosts, but early fall frosts occasionally damage late seeded small grains on the high tablelands and in the irrigated valleys.

TABLE 2.—AVERAGE MONTHLY, SEASONAL AND ANNUAL PRECIPITATION RECORDS FOR SELECTED STATIONS IN OR NEAR JUDITH BASIN COUNTY

Month	Mean				Total Amount Driest Year				Total Amount Wettest Year				Snowfall (Depth in inches)		
	Denton 1908-1922	Lewistown 1896-1935	Moccasin 1909-1931	Utica 1894-1921	Denton 1919	Lewistown 1900	Moccasin 1919	Utica 1895	Denton 1916	Lewistown 1909	Moccasin 1909	Utica 1909	Denton	Lewistown	Utica
December	0.46	0.85	0.72	0.58	0.68	0.90	0.73	1.52	1.35	1.21	1.21	1.20	7.6	10.9	7.9
January	0.72	0.76	0.68	0.65	0.36	0.59	0.13	0.51	0.96	1.25	0.90	0.90	13.4	11.6	8.1
February	0.33	0.79	0.56	0.38	0.26	0.50	0.71	0.20	0.19	0.10	0.08	0.08	6.2	9.5	5.2
WINTER	1.51	2.40	1.96	1.61	1.30	1.99	1.57	1.23	2.50	2.56	2.19	2.18	27.2	32.0	21.2
March	0.48	0.60	0.78	0.80	0.37	0.16	1.20	0.15	0.05	1.27	1.22	1.22	6.2	10.4	9.1
April	0.91	1.34	1.18	1.17	0.06	0.36	1.17	0.75	0.93	1.19	1.03	0.95	6.1	6.0	5.1
May	1.85	2.86	2.25	2.83	0.32	0.20	0.73	0.39	2.45	2.50	1.34	1.84	2.6	3.9	3.5
SPRING	3.24	4.80	4.21	4.80	0.75	0.72	2.10	1.29	3.43	4.96	3.59	4.01	14.9	20.3	17.7
June	3.09	3.54	2.94	3.39	1.60	1.50	1.08	3.76	5.90	4.86	5.99	6.66	0.0	T	0.5
July	1.85	2.23	1.79	2.10	0.72	0.55	1.02	1.31	3.09	4.20	2.54	4.97	0.0	0.0	0.0
August	1.00	1.39	1.56	1.19	0.12	4.20	0.29	0.00	0.53	2.73	4.21	1.28	T	T	0.0
SUMMER	5.94	7.16	6.29	6.68	2.44	6.25	2.39	5.07	9.52	11.79	12.74	12.91	T	T	0.5
September	1.76	1.60	1.64	1.38	1.98	0.80	1.48	0.45	1.88	4.23	4.47	4.27	1.3	1.5	1.6
October	0.85	1.21	0.93	1.15	1.03	1.00	1.43	0.00	0.78	0.50	0.49	0.49	5.2	6.6	7.1
November	0.43	0.75	0.72	0.81	0.35	0.32	0.93	0.80	0.74	0.91	0.30	0.30	5.2	8.6	9.2
FALL	3.04	3.56	3.29	3.34	3.36	2.12	3.84	1.25	3.40	5.64	5.26	5.06	11.7	16.7	17.9
ANNUAL	13.74	18.37	15.79	16.43	7.85	11.08	9.90	8.84	18.85	24.95	23.78	24.16	53.8	69.0	57.3

Precipitation in the Juidth Basin is influenced by the different mountain ranges. It increases normally with the elevation and is greatest on the northern and western slopes of the mountains. The lowest rainfall in the area, probably, is received on the gravel-capped benches bordering the foothills of the Highwood Mountains north and West of Arrow Creek. The average annual precipitation, according to the weather records, ranges from 13.74 inches at Denton in the lower part of the basin to 18.37 inches at Lewistown located on the western slopes of the McDonald Creek Divide between the Big Snowy and Judith Mountains. Moccasin and Utica have averages of 15.79 to 16.43 inches respectively. The total amount reported for the driest years varies from 7.85 inches at Denton to 11.08 inches at Lewistown and for the wettest year from 18.85 to 24.95 inches respectively for the same stations. During the period March 1 to September 1, 65 to 75 per cent of the total annual precipitation is received. The June rainfall averages somewhat higher in the Judith Basin than for any other section in the eastern part of the state. The summer rainfall is received largely in local showers of torrential character. The average annual snowfall in the basin is 5 to 6 feet, but rarely does the snow accumulate to any great depth because of chinook or warm winds during the winter months.

Wind.—The Judith Basin is subject to brisk westerly winds, which usually are stronger during the late winter and early spring months, and locally in dry seasons may cause soil drifting and damage to fall and early spring seeded small grains. The basin lies in the paths of chinook or warm winds, which are characteristic of the high plains east of the Rocky Mountains during the winter months. Hot winds occur occasionally in dry seasons, but crop losses are usually not as great as in the lower plains area of the state. The normal evaporation from a free water surface for the period April 1 to October 1 at Moccasin is 33.23 inches. Hail storms of more or less severity occur occasionally during the summer months.

MAPS

The four maps in this report show (1) the main physiographic and geographic features; (2) the location and extent of the different soils; (3) the location and percentage of each section under cultivation; and (4) the U. S. Geological Land Classification, which indicates the adaptation of the land to agriculture.

Topography.—The topography map shows the chief physiographic and geographic features such as Mountains, lakes, badlands and the more important stream courses. The general relief of the land is divided into the following groups, namely; (1) undulating to rolling land; (2) sharply rolling land or land too

steep and broken for farming; (3) plateaus and benches; (4) mountains; (5) badlands and (6) badland basins.

*Soil.**—The soil map shows the relationship of the soils in different parts of the county. It is based on the physical properties such as color, texture, structure, thickness and relative position of the different horizons or layers found in the soil under field conditions. These horizons (observed in road cuts) are the result of natural soil forming processes, which are influenced by climate, topography, drainage, vegetation, erosion, etc. Soils having the same number, arrangement, and character of horizons are divided into large groups known as the "soil series" which are further divided into "soil types" on the basis of the proportion of sand, silt and clay in the surface layers. Reconnaissance soil surveys deal largely with the identification and isolation of the larger soil groups. Soil types are not readily isolated in traversing an area at intervals of 2 miles, and on the soil map only the most prevalent types, such as loams, sandy loams and clay loams of each series are shown. Therefore each soil type as mapped may contain small tracts of heavier or lighter soils and in some cases, isolated areas of other soil series. Areas covered by mountains, badlands, and badland basins are not included in any of the soil series and on the soil map are shown as separate physiographic features.

Area Under Cultivation.—A record of the approximate acreage under cultivation was made at the time of the survey for the purpose of locating the more intensely cropped sections of the county and for determining the reason why these areas were more favorably adapted to agriculture than others. The approximate percentage of each section in crop, in fallow and in pasture is shown on the soil map.

Land Classification Map.—The United States Geologlical Survey undertook a classification of the public lands in the western states in 1915 for the purpose of designating those areas in which 640 acre tracts could be homesteaded under the Stock Raising Act. This classification was based largely on topography and vegetation and in no instance was any information obtained in regard to the soil relationship in any one county or between two or more counties.

The land classification map is of value in indicating the general adaptation of the land to agriculture. On the map the utiliza-

*Preliminary soil reports of each county surveyed are being published by the Montana Agricultural Experiment Station. A final report covering a group of counties in central Montana will be published by the U. S. Bureau of Chemistry and Soils. The soil correlations made in Judith Basin County are tentative and have not been approved by the Soil Correlation Committee of the Bureau of Chemistry and Soils. Therefore, changes in names and regrouping of soils may be made by the correlation committee in the final report.

tion of the land is indicated as follows: (1) farm land, (2) farming grazing land, (3) grazing forage land, (4) grazing land, and (5) non-tillable grazing land. Other features such as the location of the irrigated districts also are shown.

DESCRIPTION OF SOILS

Judith Basin County, consisting of high gravel-capped tablelands, intrenched stream valleys, foothills and mountains, has a variety of soils varying with the elevation, topography, location and nature of the parent material. The mature soils, or those having well developed horizons, classified according to color belong to several groups, namely; grayish brown, dark grayish brown, very dark grayish brown, black, and in the mountains probably some gray forested soils. The grayish brown soils with carbonate zones 6 to 8 inches below the surface cover only a small portion of the county and are found chiefly in heavy stream valleys in the northeastern part. The dark grayish brown soils with carbonate zones ranging between 8 and 15 inches cover the lower tablelands and sandstone-capped areas in the north central part. The very dark grayish brown soils with carbonate zones below 15 to 20 inches occur on the higher tablelands and the foothills in the central part. Black soils without carbonate zones are found in the higher foothills and on the grassed over mountain slopes in the northwestern and southwestern parts. The grayish brown and dark grayish brown soils have developed under a short grass cover, a moderately low rainfall, and a wide range in summer and winter temperatures. The black soils have developed under a tall grass cover, greater rainfall, lower mean annual temperature and a short growing season. The very dark grayish brown soils have developed under conditions intermediate between these two groups. Gray or immature soils without distinct horizons occur on the more eroded shaly slopes of benches and ridges along Arrow and Sage Creeks in the northern and northeastern parts. The top soils in the Judith Basin often are quite shallow but the color of the surface soils is quite dark. The farm lands of Judith Basin County are found largely in those areas covered with the dark grayish brown and very dark grayish brown soils; and the better grazing lands, in the darker colored groups, such as the very dark grayish brown and black soil areas.

The mature soils or those showing distinct horizons developed over calcareous sandstones and shales and over sedimentary crystalline rocks in Judith Basin County are grouped in the Morton, Teton, and Adel series. These series have respectively darker colored surface soils and deeper horizons. The mature dark grayish brown soils of the Morton series with carbonate zones 8 to 16 inches below the surface occur on isolated tracts in the central part of the county. The tracts suitable for farming

are devoted to small grains and are well under cultivation. The more broken and stony phases have a good grass cover and a high livestock carrying capacity. The very dark grayish brown soils of the Teton series with carbonate zones below 20 inches occur on sandstone-capped plateaus in the west central part and also cover a large portion of the foothill area north of the Little Belt Mountains. The tracts are quite stony and lie at a rather high elevation for general farming and are utilized chiefly for the grazing of livestock and for the production of winter forage. A small acreage is locally devoted to early maturing small grains on some of the lower plateaus. The very dark brown, almost black soils of the Adel series without distinct carbonate zones occur in the higher foothills and in the mountains. Tracts covered with soils of this series are used mainly for summer grazing and locally for the production of early maturing forage crops.

The soils developed over the Kootenai sandstones and shales on the plateaus north of the Little Belt Mountains often have distinctive red colors. These dark reddish brown and very dark reddish brown soils with distinct gray shades are grouped according to development in the Morton and Teton series and are designated as a red phase of these series on the soil map. These red soils have about the same productive capacity and crop adaptation as the soils of the Morton and Teton series.

The soils developed over non-calcareous shales are grouped in three series, namely; Pierre, Winifred and Power. The gray immature soils composing the Pierre series with slight calcareous mulches on the surface, below which the cloddy clays often have the platy structures of the parents shales at 2 to 3 feet, cover the eroded shaly breaks along Arrow and Sage Creeks in the north central and northeastern parts of the county. The breaks are lightly grassed over and have a low livestock carrying capacity. The dark grayish brown soils of the Winifred series with carbonate zones 6 to 15 inches below the surface, occur on isolated tracts between the gravel-capped areas in the central and southeastern parts. The land has a good grass cover and the tillable phases are under cultivation. The very dark grayish brown soils of the Power series with deep carbonate zones also, cover isolated tracts in the central and southeastern parts. The tracts are under cultivation and are devoted to the production of small grains.

Several dark colored soil groups, such as the Zortman and Blaine, occur in the foothills and on the lower slopes of the mountains. The black soils of the Zortman series developed over limestone in basins and on the lower slopes of the mountains are quite stony and shallow and only the deeper and less gravelly phases are devoted to the production of small grains and forage crops. The tracts are locally under cultivation in the west central part of

the county. The very dark grayish brown soils of the Blaine series, developed over ancient trap rocks on the mountain slopes and in the foothills are utilized chiefly for the grazing of livestock. The tracts are too stony for farming.

The soils developed on the gravel-capped tablelands are grouped according to color and physical properties of the surface soil and also according to the depth and cementation of the carbonate zone in four series, namely; Moccasin, Ashuelot, Danvers and Lloyd. The Moccasin series comprises a group of undifferentiated dark grayish brown and very dark grayish brown soils with semi-consolidated carbonate zones 10 to 15 inches below the surface. The soils developed on benches, capped with quartzite, limestone and other rock and gravel in the vicinity of Geyser are quite stony, gravelly and shallow and do not rank with the better agricultural soils in the county, except on the Surprise Creek Bench. The soils developed on benches capped with limestone gravel occur in the eastern part of the county. The deeper and less gravelly soils of this series cover some of the best agricultural districts. The Ashuelot series consists of a group of dark grayish brown soils with firmly cemented gravelly carbonate zones and occurs on limestone gravel-capped benches in the southeastern part. The soils of this series are rather droughty for dry land farming and are among the marginal agricultural soils in the county. The dark grayish brown soils of the Danvers series developed over heavy material underlaid at various depths with limestone gravel are among the more productive winter wheat soils in the county. The Lloyd series includes a group of very dark grayish brown soils with stony calcareous subsoils developed on benches capped with igneous rock and gravel. Soils of this series occur chiefly on benches north of Arrow Creek. The land is too stony for farming and is used chiefly for the grazing of livestock.

The Lowry series includes an undifferentiated group of grayish brown and dark grayish brown soils developed over shallow gravel deposits in the uplands and over wash gravel on the slopes of the gravel-capped tablelands. The soils are quite variable in texture and depth; but where the land is not too shallow gravelly, and steep, it is under cultivation. The tracts have a good grass cover and a fair livestock carrying capacity.

The Phillips series includes a group of dark grayish brown soils, characterized by the so-called "scab spots" or "blow out holes." The tracts occur locally in the valley of Sage Creek. The land is not under cultivation and is classified as low grade grazing land.

The very dark grayish brown soils, comprising the Cheyenne series have developed over stratified gravel deposits occurring as secondary benches or high terraces along the larger streams, such

as the Judith River. These soils have well developed carbonate zones below 12 to 15 inches and are under cultivation where the subsoils are not too porous for holding moisture.

The very dark grayish brown soils of the Wade series with carbonate zones 10 to 18 inches below the surface occur in old stream valleys, such as Wolf, Sage and other creeks in Judith Basin County. The better drained phases are under cultivation and are well adapted to the production of small grains and forage crops.

The soils developed over recent stream deposits are grouped in the Laurel and Chouteau series. The Laurel series includes a group of undifferentiated gray calcareous soils without distinct horizons covering stream valleys at the lower elevations. In this series also is placed the stony river wash along the larger streams. The soils of the Laurel series are locally under cultivation where the land is subirrigated or where it lies below the ditch. The Chouteau series includes a group of undifferentiated black stony soils covering poorly drained valleys below the mountains. These wet bottoms often are valuable wild hay lands.

Barren rock outcrops, mountains and badlands are designated as physiographic features and are so shown on the soil map.

The soils of Judith Basin County are grouped in 18 soil series and 51 soil types and phases. Table 3 gives the area in square miles of each soil type and physiographic feature and also the the proportion of each soil type or phase, which is unsuitable for cultivation because of its broken topography.

MORTON LOAMS

The Morton loams have shallow grayish brown fine sandy mulches on the surface. The humus bearing layers are dark grayish brown columnar structured friable loams 5 to 7 inches thick. The subsurface layers are somewhat lighter colored, more compact and heavier textured. The gray silt to silty clay carbonate zone below 10 to 16 inches grades into stratified sandy silty material or into lime coated sandstone fragments at 24 to 42 inches. Sandstone outcrops occur occasionally as slabs on the surface of the more rolling and eroded phases.

The soils on some of the tracts grade locally into silt and silty clay loams. These heavier loams are characterized by deep fine grained silty surface mulches, which often have a darker color and a platy structure in the lower part. The granular or fine cloddy humus bearing layers have a columnar structure and grade into a compact silty clay carbonate zone streaked and blotched with lime below 10 inches. The lower soil depths are largely stratified silts and silty clays.

Topography—Tillable Area.—The Morton loams occupy high rolling ridges and slopes along Sage Creek in the central part of

TABLE NO. 3.—AREA AND PROPORTIONATE EXTENT OF EACH SOIL TYPE MAPPED IN JUDITH BASIN COUNTY (IN SQUARE MILES)

Soil Type	Total Area	Per cent of County	Topography: Level to Sharply Rolling	Topography: Sharply Rolling
Adel				
Adel Loams	9.7	0.5	4.9	4.8
Adel Loams—Timbered Phase	4.8	0.3	0.0	4.8
Ashuelot				
Ashuelot Gravelly Silt Loams	13.9	0.7	13.9	0.0
Ashuelot Gravelly Loams	7.2	0.4	7.2	0.0
Blaine				
Blaine Stony Loams	29.6	1.5	15.7	13.9
Cheyenne				
Cheyenne Gravelly Loams	10.7	0.6	10.7	0.0
Cheyenne Gravelly Sandy Loams	14.9	0.7	14.9	0.0
Chouteau				
Chouteau Clay Loams	6.4	0.3	6.4	0.0
Choteau Loams	69.5	3.6	69.5	0.0
Danvers				
Danvers Silty Clay Loams	7.8	0.4	7.8	0.0
Laurel				
Laurel Loams	41.5	2.2	41.5	0.0
Lloyd				
Lloyd Stony Loams	23.5	1.2	23.5	0.0
Lowry				
Lowry Gravelly Clay Loams—Dark Phase	15.8	0.8	15.8	0.0
Lowry Gravelly Clay Loams—Dark Shallow Phase	3.7	0.2	3.7	0.0
Lowry Gravelly Loams	14.7	0.7	14.7	0.0
Lowry Gravelly Loams—Dark Phase	48.7	2.7	48.7	0.0
Lowry Gravelly Silty Clay Loams—Dark Phase	8.7	0.4	8.7	0.0
Moccasin				
Moccasin Gravelly Loams—Modified Phase	11.7	0.6	11.7	0.0
Moccasin Gravelly Loams—Shallow Phase	4.2	0.2	4.2	0.0
Moccasin Gravelly Loams	49.6	2.6	49.6	0.0
Moccasin Gravelly Loams—Dark Phase	7.8	0.4	7.8	0.0
Moccasin Gravelly Sandy Loams	25.5	1.3	25.5	0.0
Moccasin Gravelly Silt Loams	150.5	8.0	150.5	0.0
Moccasin Gravelly Silt Loams—S. B.	25.4	1.0	25.4	0.0
Moccasin Gravelly Silty Clay Loams	4.7	0.3	4.7	0.0
Moccasin Stony Loams	32.1	1.9	32.1	0.0
Moccasin Stony Loams—Gravelly Phase	3.2	0.2	3.2	0.0
Morton				
Morton Loams	11.8	0.6	9.4	2.4
Morton Loams—Red Phase	3.3	0.2	3.3	0.0
Morton Loams—Shallow Phase	2.7	0.1	2.6	0.1
Morton Sandy Loams	2.5	0.1	2.1	0.4
Phillips				
Phillips Silty Clay Loams	8.8	0.5	8.8	0.0
Pierre				
Pierre Clay Loams	31.4	1.6	0.0	31.4
Power				
Power Clay Loams	19.6	1.0	19.6	0.0
Power Clay Loams—Dark Phase	19.3	1.0	19.3	0.0

TABLE 3—(Continued)

Soil Type	Total Area	Per cent of County	Topography: Level to Sharply Rolling	Topography: Sharply Rolling
Teton				
Teton Clay Loams—Dark Red Phase	2.4	0.1	2.4	0.0
Teton Loams	15.0	0.8	15.0	0.0
Teton Loams—Dark Phase	11.8	0.6	11.8	0.0
Teton Loams—Dark Red Phase	35.4	1.8	31.7	3.7
Teton Loams—Shallow Phase	22.4	1.2	22.4	0.0
Teton Loams—Shallow Dark Red Phase	25.4	1.3	25.4	0.0
Teton Stony loams	15.3	0.8	7.3	8.0
Teton Stony Loams—Dark Phase	254.9	13.4	65.7	189.2
Wade				
Wade Clay Loams	20.1	1.0	20.1	0.0
Wade Loams—Dark Phase	23.4	1.2	23.4	0.0
Winifred				
Winifred Clay Loams	40.8	2.1	24.2	16.6
Winifred Clay Loams—Shallow Phase	15.0	0.8	15.0	0.0
Winifred Clay Loams—Valley Phase	16.8	0.8	16.8	0.0
Zortman				
Zortman Loams—Deep Phase	4.9	0.3	4.9	0.0
Zortman Loams—Shallow Phase	25.3	1.3	25.3	0.0
Zortman Stony Loams	38.6	2.0	0.0	38.6
Zortman Stony Loams—Timbered Phase	14.4	0.7	0.0	14.4
Physiographic Features				
Badlands	32.8	1.7	0.0	32.8
Rock Outcrops and Outwash Gravels	7.7	0.4	7.7	0.0
Mountains	523.2	27.5	0.0	523.2

the county and isolated tracts in the vicinity of Spion Kop. The land is broken with coulees, and locally the slopes are seeped and are in need of drainage. These loams, classified as farming land and as non-tillable grazing land on the land classification map cover 11.8 square miles of which 2.4 square miles are too broken for cultivation.

Utilization.—The Morton loams were placed under cultivation soon after the railway entered the county and have been devoted largely to the production of spring and fall wheat. In 1929, the cropped acreage, amounting to approximately sixty-five per cent of the tillable area was fairly well distributed over the different tracts. Continuous cropping to small grains was practiced for some years after the land was broken out, but as the land became foul, a clean summer fallow was introduced occasionally to control weeds. The present practice is to rotate a clean summer fallow every second or third year. Stock raising is often combined with grain growing in the vicinity of rough broken land. The surface acre foot contains 4700 to 7000 pounds of nitrogen, 2600 to 2800 pounds of phosphorus and 1900 pounds of calcium or lime. The yields of spring wheat on summer fallowed land average between fifteen and twenty bushels per acre with occasional yields of

thirty bushels or more per acre on the deeper soils in favorable seasons. Some difficulty has been experienced in recent years with drifting of summer fallowed land. In some localities the yields of spring wheat have declined, but this decline is attributed usually to a lower annual rainfall received during the growing season the past few years rather than to a decline in fertility resulting from the loss of the top soil by wind erosion.

*Vegetation.**—Western wheat grass (Agropyron smithii) often associated with grama grass (Bouteloua gracilis) on the lower tracts, forms the chief cover on the Morton loams. Other grasses, such as needle grass (Stipa comata) and June grass (Koeleria cristata) are more or less prevalent in the over-grazed sections. Various shrubs, such as mountain sage (Artemisa frigida) are abundant on the loams but have no economic value as forage plants except for sheep. The forage on 12 to 15 acres of native sod land would carry a steer through a nine to ten months grazing season on most of the tracts.

MORTON LOAMS—SHALLOW PHASE

The shallow phase of the Morton loams has somewhat lighter colored and more shallow humus bearing layers than the Morton loams and is underlaid at comparatively shallow depths with disintegrated sandstones, which outcrop on the more rolling slopes.

Utilization.—The shallow phase of the Morton loams occupies a portion of the rolling divide between Willow and Coyote Creek in the northeastern part of the county. This phase, classified largely as nontillable grazing land on the land classification map covers 2.7 square miles of which 0.1 square mile is the broken escarpments of the divide. In 1929, about forty per cent of the tillable area was under cultivation. The yields of spring wheat on summer fallowed land average between ten and fifteen bushels per acre. The land has drifted severely during the past few years. Grama grass and western wheat grass form the chief cover on these shallow loams and the forage on 15 to 18 acres would be required to support a steer through a ten months grazing season.

*The vegetation is discussed from the standpoint of the economic value of the different species in their relationship to the livestock carrying capacity of the different soil types. The abundance and character of the vegetation is influenced by such adversities as drought, over-grazing, etc. The prevalence of such grasses and shrubs as needle grass, June grass, and mountain sage, indicates adverse climatic conditions or poor range management. The carrying capacity of the range for any particular season, therefore, depends on a number of factors. The acreage given for carrying a steer through a ten months grazing season on the different soil types is an estimate made by experienced stockmen in the area. In determining the carrying capacity for sheep, four to six ewes and their lambs are considered the equivalent of one steer.

MORTON SANDY LOAMS

The Morton sandy loams have deep, loose, sandy surface mulches and dark grayish brown, columnar structured sandy humus bearing layers, overlying compact sandy subsurface layers. The slightly heavier textured gray carbonate zone below 10 to 15 inches grades into compact grayish brown sands or into disintegrated fragmentary sandstones at 3 feet or more.

Topography—Vegetation.—The Morton sandy loams occur on a sloping tract, dissected with a few coulees above Sage Creek, west of Benchland. These loams, classified as non-tillable grazing land on the land classification map, cover 2.5 square miles, of which sixty-five per cent was under cultivation in 1929. The soils are rather droughty, but under normal dry land conditions they produce between eight and twelve bushels of spring wheat per acre on land occasionally summer fallowed to control weeds. These sandy loams have a fair cover of grama grass, and nigger wool (Carex filifolia) and the forage on 18 to 20 acres would support a steer during a nine months grazing season.

MORTON LOAMS—RED PHASE

The red phase of the Morton loams, developed over the red Kootenai sandstones differs chiefly from the Morton loams in having a reddish color in all sections. The humus bearing layer is a reddish brown loam underlaid with reddish gray carbonate zone at 10 inches and with fragmentary red sandstone at 2 to 3 feet or more. The soils are quite shallow on the crests of slopes above stream courses.

Topography—Vegetation.—The red phase of the Morton loams covers gently sloping tracts, locally in need of drainage, in the west central part of the county and also occurs on eroded slopes along Hay Coulee. This phase, classified as non-tillable grazing land on the land classification map, covers 3.3 square miles of which forty per cent was under cultivation in 1929. The average yield of spring wheat on summer fallowed land is between fifteen and eighteen bushels per acre on the less eroded tracts west of Geyser Creek. The slopes along the streams have a fair cover of western wheat grass and the forage on 15 acres of native sod land would carry a steer through the eight to nine months the area is open for grazing.

TETON LOAMS

The Teton loams have a shallow very dark brown almost black fine sandy surface mulch on the higher tracts. The humus bearing layers are very dark grayish brown crumbly, granular loams and silt loams 5 to 7 inches thick. The upper part of the subsurface layer is a brown granular blocky structured heavier textured loam and silt loam, grading into a lighter brown

more compact silt and silty clay loam without definite structure in the lower part. The grayish brown silty clay carbonate zone below 15 to 30 inches grades into fragmentary sandstone at 2 to 4 feet or more. The soils are quite shallow on the crests of slopes above stream courses and locally sandstones outcrop and occur occasionally as slabs on the surface.

Topography—Vegetation.—The Teton loams occur on rolling tracts in the northwestern part of the county and on isolated tracts in the lower foothills of the Little Belt Mountains. These loams, classified largely as farming land on the land classification map cover 15.0 square miles, of which approximately eighty-five per cent was under cultivation in 1909. Spring and fall wheat, grown occasionally on summer fallowed land to control the weeds, are the chief cash crops. Alfalfa is the main forage crop, grown on a fair acreage for winter feed. Stock raising is combined usually with grain growing on these loams in the vicinity of the foothills. The surface acre foot contains 5000 to 7000 pounds of nitrogen and 2700 to 3000 pounds of phosphorus. The amount of free lime in the surface soils is low. The average yield of spring wheat on summer fallowed land is between eighteen and twenty-two bushels per acre on the deeper soils, with occasional yields of thirty to thirty-five bushels in favorable seasons. These loams lie at a rather high elevation for general farming and occasionally late maturing small grains are damaged by early fall frosts. The tracts have a good cover of the tall bunch grasses, such as Festuca idahoenis and the forage on 10 to 12 acres would carry a steer through the eight to nine months the area is free from snow.

TETON LOAMS—SHALLOW PHASE

The shallow phase of the Teton loams is underlaid at comparatively shallow depths with disintegrated fragmentary sandstones, otherwise the horizons are similar to the Teton loams. Sandstones outcrop locally and occur occasionally as slabs on the surface of the land. This phase occurs on rolling and steeply sloping tracts in the northwestern part of the county and in the lower foothills of the Little Belt Mountains.

Topography—Vegetation.—The shallow phase of the Teton loams, classified largely as nontillable grazing land on the land classification map, covers 22.4 square miles of which approximately forty-five per cent was under cultivation in 1929. The cropped acreage devoted chiefly to small grains and forage crops was confined largely (1) to the tracts south of the Highwood Mountains, (2) to the eastern part of the tract west of Otter Creek, and (3) to the tracts in the extreme southeastern part of the county. The yields of spring wheat varying with the depth of soil average lower than on the deeper loams. The land has a good grass cover and its livestock carrying capacity will not differ greatly from that of the loams.

TETON LOAMS—DARK PHASE

The dark phase of the Teton loams differs from the Teton loams in having a darker colored almost black organic mulch on the surface. The humus bearing layers are deeper and darker colored. The subsoils locally are leached yellowish brown sands which effervesce with acid just above the calcareous fragmentary sandstone. These sandstones underlie the tracts at 8 to 36 inches or more. The soils are usually shallow above the crests of stream slopes, and sandstone slabs often occur on the surface.

The surface soils on the large tract west of Antelope Creek are quite shallow and are underlaid with structureless yellowish sands derived from the disintegration of the underlying sandstones. The tract bordering the gravel-capped bench in Township 12 North, Range 14 East has a shallow covering of limestone gravel on the surface. Coarse sandy loams underlaid with disintegrated sandstone at comparatively shallow depths predominate on the tract in Township 11 North, Range 15 East.

Topography—Vegetation.—The dark phase of the Teton loams occurs on rolling and sloping tracts in the foothills of the Little Belt Mountains. This phase, classified largely as nontillable grazing land on the land classification map, covers 11.8 square miles. It lies at too high an elevation for general farming and is used chiefly for the grazing of livestock and for the production of such crops as alfalfa and small grains grown chiefly for winter forage. In 1929, the cropped acreage, confined chiefly to the tract lightly covered with limestone gravel and to the tract west of Antelope Creek, amounted to approximately twelve per cent of the total area. The surface acre foot contains 6000 to 9000 pounds of nitrogen and 2700 to 3000 pounds of phosphorus. The land has a dense cover of the tall grasses and a high livestock carrying capacity during the seven to eight months the area is free from snow.

TETON STONY LOAMS

The profile of the Teton stony loams does not differ greatly from that of the Teton loams. The carbonate zone is somewhat closer to the surface and the lower soil depths consist chiefly of disintegrated fragmentary sandstone. These stony loams occur chiefly on a steeply sloping plateau north of the Little Belt Mountains in the extreme west central part of the county. Sandstone outcrops and sandstone slabs occur on the surface. The stony loams, classified as nontillable grazing land on the land classification map, cover 15.3 square miles of which 8.0 square miles are broken with deep coulees. The cropped acreage, confined largely to the less stony tracts on the plateau, amounted to approximately fifteen per cent of the tillable phase in 1929. The yields of spring wheat average about the same as on the shallow phase of the

Teton loams. The land is well covered with the tall grasses and has a high livestock carrying capacity during the time the area is open to grazing.

TETON STONY LOAMS—DARK PHASE

The dark phase of the Teton stony loams differs chiefly from the dark phase of the Teton loams in having more rock exposed on the surface. This phase includes isolated tracts of Adel stony loams, which were not separated out in the higher and more rugged foothill areas. These stony loams have developed largely over crystalline sedimentary rocks which outcrop and underlie the foothill area at comparatively shallow depths.

Topography—Vegetation.—The dark phase of the Teton stony loams covers the greater part of the foothill area of the Little Belt Mountains. These stony loams, classified as nontillable grazing land on the land classification map, cover 254.9 square miles of which 65.7 square miles are gently to steeply sloping tracts. In 1929, approximately five per cent of the total area was devoted to the production of alfalfa and the small grains grown for hay. The land has a dense cover of the tall grasses and a high livestock carrying capacity during the six to seven months the area is free from snow. Shrubs are conspicuous on the protected slopes of the foothills and at the higher elevations a light stand of scrub pine occurs on the ridges and buttes. Some of the best grazing land in the state is found in the foothills of the Little Belt Mountains.

TETON LOAMS—DARK RED PHASE

The dark red phase of the Teton loams developed over Kootenai and other geologic red sandstones and crystalline rocks differs chiefly from the Teton loams in having a reddish color in all sections. The humus bearing layer is a dark reddish brown loam underlaid at 15 to 36 inches with a reddish brown to reddish gray silty clay carbonate zone. Disintegrated, fragmentary red sandstones underlie the tracts at varying depths of 2 to 3 feet or more. The soils are usually shallow on the crests of slopes of stream courses.

Topography—Vegetation.—The dark red phase of the Teton loams occupies rolling benchlands below the foothills of the Little Belt and Highwood Mountains in the west central and central parts of the county. This phase, classified as farming land and nontillable grazing land on the land classification map, covers 35.4 square miles, of which 3.7 square miles are too broken for cultivation. The cropped acreage, amounting to approximately eighty-five per cent of the tillable area in 1929, was well distributed over the larger tracts. The chief cash crops, grown oc-

casionally on summer fallowed land to control weeds, are spring and fall wheat, and the more important forage crops are alfalfa and the small grains such as oats, grown for hay. The surface acre foot contains 6000 to 9000 pounds of nitrogen and 2500 to 3000 pounds of phosphorus. The yields of spring wheat on summer fallowed land average between eighteen and twenty-two bushels per acre on the deeper soils. Although late maturing crops are occasionally damaged by early fall frosts, these loams constitute some of the best agricultural soils in the county. They have a good cover of the tall bunch grasses and their livestock carrying capacity is between 10 and 12 acres per steer during the eight to nine months the area is open to grazing.

TETON LOAMS—SHALLOW DARK RED PHASE

The shallow dark red phase of the Teton loams has the same surface horizons as the dark red phase. Fragmentary red sandstones, often occurring as red sandstone slabs on the surface, underlie the tracts at comparatively shallow depths.

Topography—Vegetation.—The shallow dark red phase of the Teton loams, classified as farming land and as non-tillable grazing land on the land classification map, occurs on rolling tracts below the foothills of the Little Belt Mountains. These shallow loams cover 25.4 square miles of which approximately sixty per cent was under cultivation in 1929. The yields of spring wheat average lower than on the deeper loams. The land has a good cover of the tall bunch grasses and the forage on 10 to 12 acres would support a steer through the seven to nine months the area is open for grazing.

TETON CLAY LOAMS—DARK RED PHASE

The dark red phase of the Teton clay loams has a fine grained, reddish brown silty clay mulch on the surface. The humus bearing layers are cloddy granular dark reddish brown clay loams, underlaid with compact lime blotched and streaked carbonate zones at 10 inches or more. Disintegrated red shales underlie the tracts at various depths. These shales outcrop locally and the wash from them gives rise to soils with intensely red colors.

Topography—Vegetation.—The dark red phase of the Teton clay loams, classified largely as nontillable grazing land on the land classification map, covers rolling eroded tracts in the northwestern part of the county. The tract in the vicinity of Spion Kop has a gentle relief and locally is in need of drainage. This phase covering 2.4 square miles is rather refractory for dry land farming, as less than twenty per cent of the area was under cultivation in 1929. The yields of spring wheat on land occasionally summer fallowed average between twelve and fifteen bushels per acre on the deeper and less eroded phases. The land has a fair grass cover giving it a fair livestock carrying capacity.

ADEL LOAMS

The Adel loams include a group of undifferentiated black soils developed over crystalline sedimentary rocks at elevations above 5500 to 6000 feet. These loams are characterized by a dark colored organic mulch, which is often a fibrous mat of organic matter at the higher elevations. The humus bearing layer is a black granular silt loam 6 to 10 inches thick. The subsurface layers often having a reddish brown color, are granular silty clays, grading into structureless non-calcareous, gritty silty clays with depth. Crystalline sandstones underlie the tracts at various depths and slabs and fragments of these sandstones occur on the surface and in the soils in varying quantity. A light stand of timber occurs in the higher foothills but does not greatly modify the character of the soil. The timbered area is designated on the soil map as a timbered phase of these loams.

Topography—Vegetation.—Adel loams occur in the higher foothills and on the grassy slopes of the mountains. These loams, classified as non-tillable grazing land on the land classification map cover 14.5 square miles of which 9.6 square miles are rough broken land. The timbered phase covers about one-third of the area classified as rough broken land. The Adel loams are too stony and lie at too high an elevation for farming and are used chiefly for summer grazing lands. Small tracts, devoted to the production of forage crops such as the tame grasses and the small grains grown for hay, are under cultivation in the foothills. Various shrubs and also grasses such as red top, mountain timothy and upland sedges predominate on these loams. The type of vegetation is somewhat better adapted to the grazing of sheep than cattle. The land has a high livestock carrying capacity during the six to seven months the area is free from snow.

ZORTMAN LOAMS—DEEP PHASE

The surface 2 or 3 inches of the deep phase of the Zortman loams is a black organic mulch. The humus bearing layers are black friable granular loams and silt loams, 7 to 9 inches thick. The lower soil depths are dark brown to reddish brown granular silty clay loams, grading into structureless yellowish brown silty clays, which effervesce with acid immediately above the fragmentary limestone which underlies the tracts at 3 feet or more.

Topography—Vegetation.—The deep phase of the Zortman loams, classified as farming land and as nontillable grazing land on the land classification map, covers 4.9 square miles on the mountain slopes and in basins below the mountains in the southwestern part of the county. The basins in the west central part of the county are under cultivation and are devoted to the production of early maturing small grains and forage crops. The surface

acre foot in the cultivated basins contains 6000 to 8000 pounds of nitrogen and 3000 to 3500 pounds of phosphorus. The higher basins and mountain slopes are used chiefly for summer grazing of livestock and for the production of native wild hay. The grasses, sedges and shrubs predominating on these loams are much the same as found on the Adel loams. The land has a high livestock carrying capacity during the six to eight months the area is open for grazing.

ZORTMAN LOAMS—SHALLOW PHASE

The shallow phase of the Zortman loams differs chiefly from the deeper phase in having yellowish brown, silty clay subsoils, grading into disintegrated limestone at one to 3 feet. This phase often having limestone fragments distributed through the soils is associated with the deeper phase in the basins below the mountains.

Topography—Vegetation.—These shallow loams, classified as non-tillable grazing land on the land classification map, cover 25.3 square miles. Approximately fifteen per cent of the area was under cultivation in 1929 and it was devoted largely to the production of forage crops. The more shallow phases are used chiefly for the grazing of livestock and for the production of wild hay. Scrubby cinquefoil, the flowers of which are economic forage for sheep, is abundant on the more shallow phases. Otherwise the forage is the same as on the deep phase. The livestock carrying capacity of the shallow phase during the six to eight months the tracts are open for grazing is lower than on the deep phase and is somewhat better adapted to the grazing of sheep than cattle.

ZORTMAN STONY LOAMS

The Zortman stony loams include a group of undifferentiated dark colored stony loams and silt loams, developed over limestone in the foothills of the Little Belt Mountains. The profiles of these loams do not differ greatly from those of the deep phase, except for a greater quantity of rock and gravel on the surface and in the soils. These stony loams, classified as nontillable grazing land on the land classification map, cover 38.6 square miles and are not under cultivation except for small isolated tracts on the more gentle slopes of the foothills. The land has a dense cover of the tall grasses and shrubs and has a high livestock carrying capacity during the six to seven months the tracts are free from snow. A light stand of scrub pine occurs in the higher foothills, and on the soil map 14.4 square miles are designated as a timbered phase of these stony loams.

BLAINE STONY LOAMS

The Blaine stony loams are characterized by very dark brown

fine sandy organic mulches on the surface and by very dark grayish brown granular humus bearing layers, ranging in texture from stony loams to stony silt loams. The reddish brown subsurface layers are granular stony silty clay loams grading into a stony carbonate zone at 12 to 30 inches. The lower soil depths consist chiefly of igneous rock and rock fragments. Dark colored shales underlie the stony outwash in the foothills of the Highwood Mountains and locally these shales are exposed on the more eroded slopes. The soils developed over igneous outcrops below the foothills are grouped in this series but often have lighter colored surface soils and more shallow horizons. The deeper and less stony soils are found on the slopes of ridges between the streams in the northwestern part of the county.

Topography—Vegetation.—The Blaine stony loams cover the foothills of the Highwood Mountains and an isolated tract on the slopes of Wolf Butte in the Little Belt Mountains. These stony loams, classified as non-tillable grazing land on the land classification map, cover 29.6 square miles of which 13.9 square miles are rough broken land. The tracts are used chiefly for the grazing of livestock, except for a small cultivated acreage along streams in Township 19 North, Range 9 East. The surface acre foot of the land under cultivation contains 4000 to 7000 pounds of nitrogen and 2200 to 3000 pounds of phosphorus. The land has a good cover of the tall bunch grasses and a fair livestock carrying capacity during the six to eight months the foothill area is free from snow. The grass cover is not as dense on the southern slopes of the Highwood Mountains as on the northern slopes of the Little Belt Mountains.

PIERRE CLAY LOAMS

The surface one to 2 inches of the Pierre clay loams is a fine grained, laminated silty clay mulch which effervesces weakly with acid. The poorly defined humus bearing layer is a cloddy grayish dark olive clay loam, also effervescing weakly with acid. The lower depths are structureless dark olive drab non-calcareous clays often having the platy structure of the parent shales below 3 feet. The subsoils are locally flecked with alkali and crystals of gypsum occur occasionally in the lower depths. These heavy soils are associated with the barren shaly outcrops on the slopes of benches and stream courses along Arrow Creek and its branches.

Topography—Vegetation.—The Pierre clay loams, classified as nontillable grazing land on the land classification map, cover 31.4 square miles of rolling broken eroded ridges and escarpments in the northern part of the county. These heavy loams are too refractory and broken for farming and are used for the grazing of livestock. A light stand of western wheat grass and annual

shrubs predominates on the tracts and sparse stands of scrub pine occur on the crests of the shaly ridges. The escarpments of benches and stream valleys often are barren. The land has a low livestock carrying capacity.

WINIFRED CLAY LOAMS

The Winifred clay loams have grayish brown fine grained silty clay mulches on the surface. The humus bearing layers are dark grayish brown fine cloddy silty clay and clay loams, effervescing with acid at 5 to 10 inches or more. The well developed carbonate zone is streaked and blotched with lime and grades into dark olive brown clays at 24 to 30 inches or more. Disintegrated dark colored shales outcrop and underlie the more rolling and eroded phases at comparatively shallow depths.

Topography—Vegetation.—Winfred clay loams cover isolated rolling to sharply rolling tracts in the northern and northeastern parts of the county. These heavy loams, classified as non-tillable land on the land classification map, cover 40.8 square miles of which 16.6 square miles are too broken for cultivation. In 1929, approximately fifteen per cent of the tillable phase was under cultivation and devoted to the production of small grains and forage crops. The surface acre foot of these loams contains 5000 to 7000 pounds of nitrogen and 2400 to 2700 pounds of phosphorus. The yields of small grains vary with the depth of soil but on an average they are between ten to fifteen bushels per acre on summer fallowed land. The land has a fair cover of western wheat grass and the forage on 20 to 25 acres would carry a steer through a nine to ten months grazing season.

WINIFRED SILTY CLAY LOAMS—VALLEY PHASE

The valley phase of Winifred silty clay loams differs from the clay loams in having somewhat lighter colored and more friable surface soils. The subsoils are deep, calcareous grayish olive brown compact silty clays and clays, often streaked and blotched with lime and occasionally containing crystals of gypsum. Locally the soils grade into the Marias clay loams which effervesce with acid in all sections.

Topography—Vegetation.—The valley phase of the Winifred clay loams, classified largely as nontillable grazing land on the land classification map, covers 16.8 square miles in the broad basin of Sage Creek in the northeastern part of the county. Most of the land suitable for farming is under cultivation and is devoted to the production of spring wheat. The surface acre foot contains 4000 to 5000 pounds of nitrogen and 2400 to 2800 pounds of phosphorus. These heavy loams are rather refractory for dry land farming and the yields of spring wheat on summer fallowed land

have averaged below ten bushels per acre. Western wheat grass predominates and the forage on 20 to 25 acres would carry a steer through a ten months grazing season.

WINIFRED CLAY LOAMS—SHALLOW PHASE

The shallow phase of the Winifred clay loams occurs in the northwestern part of the county below the Highwood Mountains. The tracts are underlaid at comparatively shallow depths with dark colored shales, which are indurated or hardened. The soils contain fragments of these shales in all sections and often do not effervesce with acid in the lower depths. The tracts covering 15.0 square miles of rolling land are locally eroded barren shale outcrops. The deeper soils are under cultivation and are devoted largely to the production of small grains. The yields of spring wheat average low. The bunch grasses predominate and on portions of the tracts the stand is sparse. The livestock carrying capacity of the shallow phase is comparatively low.

POWER CLAY LOAMS

The Power clay loams have dark colored fine grained silty clay surface mulches, which often have a platy structure in the lower part. The humus bearing layers are dark grayish brown cloddy clay loams with an occasional granular and fine cloddy structure. The subsurface layers below 7 to 9 inches are compact clay loams grading into a grayish olive brown carbonate zone streaked and blotched with lime at 12 to 18 inches. The lower soil depths below 3 to 4 feet are massive structureless grayish dark olive brown clays. The more rolling phases contain small tracts of Winifred clay loams, and in the vicinity of the Highwood Mountains fragments of shales occur in all sections.

Topography—Vegetation.—The Power clay loams occur on rolling tracts in the central part of the county and also cover isolated tracts in the northwestern part. These heavy loams, classified as farming land and as non-tillable grazing land on the land classification map, cover 19.6 square miles. In 1929, approximately sixty per cent of the area was under cultivation and devoted to the production of spring wheat and forage crops. The surface acre foot contains 5000 to 8000 pounds of nitrogen and 2700 to 3000 pounds of phosphorus. The soils are rather refractory for dry land farming and in dry seasons the yields of crops are comparatively low. The yields of spring wheat on summer fallowed land average between twelve and fifteen bushels per acre. Western wheat grass predominates on the tracts and the forage on 15 acres would carry a steer through a ten months grazing season.

POWER CLAY LOAMS—DARK PHASE

The dark phase of the Power clay loams has a very dark grayish brown granular surface soil, which effervesces with acid

at 15 inches or more. The subsoils are deep grayish dark olive brown clays, streaked and blotched with lime. Several tracts south of Muddy Creek have a shallow covering of limestone gravel on the surface and their carbonate zones are a few inches closer to the surface.

Topography—Vegetation.—The dark phase of the Power clay loams, classified as farming land on the land classification map, covers 19.3 square miles of rolling land dissected with shallow seeped drainage courses in the southeastern part of the county. In 1929, approximately sixty-five per cent of the area was under cultivation. Stock raising often is combined with grain growing in the vicinity of the foothills, and on many of the farms a fair acreage is devoted to the production of forage crops such as alfalfa. The surface acre foot contains 6000 to 9000 pounds of nitrogen and 2700 to 3000 pounds of phosphorus. The yields of spring wheat on summer fallowed land average between fifteen and twenty bushels per acre. The tall bunch grasses predominate and the forage on 12 to 15 acres of native sod land would carry a steer through a nine months grazing season.

PHILLIPS SILTY CLAY LOAMS

The Phillips silty clay loams in Judith Basin County include a group of soils characterized by numerous bare spots depressed several inches below the surface. The grassed over portion of these heavy loams has the profile of the Winifred clay loams. The bare spots have a firm silty crust on the surface, below which is a vascular or honey-comb structured layer of an inch or more The vascular structured layer overlies an impervious nutty structured silty clay grading into calcareous grayish olive brown clays.

Topography—Vegetation.—The Phillips silty clay loams occupy level tracts in the basins or valleys of Sage and other creeks in the northeastern part of the county. These loams, classified as nontillable grazing land on the land classification map, cover 8.8 square miles. The less scabby phases are under cultivation and are devoted to the production of spring wheat. In 1929, about thirty per cent of the tract in Township 16 North, Range 15 East was in crops. The yields of spring wheat on summer fallowed land average less than ten bushels per acre. Western wheat grass predominates on the grassed over portion of the tracts and the forage on 30 to 35 acres would carry a steer through a nine months grazing season.

MOCCASIN GRAVELLY SILT LOAMS

The surface one to 3 inches in the Moccasin gravelly silt loams, such as found on the Benchland Bench is a dark colored fine grained silty mulch often having a platy structure in the lower part. The humus bearing layers are dark grayish brown

columnar structured gravelly silt to gravelly silty clay loams 5 to 7 inches thick. The gray semi-consolidated gravelly silty clay carbonate zone lies 6 to 15 inches below the surface and grades into stratified unconsolidated yellowish brown limestone gravelly silty material at 3 to 4 feet. Locally, the gravelly carbonate zone is firmly cemented and occasionally cemented gravel blocks occur on the surface and in the soil. The humus bearing layers on some of the higher benches have a very dark grayish brown color and the upper 2 to 3 inches have a granular blocky structure.

The soils on the Benchland Bench are not uniform in depth nor in the amount of limestone gravel in the surface soils and subsoils, and a more detailed survey would be required to designate the various soil types and phases. The deeper and less gravelly soils are found in the central part west of Indian Creek and in the northcentral part above the breaks of Sage Creek. In the extreme southwestern part coarse sandy loams overlying semi-consolidated gravels cover a small area, and in the southern part refractory clay loams occur in several poorly drained depressions. The more shallow soils underlaid with structureless yellowish brown silts and silty clays are found on the bench between Moccasin and Kolin and above the eastern borders of the bench along the Judith River. In the eastern part of the bench the gravels do not lie at a uniform depth, but often outcrop as gravel bars on the surface. The soils are usually very gravelly on the slopes of drainage courses.

The soils on such benches as the Coyote and on the higher part of the Arrow Creek Bench also are gravelly silt and gravelly silty clay loams with semi-cemented carbonate zones within the surface 6 to 9 inches. The lower soil depths often have a smaller limestone gravel content than on the Benchland Bench. The soils also are very shallow and gravelly about the borders of the benches and on the crests of slopes above drainage courses.

The soils on the secondary bench known as the "Stanford Bench" and designated on the soil map as Moccasin Gravelly Silt loams, S. B. are dark colored gravelly and stony silt loams and silt loams with carbonate zones within 7 to 12 inches of the surface. The subsoils are quite stony and gravelly and appear to be somewhat more consolidated than on the higher benches. Stony loams predominate in the southern part and gravelly loams and silt loams, with some stone on the surface, in the northern part. The soils on the tract east of Coyote Creek are deep gravelly silty clay loams with a limited amount of rock and gravel in the subsoils.

The soils on other isolated detached gravel-capped benches without distinct physiographic or soil features are grouped in the Moccasin gravelly silt loams. Several of these benches such as those found below the foothills west of Wolf Creek have con-

siderable limestone rock on the surface while others are quite gravelly.

Topography—Vegetation.—The Moccasin gravelly silt loams were mapped on smooth, gently sloping, gravel-capped benches in the northeastern part of the county and on a secondary or lower bench along Wolf Creek in the central part. The borders of the benches often are indented with short deep coulees above the steeper escarpments. The benches have good surface drainage except locally at the head and on the slopes of drainage courses. These gravelly silt loams, classified as farming land on the land classification map, cover 175.9 square miles of which 25.4 square miles are located on the Stanford Bench. Nearly all the tillable land was brought under cultivation soon after the railway entered the county and it has been devoted largely to the production of spring and fall wheat. Exclusive grain growing is the chief enterprise on the large farms equipped with power types of farm machinery except in the vicinity of the foothills where stock raising is occasionally combined with grain growing. The low water holding capacity of the subsoils and the normal rainfall of 7 to 9 inches during the growing season has not been favorable for the introduction of a clean summer fallow every other year in the cropping system. Summer fallowing of land is not consistently practiced and is introduced chiefly to control weeds. The present practice on many of the large grain farms is to include a clean summer fallow in the cropping system about every third year with fall wheat grown on stubble land the second year after fallow. The surface acre foot on the Benchland and Stanford Benches contains 6000 to 9000 pounds of nitrogen and 2400 to 2700 pounds of phosphorus. The surface acre foot on the lower benches such as Coyote and Arrow Creek average between 500 and 1000 pounds lower in nitrogen and have about the same amount of phosphorus.

The yields of small grains on these gravel-capped benches are influenced by the depth and character of the surface soils and subsoils. The yields of spring wheat on summer fallowed land range from twelve to fifteen bushels per acre on the more shallow gravelly phases to eighteen to twenty-two bushels per acre on the deeper phases. Under the present cropping system yields of spring wheat average between fifteen and eighteen bushels per acre on the Benchland, Coyote and Arrow Creek benches. They average fifteen bushels per acre on the Stanford Bench with almost double these yields on fairly clean land in seasons of favorable rainfall and temperature. Fall wheat was grown almost exclusively on the benchlands up to 1915 when several consecutive years of severe winter killing and soil drifting caused a change to spring wheat. Since 1927, the yields of spring wheat have averaged low, the soil drifting has been difficult to control—especially on sum-

mer fallowed land. Patches of limestone gravel once covered with 4 to 6 inches of dark colored soils are now exposed in many fields which have been under cultivation for the past twenty to twenty-five years. The loss of the surface soils by soil drifting is undoubtedly one of the contributing factors in the decline in the yields of small grains, not only by reducing the fertility of surface soils, but also by reducing the effectiveness of the seasonal rainfall. Regrassing the more wind eroded tracts and the adaptation of strip farming are practical means for holding the soils in place. The native grass lands have a good cover of western wheat grass and the forage on 12 to 15 acres would carry a steer through the eight to nine months the area is open for grazing. The gravelly borders of the benches are not as well grassed over as the benchlands and a few more acres would be required to carry a steer through a nine months grazing season. Some sections of the benchlands are deficient in water for domestic and stock use.

MOCCASIN GRAVELLY SILTY CLAY LOAMS

Moccasin gravelly silty clay loams cover a basin east of Benchland on the Benchland Bench. The soils in this basin are charaterized by fine grained silty clay surface mulches, by dark grayish brown granular silty clay humus bearing layers and by calcareous yellowish brown silty clay carbonate zones overlying gravelly silty material at 2 to 3 feet. The basin covers 4.7 square miles of tillable land which is classified as farming land on the land classification map. The land is all under cultivation and the yields of spring wheat on summer fallowed land are about the highest obtained on the Benchland Bench.

MOCCASIN GRAVELLY LOAMS

The Moccasin gravelly loams have dark colored surface mulches and dark to very dark grayish brown, shallow gravelly humus bearing layers and gravelly semi-consolidated carbonate zones grading into rather loose limestone gravel at 2 to 3 feet. The soils on the bench north of Buffalo Creek are very gravelly and stony in the western part and quite shallow and gravelly on the eroded tongues of the bench between the deep coulees in the eastern part. The central part is underlaid locally with a cemented gravel hardpan; fragments and blocks of this hardpan are distributed through the soils of the tract. East of Antelope Creek, the soils on the secondary bench are very gravelly. The tracts below the foothills west of Wolf Creek carry a fair quantity of limestone rock on the surface and a large amount of gravel in the soils.

Topography—Vegetation.—The Moccasin gravelly loams occupy gently sloping gravel-capped benches, dissected occasionally

with deep coulees in the southeastern part of the county. These gravelly loams, classified as farming land on the land classification map cover 49.6 square miles of tillable land. The history of the areas covered with these gravelly loams is similar to that of the Moccasin gravelly sandy loams. The yields of small grains have steadily declined and the more shallow gravelly tracts have been abandoned locally as farm land. The surface acre foot contains a somewhat higher nitrogen content and approximately the same amount of phosphorus as the Moccasin gravelly silt loams. The yield of spring wheat on summer fallowed land averages less than ten bushels per acre on the more eroded tracts and twelve to fifteen bushels per acre on local areas with deeper and less gravelly soils. Western wheat grass and the bunch grasses form the chief cover on the tracts and the forage on 12 acres would carry a steer through an eigth to ten months grazing season.

MOCCASIN GRAVELLY LOAMS—MODIFIED PHASE

The modified phase of the Moccasin gravelly loams in the southern part of the Surprise Creek Bench and on the bench southwest of Spion Kop have shallow fine grained silty mulches on the surface. The humus bearing layer is a friable columnar structured dark grayish brown gravelly loam to silt loam 5 to 7 inches thick underlaid with a heavier textured gravelly subsurface layer. The unconsolidated grayish brown gravelly silty clay carbonate zone lies 8 to 16 inches below the surface and grades into gravelly silty material with depth. The surface soils in the northern and lower part of the Surprise Creek Bench above the breaks of Arrow Creek are fairly deep dark colored silty clays in the western part and shallow silty clays in the eastern part above Surprise Creek. Wind-borne material from the shaly breaks of Arrow Creek modifies the surface soils in the northern part of the bench, and along the western border the soils grade into the Danvers silty clay loam. The surface soils on the wind swept secondary benches west of Surprise Creek Bench are chiefly shallow gravelly loams. The rock and gravel found on the benches consist largely of metamorphic sedimentary and igneous rocks carried out of the Little Belt Mountains.

Topography—Vegetation.—The modified phase of the Moccasin gravelly loams occurs on gravel-capped benches in the north-central and northwestern parts of the county. These gravelly loams classified as farming grazing land on the land classification map, cover 11.7 square miles. Nearly all the tillable land on the benches is under cultivation and is devoted largely to the production of spring and fall wheat. The surface acre foot contains 5000 to 8000 pounds of nitrogen and 2400 to 2700 pounds of phosphorus. The yields of spring wheat on land summer fallowed every second or third year to control weeds are between fifteen

to eighteen bushels per acre. Western wheat grass predominates on the native sod lands and the forage on 12 to 15 acres would carry a steer through a nine months grazing season.

MOCCASIN GRAVELLY LOAMS—DARK PHASE

The surface 3 to 4 inches of the dark phase of the Moccasin gravelly loams is largely a fibrous mat of organic matter, overlying a shallow very dark grayish brown granular silty humus bearing layer. The lower depths consist largely of unconsolidated limestone gravel and rock. These gravelly loams, covering 7.8 square miles and classified as nontillable land on the land classification map, occur on high benches below the foothills in the southeastern part of the county. A large portion of the area was broken out and cropped for a few years, but the yields of small grains were too low and most of the cropped acreage has been abandoned. The tall bunch grasses predominate on the high benches and the forage on 10 to 12 acres of native sod land would carry a steer through the eight months the area is free from snow.

MOCCASIN GRAVELLY LOAMS—SHALLOW PHASE

The shallow phase of the Moccasin loams is characterized by shallow dark colored surface soils and by yellowish brown structureless calcareous silt to silty clay subsoils, overlying gravel and rock at various depths. The silty clay horizon is not uniform and often the gravels rise to the surface as gravel bars.

Topography—Vegetation.—The shallow phase of the Moccasin gravelly loams, classified as farming land on the land classification map, covers 4.2 square miles. The land is all under cultivation and is devoted to the production of spring wheat. The yield of spring wheat on summer fallowed land averages between eight and ten bushels per acre. Western wheat grass is the chief grass cover and the forage on 15 to 20 acres of native grass land would carry a steer through a nine months grazing season.

MOCCASIN STONY LOAMS

The Moccasin stony loams have about the same soil development as the Moccasin gravelly loams. Most of the rock and gravel occurring on the surface and in the soils are well rounded and are less than 6 to 8 inches in diameter. A few boulders occur on the tracts in the vicinity of the foothills.

The soils on the large bench east of McCarthy Creek are quite variable in character. The soils in the northern part of the bench shown as a gravelly phase on the soil map are very gravelly and shallow and in the east central part grade into the shallow phase of the gravelly loams. South of the railway the amount of rock on the surface and in the soil incerases towards the south and

locally overlies red sandstones below the foothills. The deeper and less stony soils are found in the west central part of the bench along McCarthy Creek. Southeast of Dipping Vat Coulee rises a higher bench, which has a fair amount of rock on the surface. The deeper and less stony soils are found on the benches west of McCarthy Creek.

Topography—Vegetation.—The Moccasin stony loams occupy high gravel-capped tablelands with smooth surfaces and gentle slopes in the northwestern part of the county. The drainage courses are deeply intrenched above their entrance into Arrow and Hay creeks. These stony loams, classified as farming land on the land classification map, cover 35.3 square miles of which 3.2 square miles are shown on the soil map as a gravelly phase. The land was brought under cultivation soon after the railway entered the county and has been devoted almost exclusively to the production of spring and fall wheat, grown chiefly on continuously cropped land. The topography of the benches is favorable for the use of large types of farm machinery adapted to stony soils. The amount of nitrogen and phosphorus in the surface acre foot does not differ greatly from that found in the Moccasin gravelly loams. The yields of spring wheat on land occasionally summer fallowed to control weeds is between eight and ten bushels per acre on the more shallow gravelly stony phases, and between fifteen and eighteen on the deeper and less stony phases. Summer fallowing of land does not greatly increase the yields of small grains on these stony soils with open subsoils. Western wheat grass, associated with the bunch grasses on the higher benches, predominates and the forage on 12 to 15 acres of native sod land would support a steer through an eight to nine months grazing season.

MOCCASIN GRAVELLY SANDY LOAMS

The Moccasin gravelly sandy loams have sandy surface mulches and dark grayish brown gravelly fine sandy to sandy humus bearing layers. The carbonate zone below 6 to 9 inches is a yellowish gray semi-consolidated gravelly sand. The lower soil depths consist of yellowish brown gravelly sandy material which is stratified in the northern part of the bench along the Judith River. These gravelly sandy loams become somewhat heavier in a shallow basin or drainage course in the western part of the area.

Topography—Vegetation.—The Moccasin sandy loams occur on a gravel-capped bench south of the Judith River in the southeastern part of the county. These sandy loams, classified as farming land on the land classification map, cover 25.5 square miles of land suitable for farming. The bench was placed under cultivation at the time of the settlement of the benchlands and it has been devoted largely to the production of spring and fall wheat. The yields of fall wheat were fair for some years after the land

was broken out; but after the root fiber was destroyed, soil drifting became increasingly more difficult to control and the yields have steadily declined. The introduction of grass crops and strip farming will assist in keeping these sandy loams in production. The amount of nitrogen and phosphorus in the surface acre foot is somewhat lower than that found in the Moccasin silt loams. The yields of spring wheat on summer fallowed land during the past few years have averaged less than ten bushels per acre. The yields of spring wheat on the slopes of the basin in the western part of the area average between twelve and fifteen bushels per acre. The land, before it was placed under cultivation, had a good grass cover and the forage on 15 acres of native sod land would have carried a steer through a nine months grazing season.

ASHUELOT GRAVELLY SILT LOAMS

The Ashuelot gravelly silt loams differ chiefly from the Moccasin gravelly silt loams in having somewhat darker surface mulches, more granular humus bearing layers, and carbonate zones with firmly cemented gravelly layers several inches thick at 10 to 18 inches. The lower soil depths consist largely of unconsolidated limestone gravel and yellowish brown silty material. The cemented layer on the tract designated as the Ashuelot gravelly silt loams on the soil map is fragmentary and not uniform in the northern part of the tract. In the southern part, the gravelly hardpan is better developed and blocks of this cemented layer occur on the surface and in the soil.

Topography—Vegetation.—The Ashuelot gravelly silt loams, classified as farming land on the land classification map, cover 13.9 square miles on gently sloping benches in the Triangle, east of Antelope Creek. The tract is all under cultivation and is devoted largely to the production of spring wheat. The soils average somewhat higher in nitrogen and have about the same phosphorus content as the Moccasin gravelly silt loams. The yields of spring wheat on summer fallowed land average between fifteen to twenty bushels per acre, but where the land is underlaid with an unbroken uniform cemented layer, the yields are below fifteen bushels per acre. Western wheat grass, giving way to the bunch grasses on the higher part of the tract, is the chief grass cover and the forage on 12 acres would carry a steer through the nine months the bench is open for grazing.

ASHUELOT GRAVELLY LOAMS

The surface soils on the benches in the vicinity of Lehigh are dark grayish brown gravelly sandy loams, and on the benches west of Antelope Creek are very dark grayish brown gravelly silt and silty clay loams. These benches are underlaid at 10 to 15 inches or more with cemented gravelly hardpans.

Topography—Vegetation.—The Ashuelot gravelly loams, classified as farming land on the land classification map, cover 7.2 square miles. The benches were placed under cultivation in 1907 and 1908 and continuously cropped to fall wheat up to 1915 when soil drifting became a factor, resulting in the exposure of the cemented hardpan and the abandonment of a large acreage on the benches. The cropped acreage, confined chiefly to the large bench west of Antelope Creek was approximately fifteen per cent of the area in 1929. The yields of spring wheat on the tracts have steadily declined since 1915. The native sod lands have a good cover of the tall bunch grasses and the forage on 10 acres would carry a steer through an eight months grazing season.

DANVERS SILTY CLAY LOAMS

The surface 2 to 3 inches of the Danvers silty clay loams in the central part of the Arrow Creek Bench is a dark colored, laminated fine grained silty clay mulch. The humus bearing layers, 5 to 7 inches thick, are dark grayish brown, columnar structured silty clay to clay loams, breaking into fine angular fragments. The subsurface layers are compact yellowish brown silty clay loams and clay loams without definite structure. The grayish olive brown heavy carbonate zone streaked and blotched with lime below 6 to 18 inches grades into limestone gravelly silty material, such as found on the Benchland Bench at 2 to 4 feet. Wind-borne, silty clay material from the shaly breaks of Arrow Creek modifies the surface soils over the greater part of the bench. The deeper soils are found in the western part of the bench, where the wind-borne silty clay material rises as low mounds along the western border.

Topography—Vegetation.—The Danvers silty clay loams in Judith Basin County cover 7.8 square miles on the Arrow Creek Bench in the northern part of the county. These heavy loams, classified as farming land on the land classification map, are all under cultivation and devoted largely to the production of fall wheat. The surface acre foot has approximately the same amount of nitrogen and somewhat more phosphorus than the Moccasin gravelly silt loams. The yields of spring wheat on summer fallowed land are between eighteen and twenty-two bushels per acre. Western wheat grass forms the chief cover on these silty clay loams and the forage on 15 acres of native sod land would carry a steer through a nine months grazing season.

LLOYD STONY LOAMS

The Lloyd stony loams in Judith Basin County include an undifferentiated group of dark grayish brown and very dark grayish brown stony gravelly loams found on benches capped with igneous outwash from the Highwood Mountains. The stony

loams on the higher benches below the foothills have dark colored fine sandy surface mulches often containing a fair amount of organic matter. The humus bearing layers are friable granular very dark grayish brown stony loams and stony silt loams 5 to 7 inches thick and underlaid with a compact heavier textured subsurface layer occasionally having a reddish brown color. The grayish brown stony carbonate zone lies 10 to 15 inches below the surface and grades into unconsolidated igneous rock and rock fragments with depth. On the lower benches, the surface soils are dark grayish brown, columnar structured gravelly loams, overlying semi-consolidated gravelly carbonate zones at 8 to 12 inches. The lower soil depths often are loose gravels. Locally, the very gravelly horizon lies several feet below the surface at the head of drainage courses on the benches. The soils are usually very shallow and gravelly about the borders of the benches.

Topography—Vegetation.—The Lloyd stony loams occur on long narrow benches between deep coulees and wide intervening stream courses in the north central part of the county. These stony loams, classified largely as non-tillable grazing land on the land classification map, cover 23.5 square miles. These benches are too stony and gravelly for farming and are utilized chiefly for the grazing of livestock. The cropped acreage amounting to approximately fifteen per cent of the total area was confined largely to the deeper and less gravelly phases on the lower benches. The surface acre foot contains 5000 to 8000 pounds of nitrogen and 3000 to 3500 pounds of phosphorus. The yields of spring wheat on summer fallowed land average between 10 and 15 bushels per acre depending on the depth of soil. The tall bunch grasses predominate on the higher benches and western wheat grass on the lower benches. The forage on 15 to 20 acres would carry a steer through the eight to nine months the area is free from snow.

LOWRY GRAVELLY LOAMS—DARK PHASE

The soils developed over gravelly wash on the slopes of the gravel-capped benches are grouped in the dark phase of the Lowry gravelly loams. The texture and depth of the surface soils do not differ greatly from those found on the benches, but wide variations often occur in the character and cementation of the subsoils on the different tracts. In general, the subsoils on the more gently sloping tracts contain less gravel and are less consolidated than on the benches. However, there are local exceptions; for instance, cemented gravel blocks are found occasionally on the slopes of Coyote Bench. In Judith Basin County, the soils on the slopes of the benches are of considerable depth and only on the steeper and more eroded slopes do sandstones and shales, or residual material derived from these sedimentary rocks outcrop or underlie the wash at comparatively shallow depths. The shallow, gravelly and

occasionally stony soils covering the slopes of coulees and drainage courses are grouped in this phase.

Topography—Vegetation.—The dark phase of the Lowry gravelly loams occurs on the slopes of gravel-capped benches in different parts of the county. The tracts, though often dissected with coulees, are locally seeped and are in need of drainage. These gravelly loams, classified as farm land on the land classification map, cover 48.7 square miles. The tillable land is all under cultivation and devoted chiefly to the production of spring wheat. The poorly drained phases are often valuable wild hay lands. The amount of nitrogen and phosphorus in the surface acre foot is approximately the same as on the benches. These loams, often occupying protected positions, cover some of the more productive farm lands in the county. The grass cover consists chiefly of western wheat grass and the forage on 12 to 15 acres of native grass land would carry a steer through a nine months grazing season.

LOWRY GRAVELLY SILTY CLAY LOAMS—DARK PHASE

Many upland tracts in the county have a shallow covering of gravel on the surface, but where these deposits did not greatly influence the character and productiveness of the soils, they were grouped in the nearest related series. North of Merino, a gravel-capped area lies below the shaly escarpment of Surprise Creek Bench. The surface soils on this tract are dark grayish brown gravelly silty clay loams with carbonate zones below 8 to 10 inches. The lower depths are compact, grayish olive brown silty clay loams overlying residual material derived from dark colored shales at 3 to 10 feet or more. The tract east of Stanford has somewhat lighter textured surface soils underlaid at comparatively shallow depths with shaly sandstone.

Topography—Vegetation.—The dark phase of the Lowry gravelly silty clay loams covers several rolling tracts in the northwestern and central parts of the county. This phase, classified as farming land and non-tillable grazing land on the land classification map, covers 8.7 square miles of tillable land, nearly all of which is under cultivation. The yields of spring wheat on the tract north of Merino average between fifteen and eighteen bushels per acre on summer fallowed land and on the tract east of Stanford, a few bushels lower. Western wheat grass predominates and the forage on 15 acres of native sod land would carry a steer through a nine months grazing season.

LOWRY GRAVELLY CLAY LOAMS—DARK AND DARK SHALLOW PHASES

The dark phase of the Lowry gravelly clay loams does not differ greatly from the Power clay loams. The surface soils con-

taining more or less limestone gravel are somewhat more friable, and the carbonate zone lies a few inches closer to the surface.

In the southeastern part of the county, a small tract is designated on the soil map as a dark shallow phase of these loams. These soils have the profile of the Winifred clay loams, except for the limestone gravel in the surface soils.

Topography-Vegetation.—The dark phase of the Lowry gravelly loams occurs on the rolling tracts, locally in need of drainage, along stream courses in the central part of the county. This phase classified largely as farming land on the land classification map, covers 15.8 square miles of which approximately seventy-five per cent was under cultivation in 1929. The dark shallow phase of these loams, also classified as farming land, covers 3.7 square miles of gently sloping undulating land below a shaly escarpment in the southeastern part of the county. The productiveness of these soils is somewhat higher than for the Power and Winifred clay loams. The tracts are well covered with western wheat grass and the forage on 15 acres would carry a steer through a nine months grazing season.

LOWRY GRAVELLY LOAMS

The Lowry gravelly loams in the basin of Sage Creek in the northeastern part of the county have about the same soil development as the valley phase of the Winifred clay loams. The lower tracts have a shallow covering of wash limestone gravel on the surface, and the higher levels often consist of gravelly ridges and alkali seeped drainage courses below the shaly escarpments of the high benches. The surface soils, ranging in texture from clay loams to gravelly clay loams are underlaid at various depths with residual material derived from shales. The tracts classified as farming land on the land classification map cover 14.7 square miles of which approximately thirty per cent was under cultivation in 1929. The yields of spring wheat average low on the tracts and the livestock carrying capacity is fair.

CHEYENNE GRAVELLY SANDY LOAMS

The Cheyenne gravelly sandy loams have dark colored sandy mulches on the surface. The humus-bearing layers are dark grayish brown columnar structured gravelly sandy loams. The gray, semi-consolidated, carbonate zone below 6 to 10 inches grades into stratified loose sands and gravels at 2 to 3 feet or more. The sandy tract east of Mindon, along Ross Fork Creek does not carry as much gravel in the soils as tracts along the Judith River, and the subsoils are more uniformly gravelly sandy loams.

Topography—Vegetation.—The Cheyenne gravelly sandy loams occupy secondary benches dissected with coulees along the Judith River and Ross Fork Creek. These gravelly loams, classi-

fied largely as farming land on the land classification map, cover 14.9 square miles. The tillable land on these benches was nearly all broken out and placed in crops at the time of settlement of the dry land areas in the county. The soils, although containing a fair amount of nitrogen and phosphorus in the surface acre foot, are rather droughty for dry land farming, and a large cropped acreage has been abandoned in recent years. Soil drifting has removed a large portion of the surface soils on the benches, and it has been one of the chief factors in land abandonment on the tracts. The yields of spring wheat on land summer fallowed occasionally to control weeds have been steadily declining, and only on the deeper and more uniform soils along Ross Fork Creek do the yields run above ten to twelve bushels per acre. These gravelly sandy loams had a fair grass cover before they were placed under cultivation, and 15 to 20 acres would have carried a steer through a nine months grazing season.

CHEYENNE GRAVELLY LOAMS

The Cheyenne gravelly loams in Judith Basin County include an undifferentiated group of dark grayish brown and very dark grayish brown soils occurring on low terraces or benches in the valleys of the larger streams. The large tract in the valley of the Judith River has dark colored gravelly sandy soils grading into loose gravels in the eastern part. The gravelly carbonate zone below 6 to 10 inches grades into stratified gravels and sands at comparatively shallow depths. Gravelly silty clay loams, with compact stratified gravelly silty clay subsoils occur on the low benches along Arrow and Willow Creeks.

Topography—Vegetation.—The Cheyenne gravelly loams, classified as farming land on the land classification map, cover 10.7 square miles in the valleys of the Judith River, Arrow, Willow, and other creeks. The terraces have good surface drainage except for local seeped areas below the higher benches. Fair yields of spring wheat on summer fallowed land are obtained on the low benches along Willow and Arrow Creeks, but in the valley of the Judith River the soils are rather droughty for dry land wheat production and the yields average low. Western wheat grass and grama grass form the chief cover on the native grass lands, and the forage on 12 to 15 acres would carry a steer through a nine months grazing season on the less gravelly and sandy benches.

WADE LOAMS—DARK PHASE

The Wade loams include another group of undifferentiated dark colored soils found in the larger stream valleys below the foothills. The soils on the tract in the valley of Wolf Creek are very dark grayish brown stony loams, effervescing with acid at 8 to 10 inches and underlaid with stony subsoils. Very dark

grayish brown granular silt and silty clay loams, with carbonate zones below 10 inches cover the upper part of the valley of Sage Creek. The subsoils are deep structureless silty clays, grading into gravels in the vicinity of Windham. East of Windham the surface soils are more shallow and the subsoils are more variable in texture. In the upper part of this valley, the wash from the upland areas, capped with the Kootenai sandstones, imparts red colors to the soils. The dark colored soils on the tract north of Buffalo Creek are gravelly silty clay loams, underlaid with lime streaked and blotched gravelly silty clay subsoils. These loams grade locally into the Chouteau loams along the stream courses.

Topography—Vegetation.—The Wade loams cover the upper part of the valleys of Wolf and Sage Creek and a low gently sloping area along Buffalo Creek. A fair acreage along the stream courses is in need of drainage. These loams, classified as farming land on the land classification map cover 23.4 square miles. The stony tracts in the valley of Wolf Creek are under irrigation and are devoted chiefly to the production of forage crops, such as wild and tame hay. Nearly all the tillable land in the upper part of Sage Creek Valley is under cultivation, and some of the highest yields of small grains are obtained on land occasionally summer fallowed to control weeds. The better drained phases along Buffalo Creek are productive soils and are devoted largely to small grains and forage crops. Exceptionally high yields are obtained locally on subirrigated lands along the streams. The tall grasses predominate and the native grass lands have a high livestock carrying capacity.

WADE CLAY LOAMS

The Wade clay loams have dark colored, fine grained silty clay surface mulches, usually with a platy structure in the lower part. The humus-bearing layers are very dark grayish brown granular fine cloddy silty clay and clay loams underlaid with compact, structureless silty clay subsurface layers. The carbonate zone below 9 to 12 inches, and occasionally as deep as 18 inches, is a compact clay loam, streaked and blotched with lime. The lower soil depths are stratified grayish olive brown silty clays and clays, locally underlaid with limestone gravel below 3 to 4 feet. The tracts below the gravel-capped benches have a small amount of limestone gravel distributed through all sections. Above the mouth of Antelope Creek the gravels lie within a few feet of the surface.

Topography—Vegetation.—The Wade clay loams occur on low terraces or benches along Antelope and Ross Fork Creeks and also cover a heavy basin in the northeastern part of the county. These heavy loams, classified as farm lands on the land classification

map, cover 20.1 square miles. The tracts are all under cultivation and are devoted to the production of small grains and forage crops .The amount of nitrogen and phosphorus in the surface acre foot is approximately the same as in the Power clay loams. The yields of spring wheat on summer fallowed land are between eighteen and twenty-two bushels per acre. The native grass lands, have a good cover of the tall grasses and a high livestock carrying capacity.

LAUREL LOAMS

The Laurel loams include a group of undifferentiated gray soils covering the first stream bottoms in the northern and northeastern parts of the county. These soils range in texture from sands and gravels to refractory silty clays and clays without definite horizons. The soils along such creeks as Arrow and Sage often are impregnated with alkali.

Topography—Vegetation.—The Laurel loams in Judith Basin County are classified largely as non-tillable grazing land on the land classification map and cover 41.5 square miles. The stream bottoms are not under cultivation except where the land is subirrigated or lies below an irrigation ditch. In 1929, the cropped acreage was confined largely to the better drained and less alkali phases, such as found in the valley of Sage Creek and its branches, east of Windham, and in the valley of Hay Creek. Southeast of Windham the scabby, alkali slopes above the first bottom were grouped with these loams. The subirrigated and less alkali bottoms have a dense growth of willows and cottonwoods, and on the better drained phases western wheat grass and other grasses are found. Sedges and rushes predominate in the sloughs and greasewood and other shrubs on the more alkali bottoms. The livestock carrying capacity of these loams averages low.

CHOUTEAU LOAMS

The Chouteau loams include a group of undifferentiated dark colored soils covering the stream bottoms in the mountains and foothills and many of the poorly drained basins between the gravel-capped benches. Local seeped areas on the slopes of the gravel-capped benches also are included in these loams. The soils range in texture from loams to silty clay loams in the basins to stony loams in the mountains and foothills. The soils effervescing occasionally with acid are without distinct horizons, except those produced by poor drainage.

Topography—Vegetation.—The Chouteau loams, classified largely as non-tillable grazing land on the land classification map cover 69.5 square miles. The subirrigated and irrigated lands are locally under cultivation and are devoted chiefly to grass crops, such as timothy. The poorly drained and subirrigated lands are among the more valuable hay lands in the mountains and foothills.

The first bottoms of Wolf and Meadow creeks, utilized for hay and pasture lands, are poorly drained and have the character of swamps. A similar tract is found along Ross Fork Creek. These first bottoms are covered with wire grass, sedges, willows and shrubs, and have a high livestock carrying capacity during the times the areas are free from snow.

CHOUTEAU CLAY LOAMS

The Chouteau clay loams, covering 6.4 square miles between Meadow and Wolf Creeks in the northern part of the county, are dark colored structureless cloddy clay loams effervescing weakly with acid at the surface. The lower depths are compact clays showing the influence of poor drainage. A shallow covering of limestone gravel overlies the eastern part of the tract and the surface soils are somewhat more friable.

Topography—Vegetation.—The Chouteau clay loams are utilized chiefly for pasture and for wild hay because of the poor drainage. The area having a shallow covering of limestone gravel on the surface lies at a slightly higher level, and locally it has been placed under cultivation. The vegetation consists largely of the grasses and sedges adapted to poorly drained conditions and the land has a good livestock carrying capacity during the time the area is open for grazing.

BADLANDS

Barren gullied clay hills and ridges and shaly escarpments occur along Arrow Creek and its branches in the northern part of the county. These badland tracts, classified as non-tillable grazing land on the land classification map, cover 32.8 square miles. The vegetation found on the tracts consists chiefly of isolated plants of western wheat grass, wheat bunch grass and annual weeds. Greasewood and salt grass occur on the poorly drained slopes and bottoms impregnated with alkali, and creeping juniper and scrub pine are occasionally found on the higher ridges. The livestock carrying capacity of badland shaly areas is very low.

ROCK OUTCROPS AND OUTWASH GRAVELS

Rock outcrops, consisting chiefly of limestone in the foothills and on the slopes of the Little Belt Mountains and shales below the Highwood Mountains, cover 6.5 square miles in the western part of the county. Gravelly outwash covering 1.2 square miles occurs along some of the mountain streams, emerging from the Little Belt Mountains through limestone canyons. These tracts of rock outcrops and outwash gravels are lightly covered with vegetation and have a low livestock carrying capacity.

MOUNTAINS

The Little Belt and Highwood Mountains cover approximately

523.2 square miles in Judith Basin County. The higher parts of the mountains consist largely of bald peaks, serrated ridges and talus covered slopes. Lodge pole pine is the chief timber cover on the northern slopes and in the higher parts of the mountains. Quaking aspen and willows occur on the poorly drained slopes and in the gulches. Sedges predominate over the grasses in the open parks and shrubs make up most of the underbrush. The Little Belt Mountains are characterized by numerous tracts of open grass lands or parks on their southern slopes. The type of vegetation found in the mountains is somewhat better forage for sheep and goats than cattle.

AGRICULTURE

The development of agriculture in the Judith Basin dates from the early eighties when many prospectors turned their attention to stock raising as a more dependable and less strenuous means of gaining a livelihood than mining. The industry thrived and was consolidated into large organizations which acquired title to much of the better grazing lands in the area. During the so-called "dry land movement" many of the organizations were dissolved and their holdings divided into farming units of 160 to 320 acres or more. In most cases, the purchasers had sufficient capital to develop these farming units. Crop yields were high and farm prices were good for a number of years after the land was placed under cultivation. These yields and prices were reflected in the rapid rise in value of farm lands and in the development of urban centers. Since 1929, the yields and prices have averaged much lower and farm lands have depreciated greatly in value.

The general trend of agriculture in Judith Basin County is shown by the U. S. Census reports for 1925, 1930 and 1935. In 1925, 72.0 per cent of all farms in the county had a mortgage indebtedness of $12.50 on land valued at $24.07 per acre, and in 1930, 69.5 per cent had a mortgage indebtedness of $10.69 on land valued at $25.09 per acre. The liquidation of farm mortgages during the five year period has not been as great in Judith Basin County as in other counties in Central Montana. The farm tenacy during the ten year period from 1925 to 1935 has increased from 35.0 to 46.0 per cent. The percentage of the total area of the county in farms during the ten year period increased from 55.2 to 64.7 per cent. The number of farms for the same period decreased from 783 to 742, while the acreage per farm increased from 838.9 to 1058.5 acres. Land values have declined greatly during the past few years, but in the better farming sections the non-irrigated land is usually held at $15.00 to $30.00 per acre and the irrigated lands at over $50.00 per acre. Non-tillable grazing land ranges in price from less than $2.00 per acre in the breaks of Arrow Creek to over $10.00 per acre in the foothills, depending

upon the presence of perennial streams and the livestock carrying capacity of the land. The gross agricultural income of the county is derived largely from livestock and from farm products grown on the dry and irrigated farms.

Stock Raising.—The foothills of the Little Belt and Highwood Mountains and the breaks of Arrow Creek are primarily grazing areas. The foothills are under fence and are largely under controlled grazing. The larger operators usually run their stock in the mountains or on leased and privately owned lands in the foothills during the grazing season and winter the herds on home ranches located in the larger stream valleys. The smaller stockmen and farmers, also leasing tracts in the foothills and making use of the National Forests through permit during the grazing season, usually supplement their winter grazing lands with straw and small grain hays grown on the dryland farms. The county is well watered, but on many of the gravel-capped benches stock water is short unless the wells are drilled to considerable depth.

Cattle.—Grade Shorthorns and Herefords are the most important beef breeds found on the farms and ranches. The total number of cattle in the county in 1925 was 29,161; in 1930, 26,609; and the figure for 1935 which does not include calves under three months of age was 29,294. The number of cows used for milking purposes increased during the period 1925 to 1930 from 1,122 to 2,297. Most of the cows used for milking purposes are crosses of the beef and dairy breeds.

Sheep.—The range conditions in Judith Basin County are somewhat more favorable for running cattle than sheep. Sheep were brought into the county at a fairly early date, but they have not competed with cattle until recent years. The number of sheep on the farms and ranches for the three census years is as follows: 1925, 49,068; 1930, 64,948; and 1935, 45,327. Rambouillet is the more important breed on the range.

Horses.—The number of horses on the farms has declined steadily with the increasing use of small tractors as in other counties in the state. The number of horses has decreased from 8,827 in 1925 to 4,665 head in 1933.

Swine.—The swine industry is unimportant as only 1,667 head were found on the ranches in 1935. The Duroc Jersey is the most popular breed.

Dry Land Farming.—The assessed non-irrigated tillable land in Judith Basin County in 1934 was 392,121 acres. The 1935 census reports a total of 261,131 acres of non-irrigated and irrigated crop lands, of which 136,057 acres produced harvested crops; 85,156 acres were idle or fallow land; and 39,918 acres are listed as crop failures. During the past ten years the average acreage of farm land has been 277,582. acres.

An extensive type of grain farming is practiced on the benches

and plateaus in Judith Basin County. The large grain farms often have an annual cropped acreage of 200 to 400 acres or more, which is largely devoted to the production of spring and fall wheat. Tractor operated types of farm machinery are employed on the large grain farms. In the vicinity of the foothills and about the borders of the benches, stock raising often is combined with grain growing and the acreage devoted to forage crops is fair. Exclusive stock raising is carried on largely in the more broken sections, such as in the foothills.

The crops grown in the Judith Basin are chiefly the early and medium early maturing varieties of small grains and forage crops. The more important small grains are wheat, oats, barley, rye and flax. Approximately 70 per cent or 118,319 acres of the total harvested area in the county during the past ten years has been devoted to the production of wheat, of which about one-third was winter wheat and the other two-thirds spring wheat. Fall wheat was grown almost exclusively in the Judith Basin for a number of years after the benchlands were brought under cultivation. Since 1915, fall wheat has winter killed too frequently to be depended upon and spring wheat is more generally grown. The climatic conditions in the Basin are somewhat more favorable for the growing of winter wheat than of spring wheat as fall wheat is usually well along to maturity before the dry weather sets in during the last of July. The yields of spring wheat and other spring seeded small grains often are reduced greatly by drought late in July and early in August. The minor crops, such as oats, barley, rye and flax are grown on a limited acreage. The climate is too cool to mature the semi-dent varieties of corn—hence only a small acreage is grown.

The average acreage devoted to wild and tame hay during the past ten years is 42,881 acres of which approximately 25 per cent was wild hay. Alfalfa is grown on about 16,000 acres, timothy and other tame grasses on 9,000 acres, and small grains, such as oats and other miscellaneous forage crops, on the remaining acreage. Sweet clover is grown occasionally for pasture and hay in short rotations on the dry land farms located on the benchlands. The yields of alfalfa on the benchlands are comparatively low, ranging between three-fourths to one and one-quarter tons per acre. The yields of root crops such as potatoes also average low. The quantity of potatoes produced is not sufficient for home consumption.

Irrigation Farming.—The acreage of irrigated land assessed in Judith Basin County in 1934 was 6,722 acres. The small grains grown under irrigation are chiefly the medium early maturing varieties. Most of the better drained land is devoted to alfalfa at the lower elevations and to tame grasses at the higher. The more poorly drained irrigated tracts are largely used for pasture

TABLE NO. 4.—ACREAGE AND YIELDS OF THE MORE IMPORTANT CROPS GROWN IN JUDITH BASIN COUNTY

	1925*		1930*		1935*		Average	
	Acreage	Acre Yields	Acreage	Acre Yields	Acreage	Acre Yields	Acreage	Acre Yields
Crop Land Harvested	179,338		194,061		156,057		169,819	
Crop Land—Failure	6,854		21,187		175,975		22,653	
Crop Land—Idle or Fallow	72,587		97,589		85,156		85,110	
Crop Land—Total	258,779		312,837		417,188		277,582	
Barley	3,286	14.6 B.u	5,031	9.1 Bu.	1,454	9.2 Bu.	3,256	10.8 Bu.
Corn—Total	429	16.6 Bu.	130	———	378	1.0 Bu.	315	7.8 Bu.
Flax	34	1.5 Bu.	329	1.8 Bu.	52	4.1 Bu.	138	2.5 Bu.
Hay—Wild and Tame	42,225	0.9 Ton	47,087	0.8 Ton	39,331	0.4 Ton	42,881	0.7 Ton
Oats	7,044	19.2 Bu.	2,065	11.4 Bu.	3,440	11.9 Bu.	4,183	14.5 Bu.
Potatoes	181	66.4 Bu.	205	51.4 Bu.	232	48.7 Bu.	206	55.5 Bu.
Rye	———	———	122	11.0 Bu.	552	6.1 Bu.	225	5.7 Bu.
Wheat—Fall and Spring	125,558	14.1 Bu.	135,929	7.1 Bu.	125,558	14.2 Bu.	118,319	9.7 Bu.

*U. S. Census Reports.

and wild hay lands. The production of winter feed is important in Judith Basin County and most of the irrigated lands should be devoted to the production of hay.

Table 4 gives the acreage and yields of the more important crops grown in Judith Basin County since 1925. These data represent the entire county, no distinction being possible between crops grown under irrigation and those grown on the non-irrigated lands.

SOIL PROBLEMS

One of the more important problems in the Judith Basin County is the consolidation of farms of 160 acres or less on the benchlands into larger and more economical farm units. The setups on some of the large stock ranches are good; but in many cases greater utilization could be made of the irrigated and other agricultural lands in connection with the stock ranches. The grazing lands can support more stock during the grazing season than can be wintered in the area on the feed produced on the dry land and irrigated farms.

Dry Land Problems.—Continuous cropping to spring and fall wheat with an occasional summer fallow to control weeds has resulted in a severe soil drifting on the benchlands after the root fiber has been destroyed. Cultural methods, such as ridging the land and leaving the stubble on the surface have been ineffective in controlling soil drifting. Strip farming and seeding a greater acreage to grass and legumes, thereby restoring the root fiber, are probably the most practical means of holding the soil in place.

The yields of small grains often vary greatly in different localities under the same cultural method. These variations in yields are attributed usually to poor farming and to low rainfall. Soil drifting, reducing the water holding capacity of the surface soils and influencing the effectiveness of the seasonal rainfall, is probably an important factor in the variations of crop yields on the older cropped lands. Analyses of the potential productivity of the lands in the county indicate variability in the original fertility of the soil which may also be a factor.

Irrigated Lands.—The stony gravelly bottoms of many of the irrigated stream valleys often are in need of drainage, but the cost of reclamation in many cases exceeds the value of the land after drainage. These poorly drained bottoms will continue to be used for wild hay and pasture lands until the land in the area has a much greater value than at the present time.

IRRIGATION

The irrigated lands located chiefly in the larger stream valleys are largely private enterprises used in connection with the stock ranches. Several irrigated districts have been proposed in

the county, but the more feasible one is the irrigation of several thousand acres on the bench south of the Judith River. Water for the project would be diverted from the Judith River and conveyed to the project by gravity. The gravelly sandy loams on the proposed project are suitable for irrigation.

FUEL AND WATER RESOURCES

The agricultural development of some sections of Montana is influenced by the water and fuel resources. Judith Basin County is supplied with an excellent quality of water for domestic use. Water is often difficult to obtain in large quantities on the gravel-capped benches in the central part of the county. The benches south of the Judith River, such as the Triangle, are well supplied with water at comparatively shallow depths. The water obtained from the Colorado shales in the northern part of the county is usually brackish and unfit for domestic use. The Kootenai formation carries several veins of coal of good quality and together with wood obtained in the mountains is the chief fuel supply.

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