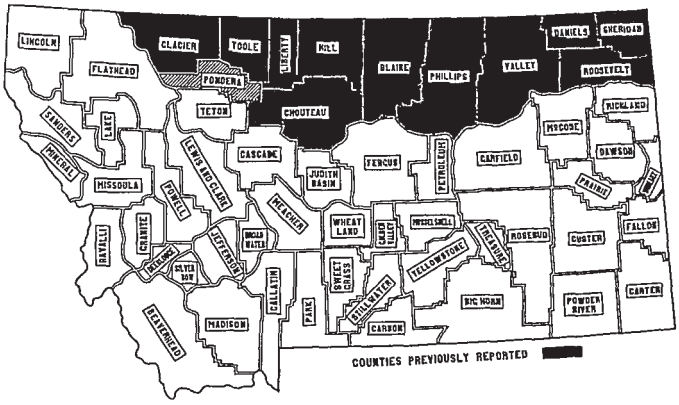
BULLETIN NO. 291 JUNE, 1934

SOILS OF PONDERA COUNTY



SOIL RECONNOISSANCE OF MONTANA

PRELIMINARY REPORT

BY

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IN CHARGE OF SOIL SURVEY

COOPERATING WITH BUREAU OF SOILS AND CHEMISTRY
UNITED STATES DEPARTMENT OF AGRICULTURE

MONTANA STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
BOZEMAN, MONTANA

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The primary purpose of this soil reconnoissance of Montana is to obtain general information in regard to (1) the soil resources of the state, (2) the adaptability of the topography to agriculture, and (3) the carrying capacity of the different soil areas for livestock. Such a survey is of a general nature and the areas shown on the soil and topographical maps simply represent the prevailing character of the soil and topography.

The Pondera County report is the eleventh to be issued. Reports on Sheridan, Daniels, Roosevelt, Valley, Phillips, Blaine, Hill, Chouteau, Liberty and Toole, and Glacier counties are also available and may be obtained from the Montana Experiment Station, Bozeman.

SOILS OF PONDERA COUNTY

LOCATION

Pondera County is located in the north-central part of Montana, near Glacier National Park. The continental divide forms its western, and Marias River a part of its northern, boundary. The county covers a total area of 1,634 square miles, lying between Townships 25 and 32 North of Base Line Montana and Ranges 3 East and 14 West of Principal Meridian Montana. Its boundaries enclose a long, irregular area extending east from the continental divide for 80 to 90 miles, and ranging from 12 to 30 miles wide. Pondera County was organized from the central part of Teton County in 1919, and within its borders are located some of the more important dry and irrigated districts in the state.

PHYSIOGRAPHIC FEATURES

Pondera County occupies a transitional area between the Great Plains to the east and the mountains to the west. In this part of the state the mountains rise abruptly without distinct foothills. Gravel-capped plateaus, eroded into narrow ridges, extend east from the mountains for 30 miles and form the higher divides between the streams in the southeastern part of the county. The north-central part is an undulating glacial lake basin, while the eastern part is a rolling, drift-covered plain. The larger streams traversing the county are deeply intrenched and flow through narrow valleys.

GLACIATION.—During the late Wisconsin Glaciation, the main divide of the Rocky Mountains was a collecting ground for glaciers. In Pondera County there is evidence that the glaciers in the canyons of Sheep, Birch, Blacktail, Badger, and other streams united below the mountains and formed a continuous ice sheet stretching north along the base of the mountains as far as Cut Bank Creek in Glacier County. In the western part of Pondera County the terminal moraine of this ice sheet lies within 12 to 15 miles of the mountains. The Keewatin or continental ice sheet covered the eastern half of the county. It extended well up the valleys of Dry Fork of Marias River and Pondera Coulee, but did not cover the gravel-capped benches and buttes south of Valier and the sandstone-capped benches west of Conrad.

The eastern limits of the mountain glaciers are defined by high stony morainic ridges, back of which lie recessional ridges separated

by gravelly lake basins. The mountain drift is very stony and hummocky and near the mountains fresh-water lakes are quite numerous. The rock carried out of the mountains consists largely of limestone and various colored argillites and quartzites. The drift of the mountain glaciers is of variable depth, and covers an area more than 4,400 feet in elevation east of the mountains. The western limits of the continental ice sheet are not so well defined since locally the drift is covered with glacial lake silts and clays and in the rolling uplands it is often very shallow. In the eastern part of the county the drift has a billowy relief characterized by low mounds, ridges, and potholes; but to the west and above the glacial lake basin, it has more of a so-called "swell and saucer" type of topography. The more stony, hummocky sections are found (1) in the northwestern part of the county, (2) south of Marias River, and (3) in the southeastern part on the Pondera-Teton divide. The drift is also very stony and quite hummocky on the eastern slope of Trunk Butte and locally on the divide between Pondera Coulee and Dry Fork of Marias River. Granitic rock composes many of the boulders, while fragments of sedimentary rock, such as the Colorado shales, are quite numerous in the drift and glacial lake deposits. Over the eastern part of the county the drift is 20 to 30 feet deep and covers an area having an elevation of 3,300 to 4,000 feet.

Glacial Lake Basins.—Large glacial lakes were formed in this part of the state by the damming of the mountain streams by the continental ice sheet. Lake deposits locally modified by drift cover the north-central part of the county. These deposits, consisting chiefly of glacial silts and silty clays, have a maximum thickness of 80 to 100 feet and lie at elevations between 3,750 and 3,950 feet. Glacial lake and stream deposits also modify the character of the drift in the Pondera basin. Gravelly outwash from the mountain glaciers covers the valleys of many of the larger streams, such as Birch and Dupuyer, and also has been found locally underlying the glacial lake deposits.

Francis Heights, Dupuyer, and Other Benches.—In the south-central part of Pondera County are buttes, ridges, and benches capped chiefly with quartzite gravel. Francis Heights is a gravel-capped bench 6 miles long and 1 to 2 miles wide, lying south of Lake Francis and rising more than 100 feet above the lake. This bench, eroded into gravelly ridges between deep coulees in the eastern part, has an elevation of 3,900 to 4,100 feet, with a gentle slope to the south and

east. Along Dupuyer Creek are several benches occupying lower erosional levels, which are somewhat more stony and gravelly than Francis Heights. These benches are between 3,900 and 4,400 feet in elevation and slope gently towards the creek. Dupuyer Bench, north of Dupuyer Creek, is 15 miles long by 1 to 3 miles wide, and lies 10 to 50 feet above the gravelly terraces along the stream. A similar bench 6 miles long and from ½ to 1 mile wide is also found between Dupuyer and Sheep creeks. South of Dupuyer Creek is a high, flat-topped, gravelly ridge, which is eroded into buttes south of the town of Dupuyer. Along Dry Fork of Marias River are also isolated gravel-capped buttes and ridges rising several hundred feet above the valleys of this stream. The gravels found on all the benches and ridges are semiconsolidated and on some of the lower benches are quite firmly cemented. Wash gravel from the eroded benches and ridges influences the texture of the soils over a large area in the south-central part of the county.

Glacial Outwashes.—An outwash gravel flat, rising 40 feet or more above the stream, borders Birch Creek on the south in Range 7 West. It covers an area of 7 to 8 square miles, and to the east grades into a swampy tract covering more than 3 square miles. The gravelly flat has an elevation of 3,800 to 3,900 feet and slopes gently to the east. Other gravelly tracts occur as terraces along the stream to the west. Gravelly terraces varying from ¼ to 1½ miles wide and having elevations of from 3,800 to 3,900 feet also border Dupuyer Creek between Dupuyer and Lake Francis. The gravels on these terraces are semicemented and underlie the glacial lake silts and clays west of Lake Francis.

Escarpments.—The sandstone-capped benches west of Conrad overlie bold sandstone escarpments which often rise 75 feet above the drift-covered uplands. Sandstones also are exposed on the steeper slopes of the gravel-capped buttes along such streams as Marias River, Dry Fork of Marias River, and Birch Creek in the northern and south-central parts of the county.

Bad Lands and Bad-Land Basins.—Exposures of soft shales, such as the Claggett, are eroded into barren, gullied clay hills and ridges along Dry Fork of Marias River and below the gravel-capped bench in Range 6 West. The larger tracts are shown as bad lands on the soil and topography maps. The exposures of the Virgelle sandstones are locally eroded into mushroom rocks and pinnacles southeast of Francis Heights and above the mouth of Birch Creek.

There is a poorly drained basin in the northwestern part of the county, south of Two Medicine Creek, which approaches the character of a bad-land basin. In the lower part of this basin the soil has drifted around greasewood and other shrubs adapted to alkaline conditions, and the surface of this land is characterized by low hummocks. The soils of the greasewood section of the basin are shown on the soil map as an alkaline phase of the Laurel clay loams.

PREGLACIAL VALLEYS AND GAPS.—The preglacial courses of many of the larger streams, which would have a bearing on the drainage of the irrigated lands and also on artesian water, are not well defined in Pondera County. Gaps and basins occur locally, but the configuration of the glacial deposits does not indicate the location of many of the preglacial valleys. Dupuyer Creek probably entered Lake Francis basin and flowed southeast, uniting with Dry Fork of Marias River. Schultz Coulee heads in an ancient stream valley or gap which connects Dry Fork of Marias River and Marias River. In the northeastern part of the county are several large basins which are now drained by deep coulees entering Marias River.

DRAINAGE

Pondera County lies in the drainage basin of Marias River, except for a small area in the southeastern corner which is a part of the Teton River drainage. Marias River, forming a natural boundary for part of the distance between Toole and Pondera counties, flows to the southeast and empties into Missouri River in Chouteau County. The larger streams traversing the county from the southwest and uniting with Marias River and its forks are Birch Creek, Dry Fork of Marias River, and Pondera Coulee.

MARIAS RIVER.—Marias River is formed by the union of Two Medicine and Cut Bank creeks in Range 5 West. These streams head on the continental divide in Glacier County and flow east to form one of the larger streams in north-central Montana. Marias River carries a large volume of water during the spring run-off and again in May and June when it is swollen by the seasonal rains and melting snows on the higher divides and in the mountains. The valley of the stream along the county line is ½ mile wide and is bordered by sandstone and shaly breaks. During the low water the stream is 50 to 60 feet wide, and 1 to 2 feet deep. It flows on a stony gravelly bottom.

TWO MEDICINE CREEK.—Two Medicine Creek enters Pondera County in the northwestern part and flows east as far as the mouth

of Birch Creek where it turns to the north. The valley of this stream in Range 7 West is ¾ mile wide, but to the east it becomes more enclosed, and above the mouth of Birch Creek it is a sandstone canyon less than ¼ mile wide. A few gravelly terraces occur along the stream below the sandstone breaks bordering the valley.

BADGER AND WHITETAIL CREEKS.—Badger Creek heads on the continental divide and drains several mountainous townships in the western part of the county. It flows northeast and enters Two Medicine Creek in Glacier County. South Fork of Two Medicine Creek rises on the divide west of Badger Creek and also drains a small mountainous area in the northwest corner. Whitetail Creek, a small perennial stream, heads on the eastern slopes of Feather Woman Mountain and flows northeast, draining a gravelly basin northeast of Heart Butte and a rolling hummocky drift-covered section south of the county line. The stream is enclosed in a narrow valley above its entrance into Badger Creek in Glacier County.

BIRCH CREEK.—The forks of Birch Creek head on the continental divide in the southwestern part of the county and in the northwestern part of Teton County. The forks unite in the mountains to form Birch Creek which flows northeast through a deep canyon between Major Steele's Backbone and Walling Reef. Birch Creek, one of the larger streams in the county, takes a northeasterly course east of the mountains and empties into Two Medicine Creek in Range 5 West. Below the mouth of the canyon the stream flows through an outwash stony flat before entering an enclosed valley, bordered by sandstone breaks and stony morainic ridges. East of the moraines the valley becomes more open and is bordered by a rolling residual area on which sandstones outcrop. In Range 7 West the stream again enters an enclosed valley and north of the mouth of Dupuyer Creek its course is through a sandstone canyon. The valley of Birch Creek averages ¼ mile wide through the county and is largely covered with river wash. A few low gravelly sandy terraces occur along the stream below the terraced glacial lake and stream deposits. Birch Creek is dammed at the mouth of the canyon to form Swift Reservoir, which supplies water for the Valier irrigation project.

DUPUYER CREEK.—Dupuyer Creek is formed by several small streams rising on the continental divide in the northwestern part of Teton County and uniting below high stony benches on the eastern slopes of the mountains. The stream carries a fair volume of water

and enters Birch Creek west of Valier. Below the mountains the valley of Dupuyer Creek is narrow and bordered by high gravel-capped ridges and sandstone buttes, but in Range 8 West, below the gravel-capped benches, it is ¼ to ½ mile wide. The valley is swampy and very stony west of Dupuyer.

Sheep Creek, emptying into Dupuyer Creek north of Dupuyer, is a small perennial stream rising on the eastern slopes of Walling Reef. East of the mountains its swampy valley is ¼ mile wide, but above its entrance into Dupuyer Creek it is ½ mile wide. Dry Fork of Sheep Creek, flowing through a poorly drained bottom, is an intermittent stream draining a morainic section south of Birch Creek and entering Sheep Creek from the west. Scoffins Creek, another small perennial stream flowing through a narrow seeped valley below high ridges and buttes, enters Dupuyer Creek from the west, north of the county line.

Dry Fork of Marias River.—Dry Fork of Marias River and its upper branches head on dissected plateaus east of the mountains in the northwestern part of Teton County. It is a fair-sized perennial stream draining a rolling area, characterized by gravel-capped ridges and sandstone buttes, in the south-central part of the county. In the central part it drains a glacial lake basin and in the northeastern part a rolling drift covered area. The valley of this stream, averaging ¼ mile wide, is open in the south-central part and also in the central part southeast of Williams, but south of Francis Heights and north of Conrad it is enclosed in sandstone breaks. Below the gravel-capped benches and buttes in the south-central part its valley is poorly drained and alkaline.

The streams entering Dry Fork of Marias River from the south head on high plateaus in the northern part of Teton County. These streams flow through narrow valleys which often are seeped and swampy. Most of the streams have an intermittent flow, but many of them have perennial springs along their courses. Spring Creek, the largest stream entering Dry Fork from the south in Pondera County, heads on Porter's Bench in Teton County and empties into the river northwest of Conrad. It is a small perennial creek draining a rolling basin between high gravel-capped and sandstone-capped ridges to the west and a gently sloping section north of the sandstone-capped benches west of Conrad. The streams entering Dry Fork from the north are all small and intermittent. A poorly drained depression lying below a gravelly ridge extends east from Dupuyer and joins the

valley of this stream. The outlet of Lake Francis is through a deep sandstone gorge east of Francis Heights.

PONDERA COULEE.—Pondera Coulee, heading on the eastern slopes of Porter's Bench in Teton County and flowing in an easterly direction through the east-central part of the county, is a small perennial stream. Below the bench the stream passes through a morainic section for a few miles before entering a wide basin which is terraced locally along the stream south and east of Conrad. The rolling land around the basin is covered with drift. About 10 miles east of Conrad the basin gives way to a narrow open valley below the billowy drift-covered uplands. In the eastern part of the county the valley of the stream is less than ¼ mile wide.

South Fork of Pondera Coulee rises in a morainic section west of Brady and flows northeast, emptying into Pondera Coulee in Range 1 East. It is an intermittent stream with a few water-holes along its course. The area drained by the stream is an undulating, poorly drained basin, lying between low drift-covered divides. East of Brady is another branch of Pondera Coulee flowing northeast and joining the creek about 5 miles east of Dry Fork of this stream. It is an intermittent stream, draining a basin below the undulating drift-covered uplands. Above its entrance into Pondera Coulee its poorly drained valley is ¼ mile wide.

SCHULTZ COULEE.—Schultz Coulee is an intermittent stream rising on the southern slopes of Trunk Butte and flowing north through a gap into Marias River. North of Trunk Butte, Bullhead Creek enters the coulee from the west. The land along the stream below the rolling to broken uplands is poorly drained.

SETTLEMENT

The present boundary of the Blackfeet Indian Reservation in north-central Montana was not established until about 1885 and the unreserved public lands were not thrown open for settlement until 1887. Stock raising was taken up soon after the Indians were confined to the reservations and the land opened for settlement. Most of Pondera County was sectionized during the nineties.

HISTORY.—The Blackfeet Indians, consisting of the Piegan and Blood tribes, were in possession of the area east of the mountains in north-central Montana at the time of the Lewis and Clark Expedition to the Northwest in 1806. The Blackfeet nation was hostile to Amer-

ican trappers and Indian traders until about 1842, when the American Fur Trading Company established a permanent post at Fort Benton in the Blackfeet territory. During the sixties and seventies these Indians made frequent attacks on stages moving in and out of Fort Benton to the gold fields of western Montana.

Trapping and trading with the Indians were the chief industries in this part of the state for many years after the Lewis and Clark Expedition. Temporary trading posts around which some of the local towns have sprung up were established at such points at Dupuyer, Choteau, Robare on Birch Creek, and Conrad, then located on Marias River. The early freight trails from Fort Shaw north through Choteau to Blackfoot in Glacier County may still be located by deep wagon ruts in the unbroken prairies of Pondera County.

The Pondera oil field, discovered in 1927, has developed into one of the more important oil-producting sections of Montana. The wells are comparatively shallow, ranging from 1,500 to 1,800 feet deep. Natural gas is also found in commercial quantities in the area.

Time of Settlement.—The first permanent settlements in the area were made by squatters around military forts and trading posts and by stockmen, who generally located on the larger streams and in the foothills of the mountains. Irrigation was developed by the early stockmen during the late eighties and nineties. Before 1910 most of the land above the ditch was used for stock ranges, although locally a small acreage was dry-farmed. In 1909 the tillable public range land was homesteaded and broken out by the so-called "dry-land" farmer. The land was settled in tracts of 160 and 320 acres largely between 1909 and 1915.

Settlers.—The managers of many of the early stock companies were of English and Scotch descent. The people attracted to this part of the state during the "dry-land movement" were largely native Americans, who migrated from the industrial centers and agricultural districts of the north-central states. The more recent influx into the Pondera oil field has been from such states as Wyoming and Oklahoma, and settlers on the irrigated projects have come from Idaho and Utah. A few Japanese, Chinese, and Negroes are found in the larger towns.

Population.—The area was sparsely settled during the time that stock raising was the chief industry, but with the settlement of the dry and irrigated districts between 1909 and 1917 the farm and urban

population grew rapidly. The census report for 1930 gave Pondera County a total population of 6,378, of which approximately 300 were Indians. The farm population in 1925 was given as 3,615, of which 35 were Indians on the Blackfeet Indian Reservation.

TOWNS.—Conrad, the county seat, is located in the east-central part of the county on the Great Falls-Shelby connection of the Great Northern Railway. The town has grown rapidly since the development of the Pondera oil field. Brady, south of Conrad, is located in a large spring wheat producing section, and Fowler to the north is a local trading center. Valier, serving the western part of the Valier irrigation project and a large stock-raising section to the west, is a terminus of the branch railway line from Conrad. It has a population of approximately 575. Williams and Manson are small distributing centers between Valier and Conrad. Dupuyer is an inland town serving a stock-raising section southwest of Valier. Heart Butte is a subagency on the Blackfeet Indian Reservation.

The larger towns, like Conrad and Valier, have many of the modern municipal improvements, such as electric lights, water and sewerage systems. The educational facilities in the larger towns are good, but in the more distant dry-land districts they are often below state standards. All the towns located on the railways are served by power and telephone companies.

TRANSPORTATION AND MARKETS.—The Great Falls-Shelby connection of the Great Northern Railway, constructed as a narrow-gauge road during the early nineties, runs through the eastern part of the county. The Conrad-Valier branch of this railway was built in 1910. These railways provide facilities for the shipment of freight to eastern and western markets such as Chicago, St. Paul, and Portland and Spokane. Most of the exports consist of grain, livestock and livestock products, and, since the development of the oil field, also crude oil. Local markets for farm products are limited, as Great Falls, Helena, and Butte are the largest industrial centers within shipping distance.

The Yellowstone-Glacier Park Trail, a graveled highway, runs northwest through Dupuyer, and the Great Falls-Shelby highway, an improved dirt road, parallels the railway in the eastern part of the county. The larger towns are connected by graded roads, some of which have graveled surfaces. Many of the roads in the rural districts are improved but during the late summer and fall become very

rutty and dusty. Other upland roads are passable the greater part of the year.

BLACKFEET INDIAN RESERVATION

The Blackfeet Indian Reservation covers a large area lying between the Canadian line and Birch Creek and extending east from the mountains for 50 to 60 miles. In Pondera County the reservation covers the area north and west of Birch Creek, east of the mountains. The land on the reservation has been allotted to the Indians, except the tribal timbered lands. Title to land on the reservation may be obtained by purchase from Indians declared competent and from the sale of allotments of deceased Indians. A large acreage on the reservation is under lease by several large stock companies. The Indians, numbering approximmately 2,000, belong largely to the Piegan tribe. The Indian Agency is located at Browning.

LEWIS AND CLARK NATIONAL FOREST

The mountainous portion of Pondera County is included in the Lewis and Clark National Forest. The area has a fair stand of timber and is open for grazing between June and October. Grazing permits may be obtained from the forest supervisor located in Helena.

STATE LANDS

There were approximately 43,000 acres of state land in Pondera County at the time of the survey. The sale or lease of these lands is in charge of the Registrar of State Lands, Capitol Building, Helena. A minimum sale price of $10 per acre has been placed upon these lands by legislative enactment.

CLIMATE

The climate of this part of the state is semi-arid. It is influenced by the elevation and by the mountains. The lower plains of the county have a comparativvely low rainfall, great temperature extremes, large numbers of sunshiny days, and a low relative humidity. The midsummmer temperatures are not oppressive because of the low humidity, and the winter extremes are not especially severe as the cold waves are not often accompanied by strong winds.

Tables 1 and 2 give the normal, monthly, seasonal, and annual temperature and precipitation at Blackleaf and Choteau in Teton County, Cut Bank in Glacier County, and Lytle and Valier in Pondera County. The stations range in elevation from 3,435 feet in the lower

TABLE 1.—TEMPERATURE

	Mean					Absolute maximum					Absolute minimum				
	Black-leaf 1905-1920	Choteau 1890-1929	Cut Bank 1903-1931	Lytle 1912-1931	Valier 1911-1931	Black-leaf	Choteau	Cut Bank	Lytle	Valier	Black-leaf	Cho-teau	Cut Bank	Lytle	Valier
December	20.8	24.5	21.2	23.1	21.4	60	78	60	57	62.0	-43	-28	-29	-29	-34
January	16.2	20.6	17.0	17.1	18.0	62	79	57	69	61.0	-46	-42	-46	-39	-39
February	17.6	22.6	20.0	18.9	20.8	65	64	62	54	63.0	-39	-40	-45	-29	-30
Winter	**18.3**	**22.5**	**19.4**	**19.7**	**20.1**	**65**	**79**	**62**	**69**	**63.0**	**-46**	**-42**	**-46**	**-39**	**-39**
March	25.8	31.9	28.0	30.0	29.1	75	82	72	71	69.0	-32	-28	-30	-32	-32
April	38.1	42.4	40.5	43.0	41.0	84	85	87	82	78.0	- 5	- 9	- 1	- 1	- 1
May	45.7	51.4	49.0	52.0	50.0	93	92	86	102	89.0	11	18	13	18	18
Spring	**36.6**	**41.9**	**39.2**	**41.7**	**40.0**	**93**	**92**	**87**	**102**	**89.0**	**-32**	**-28**	**-30**	**-32**	**-32**
June	54.1	59.5	57.3	60.9	58.1	90	96	96	102	98.0	12	28	27	27	29
July	60.2	65.1	63.3	67.7	64.9	96	101	99	105	98.0	27	34	34	34	30
August	58.2	63.1	61.8	65.9	63.0	95	98	98	100	97.0	23	29	25	35	35
Summer	**57.3**	**62.6**	**60.8**	**64.8**	**62.0**	**96**	**101**	**99**	**105**	**98.0**	**12**	**28**	**27**	**27**	**29**
September	51.2	54.4	52.3	55.5	53.0	94	92	88	94	87.0	6	10	4	21	8
October	42.8	44.4	42.1	45.4	44.0	86	86	79	92	82.0	-20	-15	-14	5	-18
November	30.9	33.2	30.2	33.9	32.5	82	77	69	70	69.0	-21	-25	-29	-20	-22
Fall	**41.6**	**44.0**	**41.5**	**44.9**	**43.2**	**94**	**92**	**88**	**94**	**87.0**	**-21**	**-25**	**-29**	**-20**	**-22**
Annual	**38.5**	**42.7**	**40.2**	**42.9**	**41.4**	**96**	**101**	**99**	**105**	**98.0**	**-46**	**-42**	**-46**	**-39**	**-39**

TABLE 2.—PRECIPITATION

	Total amount driest year (inches)					Total amount wettest year (inches)				
	Blackleaf 1914	Choteau 1905	Cut Bank 1919	Lytle 1919	Valier 1919	Blackleaf 1911	Choteau 1896	Cut Bank 1927	Lytle 1927	Valier 1927
December	0.19	T	0.05	0.49	0.20	0.24	0.05	0.71	1.27	0.54
January	.18	.50	.32	T	.04	9.41	1.45	1.22	.85	.80
February	.23	.12	.48	.95	.34	.20	1.02	.60	.80	.19
Winter	**.60**	**.62**	**.85**	**1.44**	**.68**	**.85**	**2.52**	**2.53**	**2.92**	**1.53**
March	.54	.56	.00	.38	T	T	1.30	.40	.43	.37
April	1.23	.55	.00	.09	.13	.57	1.05	.58	1.41	.97
May	1.11	1.45	1.39	1.95	1.40	5.10	3.84	7.01	8.30	8.18
Spring	**2.88**	**2.56**	**1 39**	**2.42**	**1.53**	**5.67**	**6.19**	**7.99**	**10.14**	**9.52**
June	3.07	2.63	.68	.95	.70	5.86	.60	2.76	1.96	1.62
July	.34	1.25	T	.01	.38	2.86	1.67	2.03	1.12	1.77
August	.63	.70	1.58	.84	.64	3.59	2.52	1.83	2.21	2.65
Summer	**4.04**	**4.58**	**2.26**	**1.80**	**1.22**	**12.31**	**4.79**	**6.62**	**5.29**	**6.04**
September	.24	.27	.71	1.62	.97	6.93	2.53	1.56	.55	1.17
October	1.75	.10	.35	.93	.58	1.42	1.50	.97	.95	.67
November	.46	.26	.03	.32	.28	1.52	1.20	1.32	1.68	1.15
Fall	**2.46**	**.63**	**1.09**	**2.87**	**1.83**	**9.87**	**5.23**	**3.85**	**3.18**	**2.99**
Total	**9.98**	**8.39**	**5.59**	**8.53**	**5.66**	**28.70**	**18.73**	**20.99**	**21.53**	**20.08**

TABLE 2.—PRECIPITATION (Continued)

	Mean (degrees Fahrenheit)					Snowfall (depth in inches)				
	Blackleaf 1905-1920	Choteau 1890-1931	Cut Bank 1912-1931	Lytle 1912-1931	Valier 1911-1931	Blackleaf	Choteau	Cut Bank	Lytle	Valier
December	0.47	0.53	0.28	0.50	0.47	6.1	5.4	1.2	6.1	4.2
January	.67	.68	.43	.60	.44	9.1	9.0	4.9	8.8	6.3
February	.56	.56	.34	.58	.30	6.0	7.7	4.9	6.9	4.5
Winter	**1.70**	**1.77**	**1.05**	**1.68**	**1.21**	**21.3**	**22.1**	**11.0**	**21.8**	**15.0**
March	.56	.65	.35	.55	.40	6.2	9.7	1.7	4.6	2.7
April	1.07	.83	.65	.91	.77	10.3	5.5	1.7	5.1	3.1
May	3.09	2.00	1.65	1.85	1.67	3.2	2.8	.2	1.9	1.7
Spring	**4.72**	**3.48**	**2.65**	**5.31**	**2.84**	**19.7**	**18.0**	**3.6**	**11.6**	**7.5**
June	3.72	2.92	2.43	2.24	2.50	T	.0	.0	T	T
July	1.55	1.75	1.84	1.45	1 85	.0	.0	.0	.0	.0
August	1.55	1.28	1.32	1.37	1.50	T	.0	.0	.0	.0
Summer	**6.82**	**5.95**	**5.59**	**5.06**	**5.85**	**T**	**.0**	**.0**	**T**	**T**
September	1.94	.96	1.05	1.06	1.12	4.7	1.8	1.4	1.7	1.6
October	1.08	.74	.47	.74	.70	9.4	1.3	1.6	6.8	4.8
November	.65	.31	.18	.41	.24	4.6	7.3	1.5	2.8	4.4
Fall	**3.67**	**2.04**	**1.60**	**2.21**	**2.06**	**18.7**	**10.4**	**4.5**	**11.3**	**10.8**
Total	**16.91**	**13.28**	**10.99**	**12.26**	**11.97**	**59.6**	**50.5**	**19.1**	**44.7**	**33.3**

plains at Lytle to 4,260 feet on a high bench below the mountains at Blackleaf. Cut Bank, Valier, and Choteau have approximately the same elevation—3,800 feet.

TEMPERATURE.—The average annual temperature for the different stations ranges from 38.5° at Blackleaf to 42.9° at Lytle. The annual temperature of the area increases a few degrees to the east and south according to table 1. January, with averages of 16.2° to 20.6°, is the coldest month; and July, with averages of 60.2° to 67.7°, is the warmest. Midsummer temperatures of over 100° have been recorded at Choteau and Lytle. The minimum temperatures vary from –39° to –46°. The average frost-free period dates from early in June to the last of September at the higher elevations and from the middle of May to the middle of September at the lower elevations. Temperatures of 32° or lower have been reported in every month of the year except July at Choteau, Cut Bank, and Lytle, and August at Lytle and Valier. Small grains are usually seeded in the plains during the latter part of April and early in May. Spring grains are rarely injured by late spring frosts, but early fall frosts may do damage to late-seeded grain on the high benches and also to crops grown under irrigation.

PRECIPITATION.—The precipitation in the area varies with the elevation and with the location. The average annual precipitation varies from 10.99 inches at Cut Bank to 16.91 inches at Bleackleaf, with an average of 12.50 inches for the stations located in the plains. The averages for the driest years range from 5.59 inches at Cut Bank to 9.98 inches at Blackleaf, and for the wettest years from 18.73 inches at Choteau to 28.70 inches at Blackleaf. Between 65 and 75 per cent of the total precipitation falls between March 1 and September 1 at all the stations. The rainfall of the summer months is largely received in heavy local showers and on the heavier soils the runoff is quite large. The annual snowfall of the plains is 3 to 3½ feet and for the higher elevations between 4 and 5 feet. The monthly averages are quite uniform between November 1 and April 1, but in some years are not so evenly distributed.

WINDS.—The area is subject to strong westerly and southwesterly winds, which are usually more severe during the early spring months. In dry seasons they may cause considerable soil drifting of summer-fallowed land and some damage to early seeded crops. Warm winds, known as chinooks, occur in this part of the state during the winter

months and at the lower elevations often clear the winter grazing lands of snow. Occasionally hot winds from the southwest in dry summers may cause serious crop losses on the dry lands. Hail-storms of more or less severity may occur locally during the summer months.

MAPS

The four maps accompanying this report show (1) the location and extent of the different soils, (2) the main physiographic and geographic features, (3) the location and percentage of each section under cultivation, and (4) the United States Geological Survey classification, which indicates the adaptation to agriculture.

Soil Map.—The soil map shows the relationship of the soils in the different parts of the county. It is based on physical properties such as color, texture, structure, and thickness, and relative position of the different horizons or layers found in the soils under field conditions. These horizons which may be observed in road cuts and coulees, are the result of the natural soil-forming processes, influenced by climate, topography, drainage, vegetation, etc. Soils having the same profile, that is the same number, arrangement, and character of horizons, are divided into large groups known as soil series, which are further divided into soil types on the basis of the proportions of sand, silt, and clay in the surface layers. Reconnoissance soil surveys deal largely with the identification and isolation of the larger soil groups. Soil types are not easily isolated in traversing an area at intervals of two miles, and on the soil maps only the most prevalent types, such as loams, sandy loams, etc., of each series are shown. Therefore each 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, bad lands, and bad-land basins are not included in any of the soil series and are shown as separate physiographic features.

Topography.—The chief physiographic and geographic features of the county are shown on the topographic map. The location and extent of such geographic features as mountains, lakes, bad lands, and the more important stream courses are presented. The general relief of the land is divided into the following phases: (1) undulating to rolling land, (2) sharply rolling land, (3) plateaus and benches, (4) mountains, (5) bad lands, and (6) bad-land basins.

Area Under Cultivation.—A record of the approximate acreage under cultivation was made at the time of this survey for the purpose

of locating the more intensely cropped sections and for studying the conditions under which these sections are more favorably adapted to agriculture than others. The approximate percentage of each section in crop, in fallow, and in tame pasture is shown on the map.

LAND CLASSIFICATION.—The United States Geological 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 upon topography and vegetation and in no instance was any information obtained in regard to the soil relationships 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. The utilization 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, are also shown.

DESCRIPTION OF SOILS

The regional profile of the soils of Pondera County varies with the elevation and location. The mature soils, classified according to color, belong to several groups, namely, brown, dark-brown, black, and on the high wooded mountain slopes probably some gray forested soils. The brown soils with carbonate zones 8 to 15 inches below the surface cover the rolling plains and the high plateaus less than 4,300 to 4,500 feet in elevation. The dark-brown soils with carbonate zones below 15 to 40 inches occur on the high plateaus and on the drift-covered table-lands east of the mountains. Black soils without carbonate zones, are found in a high basin north of Birch Creek in the western part of the county. The brown and dark-brown soils have developed under a short grass cover, a moderately low rainfall, and a wide range in summer and winter temperature. The black soils have developed under a tall grass and sparsely timbered cover, greater rainfall, lower annual temperature, and a short growing season. Immature soils or those without well-developed horizons cover large tracts in the south-central part of the county.

The mature soils developed over drift in Pondera County are grouped in four soil series, namely, Joplin, Scobey, Williams, and Babb. The Joplin series, covering the eastern part of the county, represents the lighter-colored phase of the brown soils with carbonate

zones 8 to 12 inches below the surface; and the Scobey series, found in the central part, the darker-colored phase with carbonate zones below 10 to 15 inches. The brown soils developed over glacial lake silts and clays in the central and north-central parts of the county are included in the Scobey series. The Williams series, occurring on the glaciated slopes of the mountains, includes the dark-brown soils with carbonate zones 15 to 40 inches below the surface. The deep, stony, black soils of the Babb series withoupt carbonate zones occur in a high basin in the western part of the county.

The Joplin sandy loams, loams, and silt loams are among the marginal agricultural soils in Pondera County. These soils produce fair yields of spring wheat on summer-fallowed land in seasons of average rainfall. The Joplin coarse sandy, stony, and silty clay loams have a fair grass cover and are utilized for grazing. The tillable types of the Scobey series, such as the loams and silt loams, are productive soils and are well under cultivation. The deeper and darker phases of these types are among the best agricultural soils in the county. The Scobey silty clays and clay loams are somewhat heavy and intractable for dry-land farming, but below the ditch they produce fair yields of the small grains and forage crops under proper management and drainage. The non-tillable phases of the different types have a good grass cover and a higher carrying capacity for livestock than the soils of the Joplin series. The types composing the Williams and Babb series in Pondera County are too stony and gravelly for farming and have a high carrying capacity for livestock during the time the areas are open for grazing.

The Cut Bank series includes a group of brown soils with carbonate zones 6 to 10 inches below the surface. The soils of this series have developed over glacial lake deposits which have been modified by stream action and wash from the gravel-capped plateaus and residual sandstone sections. The soils are somewhat shallow and light for dry-land farming, but under irrigation produce fair yields of small grains.

The Phillips series includes a group of brown soils developed over shaly drift. These soils are poorly drained and are characterized by "scab spots" or "blow-out holes". In Pondera County the soils included in this series cover chiefly scabby dry upland glacial lake beds, which are not well covered with vegetation. Many of the lake beds are too small to be shown on the soil map.

The soils developed over calcareous shales and sandstones are

grouped in the Bainville and Morton series, depending upon maturity. The calcareous immature soils of the Bainville series, covering the more broken residual sandstone areas in different parts of the county, belong to the light-colored phase of the brown soils. The Bainville soils often have the structure and stratification of the parent material below 3 to 5 inches. The soils have a fair cover of the short grasses and are utilized largely for grazing. The mature soils of the Morton series, occurring locally in the south-central part of the county, range in color from brown to rather dark brown with carbonate zones 8 to 15 inches below the surface. Rich brown soils developed over shallow gravelly wash from the high plateaus cover a large area in the south-central part of the county. These soils, underlain at variable depths with sandstones and shales, are shown on the soil map as a gravelly phase of the Morton soils. The Morton loams and gravelly loams are among the more productive dry-land soils in Pondera County.

The soils developed over non-calcareous shales and shaly drift are grouped in four series, namely, Lismas, Pierre, Marias, and Burton. The Lismas series, covering the shaly breaks of the larger streams, includes a group of heavy immature soils, without distinct horizons. The soils of the Pierre series, occurring chiefly along Dry Fork of Marias River in the south-central part of the county, also are immature but have a slightly calcareous surface mulch below which the structureless olive-brown clays often have the platy structure of the parent shales at depths of 2 to 3 feet. The soils of the Lismas and Pierre series are lightly covered with vegetation and have a low carrying capacity for livestock. The soils of the Marias series, covering several isolated tracts in the northwestern and south-central parts of the county, are characterized by deep calcareous surface mulches, grayish-brown humus-bearing layers, and deep calcareous olive-brown subsoils. The tracts have a fair carrying capacity for livestock. The brown soils of the Burton series, covering several large basins in the eastern part of the county, have non-calcareous surface mulches and humus-bearing layers. The silty clay carbonate zone lies 5 to 8 inches below the surface and grades into deep calcareous olive-brown silty clays. The soils are rather heavy and intractable for dry-land farming and are largely devoted to grazing.

The soils on the high gravel-capped plateaus and benches are grouped according to the color and physical properties of the surface soils and the depth and cementation of the carbonate zone into four

series, namely, Croffs, Fairfield, Ashuelot, and Buffalo. The Croffs series includes a group of very dark-brown, almost black, stony undifferentiated soils covering the high plateaus on the eastern slopes of the mountains above elevations of 4,800 feet. The soils of this series are not under cultivation and are devoted to the grazing of livestock during the time that the area is open for grazing. The Fairfield series comprises a group of brown to dark-brown soils found on the quartzite gravel-capped benches at elevations of 4,000 to 4,800 feet. The brown phase of this series below 4,300 to 4,500 feet in elevation has semi-cemented carbonate zones at depths of 15 to 30 inches and locally cemented gravel blocks occur within the surface 15 inches. The carbonate zone of the darker phase lies 30 inches or more below the surface and is usually less firmly cemented. The soils of the dark phase are too stony for farming and are utilized chiefly for the grazing of livestock. The less stony phases of the brown soils are well under cultivation and are devoted largely to the growing of spring wheat. The brown soils of the Ashuelot series, found largely on the secondary benches along Dupuyer Creek, are characterized by gravelly cemented blocks on the surface or by firmly cemented carbonate zones. On many of the lower benches both conditions are often found. The Ashuelot soils are not under cultivation except in irrigated sections. The Buffalo series includes a group of undifferentiated brown stony soils developed on eroded ridges capped with quartzite gravel. The land has a fair grass cover.

The brown soils composing the Cheyenne series have developed over stratified gravel deposits occurring as low terraces along some of the mountain streams at the lower elevations. The carbonate zone of this series usually lies 10 to 20 inches below the surface and often the more gravelly phases are semiconsolidated. The more barren gravelly terraces and glacial outwashes are shown on the soil map as loose gravel deposits. The Cheyenne gravelly loams are rather droughty for dry-land farming, but under irrigation produce fair yields of forage crops.

The soils of the Orman series have developed in ancient stream valleys and in old lake basins in the eastern part of the county. The mature soils of this series in Pondera County are brown, with carbonate zones at depths of 5 to 10 inches and with alkali zones at lower depths. A less mature and more shallow phase of this series is shown on the soil map. The Orman clay loams are too heavy, intractable,

and alkaline for dry-land farming and are largely utilized for grazing.

The soils developed over recent stream deposits are placed in the Laurel and Chouteau series. The Laurel series includes a group of undifferentiated gray calcareous soils without distinct soil horizons. In this series is also grouped the river wash along some of the larger streams. The valleys of many of the upland streams are very alkaline and the soils of these valleys are shown on the soil map as an alkali phase of this soil group. The Chouteau series includes another undifferentiated group of black, stony, usually non-calcareous, poorly drained soils found in the valleys of streams at the higher elevations, as in the mountains and on the high plateaus. In this series also are included deep black, non-alkaline soils occurring around fresh-water lakes and swamps. The poorly drained soils of the Chouteau series are often valuable hay lands in this area.

Barren rock outcrops, stony moraines, gravel outwashes, bad lands, bad-land basins, and mountains are shown as physiographic features on the soil map. Swampy tracts supporting a dense growth of willows, which can not be utilized for grazing and hay lands, are also shown as physiographic features.

The soils of Pondera County are grouped in 19 soil series and 42 soil types. Table 3 gives the area in square miles of each soil type and physiographic feature and also the area of each soil type which is unsuitable for agriculture because of its broken topography.

JOPLIN LOAMS

The surface 1 to 3 inches of the Joplin loams is a loose light grayish-brown fine sandy laminated mulch which is slightly compact in wet seasons. The humus-bearing layer is a light chocolate-brown friable columnar-structured loam 5 to 7 inches thick. The shallow subsurface layer is somewhat more compact, slightly heavier in texture and several shades lighter in color. The gray carbonate zone below 3 to 12 inches is a compact structureless silt loam, grading into a yellowish-brown calcareous loamy drift at 30 to 36 inches. Boulders occur on the surface, and the low mounds and ridges locally are quite gravelly. The Joplin loams grade into the Scobey loams without any marked change in the soil profile and in the relief of the land.

TABLE 3.—AREA AND PROPORTIONATE EXTENT OF EACH SOIL TYPE MAPPED IN PONDERA COUNTY

Soil type	Total area	Percentage of county	Topography	
			Level to sharply rolling	Sharply rolling
	sq. mi.	p. ct.	sq. mi.	sq. mi.
Joplin loams	159.2	9.8	158.7	0.5
Joplin sandy loams	85.7	5.2	56.1	29.6
Joplin silt loams	31.2	1.9	31.2	.0
Joplin silty clay loams	86.2	5.3	86.2	.0
Joplin stony loams	4.3	.3	4.3	.0
Scobey loams	158.1	9.7	158.1	.0
Scobey gravelly loams	32.4	2.0	26.4	6.0
Scobey sandy loams	2.1	.1	2.1	.0
Scobey silt loams—dark phase	24.2	1.4	24.2	.0
Scobey silt loams	13.6	.8	13.6	.0
Scobey silty clay loams	127.3	7.7	127.3	.0
Scobey silty clay loams—dark phase	16.7	1.0	16.7	.0
Scobey clay loams	7.7	.5	7.7	.0
Scobey stony loams	33.0	2.0	18.6	14.4
Williams loams—dark phase	5.0	.3	5.0	.0
Williams gravelly loams	12.4	.8	12.4	.0
Williams stony loams	37.5	2.3	21.7	15.8
Babb stony loams	19.1	1.1	16.9	2.2
Cut Bank loams	13.0	.8	13.0	.0
Cut Bank fine sandy loams	28.3	1.7	28.3	.0
Cut Bank silt loams	19.4	1.2	19.4	.0
Bainville loams	158.1	9.7	82.5	75.6
Bainville silty clay loams	1.0	.0	1.0	.0
Morton loams	5.4	.3	5.4	.0
Morton sandy loams	9.6	.5	9.6	.0
Morton gravelly loams	64.1	4.0	64.1	.0
Morton gravelly loams—shallow phase	7.7	.5	7.7	.0
Lismas clay loams	0.5	.0	.0	.5
Pierre clay loams	27.8	1.7	21.2	6.6
Marias clay loams	7.7	.5	7.7	.0
Burton clay loams	59.6	3.6	59.6	.0
Ashuelot gravelly loams	29.6	1.7	28.6	1.0
Fairfield loams	8.4	.5	8.4	.0
Fairfield loams—dark phase	10.9	.6	10.9	.0
Croffs stony loams	1.1	.0	1.1	.0
Buffalo loams	1.0	.0	1.0	.0
Orman clay loams	19.1	1.2	19.1	.0
Orman clay loams—deep phase	7.0	.4	3.0	4.0
Orman clay loams—shallow phase	10.8	.6	10.8	.0
Cheyenne gravelly loams	22.3	1.4	22.3	.0
Cheyenne gravelly loams—dark phase	6.0	.3	6.0	.0
Phillips loams	2.0	.1	2.0	.0
Chouteau loams	21.6	1.3	21.6	.0
Laurel loams	65.5	4.0	65.5	.0
Laurel clay loams	9.6	.6	9.6	.0
Bad lands	3.2	.2	—	3.2
Mountains	147.0	8.9	—	147.0
Swamps	1.4	.0	1.4	.0
Outwash gravels	1.0	.0	1.0	.0
Lakes	9.7	.5	9.7	.0
Total	1635.3	98.6	1328.7	306.6

The isolated tracts of the Joplin loams in the northern and central parts of the county are modified by material derived from the underlying sandstones and shales. The subsoils are often gray calcareous fine sands containing fragments of sandstone and shale. In the Pondera basin the loams grade into the Joplin sandy loams along Pondera Coulee. The soils contain a fair amount of gravel on the morainic divide in the southeastern part of the county.

TOPOGRAPHY.—The Joplin loams occur chiefly in the eastern half of the county. The larger tracts have a swell-and-saucer type of topography, but on the Pondera-Teton divide the land often is characterized by low hummocks and shallow lake basins. Drainage has not been well established on the larger undulating tracts.

TILLABLE AREA.—The Joplin loams cover a total area of 159 square miles, of which less than 10 per cent is untillable because of gravelly hummocks, lake basins, and coulees. On the land classification map it is classified as farming-grazing land, and as grazing-forage land.

UTILIZATION.—The tillable land in the eastern half of the county, not reserved for a Carey Act irrigation project, was homesteaded in tracts of 160 and 320 acres and broken out largely between 1910 and 1917. Crop yields were fair on the Joplin loams up to 1917, when the cropped acreage was greatly reduced because of several years of drought. During the past few years, the cropped acreage again has increased but largely on the more uniform tracts in the northeastern part of the county. Less than 25 per cent of the tillable land was under cultivation at the time of the survey.

Exclusive grain farming is the most important type of agriculture on the Joplin loams, but where water and grazing land are available, small herds of cattle are often kept in connection with the grain farms. The land under cultivation is devoted largely to spring wheat. Flax is produced on a small acreage, but other small grains are grown largely for feed and winter forage. The climate is too cool in this part of the state to mature corn, except some of the early flint varieties. The yields of forage crops, such as the tame grasses and legumes, are low and they are not grown on a very large acreage.

Power machinery is used on the large grain farms covering 1 to 3 sections or more. Duckfoot cultivators and similar implements are generally employed in preparing the land for spring seeding and for

summer fallowing. These implements are efficient in controlling weeds and retarding soil drifting. Small grains are grown on land summer fallowed every second or third year. Small combines are in general use for harvesting the large grain fields. Exclusive grain growing on the Joplin loams is probably not as dependable as a combination of stock raising and grain growing, but water and grazing land are important factors influencing the type of agriculture in the area.

The Joplin loams are easily maintained in good tilth and have a fair water-holding capacity. The surface acre-foot contains from 4,500 to 6,000 pounds of nitrogen and 1,800 to 2,700 pounds of phosphorus[1]. The soils are extremely high in lime. The yields of small grains have been quite variable since the land was broken, depending largely upon the amount and distribution of the seasonal rainfall. The yields of spring wheat on well-prepared summer fallowed land have been between 10 and 15 bushels per acre, and in favorable seasons often exceed 20 bushels per acre. Improved land in the better agricultural sections is held at $10 to $20 per acre.

VEGETATION[2].—Grama grass (*Bouteloua gracilis*) and its associated species form the chief cover on the Joplin loams. The black-rooted sedge (*Carex filifolia*) and slender wheat grass (*Agropyron tenerum*) are commonly associated with grama grass on the lighter-textured and more droughty loams. Other grasses, such as needle grass (*Stipa comata*) and June grass (*Koeleria cristata*) are more or less prevalent especially in the overgrazed sections. Western wheat-grass (*Agropyron Smithii*) is found on the heavier loams. The tall grasses, such as slender wheat-grass and needle grass become rather coarse upon maturity and are not as palatable as the short grasses.

[1]The chemical analyses of soils were made by the Chemistry Department of the Montana Experiment Station.

[2]The vegetation is discussed from the standpoint of the economic value of the different species in their relation to the livestock carrying capacity of the different soil types. The abundance and character of the vegetation are influenced by such adversities as drought, overgrazing, and so on. 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 upon a number of factors. The acreage given for carrying a steer through a grazing season (10 months) 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 generally considered the equivalent of one steer.

Mountain sage (*Artemisia frigida*) is abundant on the Joplin loams and prickly pear has a wide distribution. Gumweed (*Grindelia squarrosa*) and other shrubs are found on the loams but have no economic value as forage plants.

The stand of grass is quite uniform on the Joplin loams. The density increases slightly to the west on the Teton-Pondera divide. The carrying capacity of the loams for livestock is between 25 and 30 acres per steer for a grazing season of 10 months. Mountain sage is a fair range forage for sheep and in some sections the forage is better adapted to the grazing of sheep than cattle during the time the water-holes are filled. The larger streams have a perennial flow, but many of the upland streams are dry during the summer months and in the more poorly watered sections storage reservoirs should be provided.

JOPLIN SANDY LOAMS

The Joplin sandy loams are characterized by loose laminated sandy mulches and by brown friable faintly columnar-structured fine sandy humus-bearing layers. The slightly heavier-textured gray carbonate zones below 8 to 12 inches grade into brown fine sandy drift at 30 inches or more. Locally the lower soil depths are stratified sands. Boulders are not numerous on the surface and the gravel content of the soil is small.

Coarse sandy loams with carbonate zones 15 to 20 inches below the surface predominate in the sand hills above the breaks of Marias River. In the Pondera basin, the sandy loams locally grade into coarse sands with deep carbonate zones, and the subsoils often are stratified. A fair amount of gravel is found in the soils of the basins.

Topography.—The gently rolling sandy uplands and sand hills along such streams as Marias River and Dry Fork of Marias River are broken with deep coulees. In the Pondera basin the sandy loams occupy the lower undulating slopes of the basin. Glacial mounds, ridges, and lake basins are not as conspicuous on the sandy loams as on the loams. The soils are rather light textured for dry-land farming.

Tillable Area.—The Joplin sandy loams cover a total area of 86 square miles, of which 30 square miles are too broken with deep coulees for farming. On the land classification map most of the area covered by the sandy loams is shown as non-tillable grazing land, except in the Pondera basin, where it is classified as grazing-forage land.

UTILIZATION.—Most of the tillable phase of the Joplin sandy loams was at one time under cultivation, but during the dry years a large acreage was abandoned because of soil drifting. The improved land, which covered about 23 per cent of the tillable area at the time of the survey, was largely distributed over the Pondera basin and on the undulating tracts above Dry Fork of Marias River. Continuous cropping to small grains is somewhat more generally followed than on the loams because of soil drifting on clean summer-fallowed fields. Spring wheat is the most important cash crop. Other small grains and forage crops are grown on a small acreage.

The sandy loams are open and porous and in dry seasons the soils are rather droughty. The surface acre-foot contains from 3,500 to 4,000 pounds of nitrogen and 1,750 to 2,450 pounds of phosphorus. The soils are not deficient in lime. The average yields of spring wheat on the sandy loams since the sod was broken compare favorably with those on the loams, but since the root fiber has been destroyed and soil drifting is more common, the yields of small grains on the sandy loams average somewhat lower than on the loams.

VEGETATION.—Grama grass, nigger wool and sand grass (*Calamovilfa longifolia*) are the more prominent forage plants on the sandy loams. Needle grass, slender wheat-grass and June grass are distributed over the sandy loams and in some of the overgrazed sections they form the dominant vegetation. Mountain sage is not as abundant on the sandy loams as on the loams. The stand of grass is lighter than on the loams and a few more acres would be required to carry a steer through a grazing season of 10 months.

JOPLIN SILT LOAMS

The surface 2 to 3 inches of the Joplin silt loams is a loose laminated granular light grayish-brown silty mulch. The humus-bearing layer is a brown compact columnar-structured silt loam with a distinct grayish cast. The soils effervesce with acid at depths of 4 to 8 inches and above 20 to 30 inches the compact silty clay carbonate zones are streaked and blotched with lime. The lower soil depths are calcareous yellowish-brown to olive-brown silts and silty clays often containing fragments of shale. On the Teton-Pondera divide boulders are quite numerous and more or less gravel occurs in the soils.

TOPOGRAPHY AND TILLABLE AREA.—The Joplin silt loams cover undulating basins in the northeastern part of the county and hummocky, undulating tracts on the Teton-Pondera divide. Drainage

has not been well developed on the tracts. The silt loams cover 31 square miles, most of which has a topography suitable for cultivation. The hummocky tracts on the Teton-Pondera divide are classified as farming-grazing land and the undulating basins as grazing-forage land on the land utilization map.

UTILIZATION.—The hummocky phase of the Joplin silt loams is not well under cultivation, being chiefly used for grazing land. Most of the land under cultivation, covering less than 20 per cent of the total area at the time of the survey, is located in the undulating basin in the northeastern part of the county. The cultivated land is devoted chiefly to spring wheat. On this type of soil, summer fallowing of land generally is practiced on the large grain farms.

The silt loams have a good water-holding capacity, but are rather heavy and tend to puddle when wet. The runoff is likely to be large on these soils unless the surface is maintained in the proper condition for the reception of the rainfall. The surface acre-foot contains 4,200 to 4,500 pounds of nitrogen and 2,300 to 2,800 pounds of phosphorus. Yields of spring wheat average slightly lower than on the Joplin loams, but in favorable seasons often are much higher on summer-fallowed land.

VEGETATION.—The silt loams have a fair cover of grama grass and western wheat-grass. Prickly pear is conspicuous in the overgrazed sections. The carrying capacity of the silt loams for livestock in average seasons is somewhat lower than that of the Joplin loams.

JOPLIN SILTY CLAY LOAMS

The profile of the Joplin silty clay loams differs from that of the silt loams in having a platy structure in the lower part of the surface mulch, and a cloddy prismatic-structured silty clay humus-bearing layer which usually effervesces with acid at depths of 4 to 6 inches. The mottled and streaked grayish-brown heavy carbonate zone grades into structureless olive-brown silty clays, flecked with lime and alkali at 15 to 20 inches below the surface. Below 30 inches or more, the lower soil depths are structureless olive-brown silty clays and clays effervescing weakly with acid and often containing fragments of shale. The clods of the lower depths have a glazed colloidal coating along seepage lines. The soils on the large tract in the southeastern part of the county often have the profile of the Joplin silt loams but contain a greater amount of gravel.

TOPOGRAPHY AND TILLABLE AREA.—The silty clay loams cover an undulating poorly drained area of 86 square miles in the southeastern part of the county. On the land classification map, the heavier phase along South Fork of Pondera Coulee is classified as farming-grazing land and the large tract in the southeastern part as grazing-forage land.

UTILIZATION.—The Joplin silty clay loams are among the marginal dry-land agricultural soils in the county and probably should be used chiefly for grazing. A portion of the area covered by the silty clay loams was included in a proposed Carey Act project, and was not opened for entry until a few years ago. The cropped land, which amounted to less than 15 per cent of the total area at the time of the survey, was confined largely to the irrigated project north of Brady and to isolated tracts on the lighter-textured phases in the southeastern part of the county. The soils are rather plastic and tenacious, and in preparing the land for crops disc plows generally are employed. Summer fallowing of land with fall irrigation was practiced on the irrigated lands northeast of Brady at the time of the survey. Spring wheat was the most important crop grown on the dry and the irrigated lands. A more diversified type of agriculture, in which grasses and legumes are rotated with the small grains, will aid in eliminating the expensive practice of summer fallowing, all too common at present on the irrigated lands.

Under dry-land conditions the silty clay loams are summer fallowed one season to accumulate moisture in the subsoil and to pulverize the clods. The amount of nitrogen in the surface acre-foot ranges from 3,800 to 5,200 pounds and of phosphorus from 2,100 to 2,800 pounds. Excellent yields of spring wheat are obtained on well-prepared summer-fallowed land in wet seasons, but in dry seasons the yields often are low. The average yields of spring wheat are about the same as on the silt loams. Under irrigation, the yields range from 25 to 35 bushels per acre.

VEGETATION.—Western wheat-grass and grama grass form the chief cover on the silty clay loams and prickly pear is also conspicuous. The grass cover is not as heavy as on the Joplin loams and a few more acres would be required to support a steer through a 10 months' grazing season.

JOPLIN STONY LOAMS

The general profile of the Joplin stony loams is the same as that of the Joplin loams and sandy loams. The surface soils on the mounds and ridges are usually shallow. Boulders are abundant and the hummocks often are very gravelly.

Joplin stony loams cover 4 square miles of stony ridges and hummocks in the eastern part of the county. The land is too stony for farming and is utilized for grazing. The stony loams have a fair cover of grama grass and its associated species, and have about the same carrying capacity for livestock as the Joplin loams.

SCOBEY LOAMS

The surface 1 to 2 inches of the Scobey loams, such as are found on the larger tracts in the eastern and northern parts of the county, is a loose grayish-brown very fine sandy to silty mulch. The humus-bearing layer is a brown to rich brown columnar-structured loam 5 to 7 inches thick. The columnar-structured lighter brown subsurface layer is more compact and slightly heavier in texture. The gray to grayish-brown silty carbonate zone lies 8 to 15 inches below the surface and grades into structureless yellowish-brown loamy drift at 30 to 36 inches. Boulders are distributed over the surface and a small amount of gravel usually is found in the soils.

The soils in the upper part of the Pondera basin are several shades darker in color and grade into silt loams. Locally the subsoils are stratified silts and silty clays. The soils on the slopes of Lake Francis contain a fair amount of wash gravel similar to that found on the bench. The isolated tracts of Scobey loam distributed over the central part of the county are often underlain at various depths with stratified sandy silty material derived from the underlying sandstones. The more stony and gravelly phases are found on the slopes of Trunk Butte and on the tract south of Conrad along the county line.

The Scobey loams developed over mountain drift in the western part of the county are characterized by loose laminated dark-colored surface mulches, containing a fair amount of root fiber derived from a low creeping moss. The compact gray gravelly carbonate zone lies below 9 inches, and often is underlain with loose gravel and rock. Limestone makes up a large part of the gravel and rock found in the soils.

TOPOGRAPHY.—Scobey loams occur chiefly in isolated tracts in the central and north-central parts of the county above the glacial lake basin. The larger tracts have an undulating to rolling topography, characterized by low mounds, ridges, and shallow lake basins. The slopes of Trunk Butte and also the area south of Conrad along the county line are hummocky and quite stony. The tracts above Marias River and locally on the slopes of the gravel-capped benches and sandstone ridges often are dissected by deep coulees. In the Pondera basin the land has a gentle relief, but below the gravel-capped benches to the west the loams occupy slopes and ridges. In the western part of the county the loams cover basins between recessional moraines. Drainage has not been developed on many of the larger tracts.

TILLABLE AREA.—Scobey loams cover 158 square miles, of which approximately 25 per cent is too hummocky and broken by coulees for farming. On the land classification map most of the Scobey loam area is classified as farming-grazing land.

UTILIZATION.—The less stony and hummocky phases of the Scobey loams are among the better agricultural soils in the county. Boulders are sufficiently abundant on most of the tracts to preclude farming before the land is cleaned, which usually costs a few dollars per acre. The cropped acreage, which amounted to about 40 per cent of the total area at the time of the survey, was concentrated largely on the divide southeast of Conrad, in the Pondera basin, and on the larger tracts above Dry Fork of Marias River. The tracts in the west-central part of the county were not under cultivation but were used for the grazing of livestock. Spring wheat, grown largely on summer-fallowed land, is the most important crop. A small acreage of flax also is grown for seed. Other small grains and forage crops are grown for feed and winter forage to a limited extent. The cultural and tillage methods used on the Scobey loams do not differ greatly from those on the Joplin loams. Locally stock raising is combined with grain growing in the vicinity of grazing lands.

Scobey loams are retentive of the limited rainfall and have a good water-holding capacity. The surface acre-foot contains from 4,100 to 6,500 pounds of nitrogen and 2,100 to 2,800 pounds of phosphorus. The average yield of spring wheat on well-prepared summer-fallowed land is between 18 and 22 bushels per acre. In dry seasons clean summer-fallowed land is likely to drift but not to as great an extent as the Joplin loams.

VEGETATION.—Grama grass and its associated species form the chief cover on the Scobey loams. Mountain sage and prickly pear are less conspicuous than on the Joplin loams. The carrying capacity of the loams for livestock is between 20 and 25 acres per steer for a grazing season of 10 months.

SCOBEY GRAVELLY LOAMS

The Scoby gravelly loams have loose brown sandy organic mulches and rich brown columnar-structured gravelly humus-bearing layers. The carbonate zone below 10 to 12 inches consists chiefly of lime-coated stratified sands and gravels. The lower soil depths are largely loose limestone and quartzite gravel and rock.

Scobey gravelly loams cover hummocky basins between recessional moraines in the western part of the county. The 32 square miles covered by these loams is classified as non-tillable grazing land on the land classification map. The soils are too gravelly and droughty for dry-land farming. The grass cover consists largely of the bunch grasses, such as *Festuca idahoensis*. Fifteen acres would probably carry a steer through a grazing season of 10 months.

SCOBEY SANDY LOAMS

The Scobey sandy loams, such as are found on the tracts above Birch Creek in the western part of the county have loose brown sandy mulches and brown slightly columnar-structured coarse sandy humus-bearing layers. The compact gray carbonate zone lies 10 to 20 inches below the surface and grades into yellowish-brown sandy drift at 30 to 40 inches. A small amount of gravel occurs in the soils.

The Scobey sandy loams cover about 2 square miles of sloping terraces or benches above Birch Creek in the western part of the county and are classified as grazing-forage land on the land classification map. The tracts are not under cultivation and are probably too droughty for any use other than grazing. The sandy loams have a fair grass cover but the carrying capacity for livestock is somewhat lower than that of the Scobey loams.

SCOBEY SILT LOAMS—DARK PHASE

The surface 2 to 3 inches of the darker and deeper phases of the Scobey silt loams in Pondera County is a grayish-brown, fine-grained laminated silty mulch underlain locally with ¼ inch of dark-colored, platy-structured silty clay material. The humus-bearing layer is a compact slightly columnar-structured granular silt loam, grading into

a poorly defined shallow columnar-structured subsurface layer. The structurelss grayish-brown silty clay carbonate zone is well developed at 10 to 12 inches, and at 20 to 24 inches the olive-brown silts and silty clays are streaked and blotched with lime. Below 30 to 40 inches the lower soil depths are compact calcareous olive-brown silts and silty clays. A few boulders occur on the surface and a small amount of gravel in the soils.

In the Pondera basin the subsoils locally are stratified fine sands, silts, and silty clays, and in the poorly drained sections along the stream are often flecked with lime and alkali. The surface soils are modified locally by sandy wash below the sandstone benches west of Conrad. Boulders are rather conspicuous on the surface of the tract between Spring Creek and Dry Fork of Marias River below the rolling drift-covered uplands to the west.

Topography.—The dark-colored phase of the Scobey silt loams covers the upper part of the Pondera basin, the gentle slopes of the sandstone-capped bench south of Spring Creek, and another basin between Spring Creek and Dry Fork of Marias River. The slopes of the basins have good surface drainage but the lower levels along the streams often are poorly drained.

Tillable Area.—The dark phase of the Scobey silt loams covers 24 square miles, of which 75 to 85 per cent is tillable. On the land classification map this phase is classified as farming-grazing land.

Utilization.—The dark phase of the Scobey silt loams is well adapted to the production of small grains under dry-land conditions. Most of the tillable land in the Pondera basin and on the tract south of Spring Creek was under cultivation at the time of the survey. The more stony and rolling portion of the tract between Spring Creek and Dry Fork of Marias River was not extensively cropped. Spring wheat grown on summer-fallowed land is the main cash crop. Other small grains and forage crops cover a small acreage.

The dark phase of the Scobey silt loams has a high water-holding capacity and under the prevailing climatic conditions probably should be summer fallowed a season for the accumulation of moisture in the subsoils. The surface of summer-fallowed land is likely to glaze over and bake after dashing showers and the runoff will be great unless the surface is maintained in a condition for the reception of rainfall. The surface acre-foot contains 4,500 to 6,500 pounds of nitrogen and 2,100 to 2,800 pounds of phosphorus. The yields of spring wheat

on summer-fallowed land average about 20 bushels per acre but depend somewhat on the location of the land in the basins.

VEGETATION.—Western wheat-grass and grama grass form the chief cover on the Scobey silt loams. The stand of grass is fair, between 15 and 20 acres being required to carry a steer through a 10 months' grazing season.

SCOBEY SILT LOAMS[3]

The Scobey silt loams are characterized by fine-grained silty mulches and brown slightly columnar structured silty humus-bearing layers which effervesce weakly with acid at depths of 3 to 6 inches. The carbonate zone is a lime-blotched silt to silty clay loam grading into massive calcareous olive-brown silts and silty clays at 30 to 40 inches. The subsoils locally are stratified silts and silty clays and in the poorly drained sections often are flecked with alkali below 20 inches. Boulders are not usually found on the surface but a small amount of gravel is common to the soils.

The surface soils on the tract (1) in the vicinity of Manson, (2) south of Trunk Butte, (3) northeast of Manson, (4) east of Flat Coulee, and (4) locally on the darker phase south of Dry Fork of Marias River, are rather dark and are underlain at various depths with platy-structured residual material derived from dark-colored shales. Crystals of gypsum often are found in the subsoils.

TOPOGRAPHY.—The Scobey silt loams cover isolated tracts in the central part of the county. On Fisher Flat and also on Valier Flat east of Birch Creek the silt loams occupy the higher and more undulating levels. The more gentle slopes of these flats along Birch and Dupuyer creeks also are included in this soil type. In the eastern part of the area, the silt loams overlie basins and depressions below the rolling drift-covered uplands. The silt loams have a fair surface and subsurface drainage, except where the land is underlain with heavy residual material and in the more level basins.

TILLABLE AREA.—The Scobey silt loams cover 14 square miles of tillable land in Pondera County and are classified as farming-grazing land on the land classification map.

[3]The detailed survey of the Valier Irrigation Project in Pondera County groups the brown soils developed over silty drift and glacial lake deposits into three series, namely, Manson, Valier, and Scobey, depending upon local variations in color, depth, and structure of horizons. In the reconnoissance soil survey the Manson and Valier soils are grouped in the Scobey series.

UTILIZATION.—Most of the area covered by the Scobey silt loams north of Dry Fork of Marias River and on Fisher and Valier flats is under irrigation. The cropped acreage, amounting to 60 per cent of the total area in 1927, was well distributed over the different tracts. Spring wheat and a small acreage of alfalfa were the chief crops grown on the irrigated lands. On Fisher Flat the land is very weedy and summer fallowing for spring wheat was quite generally practiced.

The physical properties of the Scobey silt loams in general are the same as for the darker phase and the amount of nitrogen and phosphorus in the surface acre-foot does not differ greatly from that of the darker and deeper phase. The yields of spring wheat on the irrigated lands range from 25 to 35 bushels per acre.

VEGETATION.—Western wheat-grass is the principal cover on the Scobey silt loams. The density of the grass cover indicates that 15 to 20 acres would carry a steer through a normal grazing season of 10 months.

SCOBEY SILTY CLAY LOAMS

The Scobey silty clay loams have a shallow loose fine-grained grayish-brown laminated silty mulch on the surface, which often is underlain by a darker-colored platy-structured layer of less than ½ inch in thickness. The humus-bearing layer is a deep brown to dark brown granular silty clay loam, which usually has more of a prismatic than columnar structure. The grayish-brown carbonate zone below 5 to 7 inches is a structureless lime-streaked silty clay, grading into dark olive-brown stratified silty clays and clays with depth. Crystals of gypsum are found in the soils below 24 to 30 inches. Boulders are occasionally found on the surface and sandstone and shale fragments occur in all sections. The Scobey silty clay loams have developed over a glacial lake deposit which is 80 to 100 feet thick in the vicinity of Valier.

The surface soils of the more rolling phases found (1) bordering the Winganaw Valley, (2) north and east of Valier, and (3) on the isolated tracts bordering the Scobey loam areas in the northern part of the county, are somewhat more porous and have a richer brown color. The soils on the tract around Brady are somewhat heavier than those on Fisher and Valier flats.

TOPOGRAPHY.—The Scobey silty clay loams cover undulating benches or flats and gently rolling upland areas in the central part

of the county. Surface drainage is not well developed on the undulating benches and locally the basins and depressions are in need of drainage.

TILLABLE AREA.—The Scobey silty clay loams cover a total area of 127 square miles in Pondera County and are classified as farming and grazing land on the land classification map.

UTILIZATION.—Most of the area covered by the Scobey silty clay loams in the county is under irrigation. The cropped acreage, amounting to about 60 per cent of the total area, was well distributed over the irrigated lands in 1927. Spring wheat was the most important crop grown on the irrigated lands at the time of the survey. On Fisher Flat a fair acreage was summer fallowed below the ditch for spring wheat, probably to control wild oats and other weeds. Alfalfa confined largely to the more diversified farms, was the chief forage crop. Oats and barley also were grown on a small acreage. The more diversified type of agriculture, in which grain, hay, and livestock are combined, will probably return greater profits over a series of years on the Scobey silty clay loams than exclusive irrigated grain growing. This type of agriculture is slowly developing as indicated by the growth of dairying in a few localities and the more general practice of winter feeding sheep and cattle on the irrigated farms. Grasses and legumes do exceptionally well on the heavy loams, and excellent yields of small grains are reported on land rotated with alfalfa or with sweet clover. The climate is too cool to mature the dent and semi-dent varieties of corn in normal seasons, and the growing season is probably too short for producing satisfactory yields of sugar beets. The growing of seed peas on clean land has possibilities under irrigation. Fall irrigation of fields to be devoted to spring wheat was quite generally practiced in the vicinity of Brady.

The Scobey silty clay loams have a high water-holding capacity but are rather heavy, hence are somewhat difficult to manage under irrigation. The surface acre-foot contains from 4,000 to 7,000 pounds of nitrogen and 1,750 to 2,400 pounds of phosphorus. The amount of free lime runs very high in most localities. Crops grown on the heavy loams often do not make a rapid growth until the spring is well advanced. The physical condition of these silty clay loams is improved by growing grasses and legumes and by the application of barnyard manure. On the more diversified farms the soils appear to be better aerated and warm up early in the spring. The crops make a more

rapid start where systematic crop rotations are followed. Yields of spring wheat decline rapidly under continuous cropping. A suitable intertilled crop that will fit into a well-planned rotation on the larger farms, has not been found. The land often is summer fallowed for a season to control weeds and maintain maximum yields. The subsurface drainage is rather poor and excessive irrigation often retards crop growth. Tracts of seeped land are developing locally in the more level basins and in the shallow depressions. A few tests indicate that root crops, such as sugar beets, respond to phosphate fertilizers.

VEGETATION.—Western wheat-grass predominates on the Scobey silty clay loams. The grass cover is fair and 15 to 20 acres would probably support a steer through a grazing season of 10 months.

SCOBEY SILTY CLAY LOAMS—DARK PHASE

The dark phase of the Scobey silty clay loams has shallow fine-grained silty clay mulches, underlain with a platy-structured layer. The humus-bearing layer, having a distinctly grayish cast, is a dark-brown granular prismatic-structured silty clay loam effervescing freely with acid at 4 to 6 inches. Below the shallow humus-bearing layer the lime is fairly uniformly distributed through the upper part of the carbonate zone, but grades into structureless lime-blotched dark olive-brown silty clays and clays flecked with alkali.

The subsoils in the Winganaw Valley often contain platy-structured material derived from decomposed shale fragments. The dark soils in the basin around Williams are underlain with heavy clay subsoils which probably are derived from shales. The lower soil depths contain numerous crystals of gypsum. The dark phase of the Scobey silty clay loams covers basins in the central and north-central parts of the county. On the slopes of the Winganaw Valley, there are local outcroppings of water-bearing sandstone. These sandstones also underlie the glacial lake silty clays at various depths in the valley. The land below the sandstone outcrops is seeped locally as is also a portion of the surface of the basin around Williams. The dark phase of the Scobey silty clay loams covers 16.7 square miles and is classified as farming-grazing land. These loams are under irrigation and the better drained phases are nearly all under cultivation. The amount of plant food and agricultural adaptation of these loams are much the same as for the Scobey silty clay loams. The land is well covered with western wheat-grass and it has a fair carrying capacity for livestock.

SCOBEY CLAY LOAMS

The profile of the Scobey clay loams differs from that of the silty clay loams chiefly in having compact impervious subsoils, which are impregnated with alkali and contain crystals of gypsum in the lower part. The clay loams cover poorly drained basins and depressions in the silty clay loam area. These loams cover 8 square miles. The cropped acreage, devoted chiefly to grasses and legumes, occupied about 45 per cent of the total area in 1927. The basins would be greatly improved by surface and subsurface drainage. The grass cover and carrying capacity of the clay loams for livestock is about the same as that of the silty clay loams.

SCOBEY STONY LOAMS

The profile of the Scobey stony loams is similar to that of the loams. The deeper and darker-colored phase, with carbonate zones ranging from 5 to 7 inches on top of the mounds and ridges to 12 to 15 inches on their northern slopes, is found in the western part of the county. The stony loams occur on isolated mounds and ridges in the eastern part of the county and in morainic sections of the western part. The stony loams cover 33 square miles, of which an area of 14 square miles is classified as sharply rolling. The larger tracts are shown on the land classification map as non-tillable grazing land. The soils are too stony and often too droughty for farming, hence are utilized for the grazing of livestock. Grama grass forms the chief cover on the stony loams in the eastern part, and bunch grass in the western part of the county. The larger tracts in the western part of the county have a carrying capacity of about 15 acres per steer for a 10 months' grazing period.

WILLIAMS LOAMS—DARK PHASE

The surface 2 inches of the dark phase of the Williams loams is a very dark brown, almost black, friable loamy mulch containing a large amount of organic matter and root fiber. The humus-bearing layer is a friable dark-brown loam 7 inches thick. The subsurface layer is a brown fairly compact columnar-structured loam. The silty gray carbonate zone lies 15 to 20 inches below the surface and grades into yellowish-brown silts blotched with lime at 40 inches or more. The soils contain a fair amount of limestone gravel in all sections.

Williams loams cover 5 square miles of hummocky billowy drift-covered uplands in the western part of the county which are shown on the land classification map as non-tillable grazing land. The sur-

face acre-foot of these loams contains from 8,000 to 10,000 pounds of nitrogen and 1,500 to 2,100 pounds of phosphorus. The amount of free lime, chiefly in the form of fine limestone, often exceeds 30,000 pounds in the surface acre-foot. The area covered by the Williams loams lies at an elevation above 4,500 feet and the growing season is too short for general farming. The loams have a good cover of the tall bunch grasses and have a high carrying capacity for livestock during the time the tracts are not covered with snow. The grazing season at elevations of about 4,500 feet in this part of the state usually opens in April and closes in November and early December.

WILLIAMS GRAVELLY LOAMS—DARK PHASE

The dark phase of the Williams gravelly loams has a profile very similar to that of the Williams loams, except for the loose limestone gravels composing the lower soil depths. These gravelly loams cover hummocky, billowy uplands and basins between recessional moraines in the western part of this county. The 12 square miles of these loams are shown as non-tillable grazing land on the land classification map. The amount of nitrogen, phosphorus, and lime in the surface acre-foot is about the same as in the Williams loams. These gravelly loams are too droughty and lie at too high an elevation for general farming. The tall bunch grasses predominate and the grazing seacon usually runs from April to the last of November.

WILLIAMS STONY LOAMS—DARK PHASE

The profile of the dark phase of the Williams stony loams is in general the same as that of the Williams loams. The elevation of a portion of the area covered by the stony loams is higher than that of the loams and gravelly loams, and on the northern slopes of the high morainic ridges the carbonate zones often lie 20 to 30 inches below the surface. Limestone composes most of the rock and gravel found on the surface and in the soils. The stony loams, classified as non-tillable grazing land on the land classification map, cover 38 square miles on the eastern slopes of a high morainic basin in the western part of the county. The tall bunch grasses predominate and the grazing season runs from May to November.

BABB STONY LOAMS

The Babb stony loams include a group of stony undifferentiated soils covering a high morainic basin and its hummocky slopes in the

western part of the county. The area is characterized by open parks, bordered by patches of quaking aspens, willows and at the higher elevations with lodge-pole pines.

The soils of the open parks have 2 inches or more of black loamy organic matter on the surface. The humus-bearing layer 7 to 9 inches thick is a dark-brown granular silt loam with a distinct horizontal cleavage. The subsurface layer is a brown compact silt loam grading into a grayish-brown silty clay carbonate zone at 20 to 40 inches. Gravel and rock consisting chiefly of limestone occur in all sections and the amount increases in the lower soil depths.

The soils found under the quaking aspen have a shallow covering of leaf mold. Underneath they are usually yellowish-brown compact stony silts and silty clay loams, without definite structure, although below 12 to 15 inches the soils are more or less mottled and streaked with brown and black organic matter and other material.

The stony loams cover 19 square miles of non-tillable grazing land. With shrubs and the tall grasses predominating, the stony loams have a higher carrying capacity for sheep and goats than for cattle. The grazing season is open between May and November.

CUT BANK LOAMS[4]

The Cut Bank loams have a shallow loose fine sandy mulch on the surface. The humus-bearing layer is a brown to rich brown friable columnar-structured loam. The gray silty carbonate zone lies 5 to 8 inches below the surface and grades into structureless yellowish to grayish-brown pure sands with depth.

Topography and Tillable Area.—The Cut Bank loams cover 13 square miles of undulating land, classified as farming-grazing land on the land classification map. The soils have good surface and subsurface drainage.

Utilization.—The Cut Bank loams are among the better irrigated soils in the county. The cropped land, devoted largely to spring wheat and alfalfa, covers 80 per cent of the total area. The surface acre-foot contains from 2,500 to 3,500 pounds of nitrogen and 2,100 to 2,800 pounds of phosphorus. The soils are open and porous and warm up readily in the spring. Under irrigation they are adapted to a wide range of crops such as grains, vegetables, and sugar beets. The yields of spring wheat average a few bushels lower

[4]The soils of the Pondera series, identified as a separate group in the detailed soil survey of the Valier irrigation project, are correlated with the Cut Bank series in the reconnoissance soil survey.

than on the Scobey silt and silty clay loams. The fertility of the Cut Bank loams appears to be somewhat lower than of the heavier loams in the area that are irrigated. Crops probably would respond to an increase in the amount of organic matter in the surface acre-foot and also to light applications of phosphate fertilizers, especially for such crops as sugar beets.

VEGETATION.—Grama grass is the chief cover on the Cut Bank loams. The stand of grass is only fair and without irrigation 20 to 25 acres would carry a steer through a grazing season of 10 months.

CUT BANK FINE SANDY LOAMS

The Cut Bank fine sandy loams differ chiefly from the Cut Bank loams in having somewhat lighter-colored and lighter-textured surface soils. The gray carbonate zone lies 5 to 8 inches below the surface and grades into structureless yellowish sands with depth. The sandy tracts bordering the Pondera basin are underlain at various depths by dark-colored heavy residual material.

TOPOGRAPHY AND TILLABLE AREA.—The Cut Bank fine sandy loams cover undulating tracts below the drift-covered uplands and the lower slopes of sandstone and gravel-capped benches in the central part of the county. The soils have good surface and subsurface drainage unless underlain with impervious heavy residual material at comparatively shallow depths. The Cut Bank fine sandy loams, classified as farming-grazing land on the land classification map, cover 28 square miles in Pondera County.

UTILIZATION.—The Cut Bank fine sandy loams are largely under irrigation and are adapted to a wide range of crops. Most of the tillable land, devoted chiefly to spring wheat and alfalfa, was under cultivation at the time of the survey. The surface acre-foot is somewhat lower in nitrogen, but has about the same phosphorus content as the Cut Bank loams. The yields of spring wheat average about the same as on the loams. The fertility of these fine sandy loams can be maintained and increased by rotation of crops, addition of manure, and probably by light applications of phosphatic fertilizers.

VEGETATION.—Grama grass forms the chief cover on the Cut Bank fine sandy loams and the livestock carrying capacity without irrigation is between 20 and 25 acres per steer for a normal 10 months' grazing season.

CUT BANK SILT LOAMS

The Cut Bank silt loams in the Pondera Basin have a grayish-brown fine silty mulch on the surface. The humus-bearing layer is a brown columnar-structured silt loam 4 to 5 inches thick. The shallow lighter-colored silty subsurface layer overlies a gray structureless fine sandy carbonate zone, grading into stratified sands and silts with depth.

The Cut Bank silt loams cover an undulating area along Pondera Coulee in the vicinity of Conrad and have fair surface and subsurface drainage. These soils, covering 19 square miles classified as farming-grazing land on the land classification map, are under irrigation and adapted to a wide range of crops. The nitrogen content of the surface acre-foot is between 4,000 and 6,000 pounds and the phosphorus content from 2,100 to 2,800 pounds. The yield of spring wheat is somewhat higher than on the fine sandy loams. Grama grass, associated with wheat-grass, forms the chief cover on the silt loams. The carrying capacity of the land for livestock is about the same as that of the Cut Bank loams and sandy loams.

PHILLIPS LOAMS

The soils covering the scabby bottoms of dry upland glacial lake beds and the scabby slopes of streams in the glaciated area are grouped in the Phillips loams. Most of the bottoms and slopes are poorly drained silty clays highly impregnated with alkali. The bare spots have a firm crust on the surface below which is a porous or vascular-structured layer for an inch or more. The lower soil depths are nut-structured silty clays grading into structureless olive-brown silty clays and clays. The scabby loams covering 2 square miles have a low carrying capacity for livestock.

BAINVILLE LOAMS

The Bainville loams have loose grayish-brown sandy surface mulches and calcareous structureless brown sandy to loamy humus-bearing layers. Below 5 to 7 inches the lower depths are rusty-colored sands and loams, often having the structure and stratification of the parent material. Decomposed sandstones usually are found at depths of 3 to 5 feet. Sandstone slabs and outcrops occur on the more broken and eroded phases.

The soils of the more broken phases, such as cover the breaks along streams, consist largely of silty and sandy wash underlain at

various depths with sandstone. The wash below these sandstone escarpments often has a glazed crust.

TOPOGRAPHY.—The undulating to gently rolling phases of the Bainville loams are distributed over the west-central part of the county. The sharply rolling phase, consisting chiefly of buttes and breaks, occurs largely along the larger streams such as Marias River, Badger Creek, and Dry Fork of Marias River. The sandstone outcrops in the western part of the county also are included in the sharply rolling phase. The soils have fair surface drainage, but are likely to gully if not properly managed.

TILLABLE AREA.—Bainville loams cover 158 square miles, of which 76 square miles are chiefly breaks and buttes along streams. On the land classification map, these loams are classified as grazing and non-tillable grazing land.

UTILIZATION.—The gently rolling phases of the Bainville loams are among the marginal agricultural soils in the county. The cropped acreage, amounting to less than 10 per cent of the total tillable area, was distributed over the more desirable tracts in the west-central part of the county. Spring wheat was the most important crop grown. The acreage of summer-fallowed land was lower than on the better agricultural types because of soil drifting and gulling.

The surface soils of the Bainville loams are low in organic matter and after dashing showers are likely to crust. The surface acre-foot of the agricultural phase contains from 3,500 to 4,500 pounds of nitrogen and 2,100 to 2,400 pounds of phosphorus. The yields of spring wheat on summer-fallowed land average between 10 and 15 bushels per acre.

VEGETATION.—Grama grass and its associated species predominate on the Bainville loams. On the less broken and eroded phases 25 to 30 acres would carry a steer through a 10 months' grazing season.

BAINVILLE SILTY CLAY LOAMS

The Bainville silty clay loams have a crusted silty clay calcareous mulch on the surface. The grayish-brown humus-bearing layer is shallow and poorly defined. The compact silty clay subsoils are impregnated with alkali and often have the stratification of the parent calcareous shales.

The silty clay loams cover 1 square mile of non-tillable grazing land in the western part of the county. The soils contain too much alkali and are too intractable for dry-land farming. Grama grass

and western wheat-grass form a light cover on the silty clay loams. The livestock carrying capacity of these heavy loams is low and probably more than 40 acres would be required to carry a steer through a 10 months' grazing season.

MORTON LOAMS

Morton loams have shallow brown sandy surface mulches and deep brown friable columnar-structured loamy humus-bearing layers. The carbonate zone below 6 to 10 inches is a structureless grayish-brown silt loam, underlain at depths of 30 inches or more with yellowish brown silts and fine sands. On some of the tracts in the west-central part of the county slabs of gray sandstone occur on the surface and the subsoils locally have the stratification of the parent material. The more eroded phases grade into the Bainville loams.

The Morton loams cover 5 square miles of rolling uplands, often having the character of benches in the south-central and western parts of the county. The loams are classified as grazing-forage land and as grazing land on the land classification map. The larger tracts are devoted chiefly to spring wheat grown on summer-fallowed land. On the Blackfeet Indian Reservation the tillable land is under lease for grazing. The soils have a good water-holding capacity for dry-land soils. The surface acre-foot contains 6,000 to 7,000 pounds of nitrogen and 2,400 to 3,100 pounds of phosphorus. The soils are productive and on the more uniform tracts the yields of spring wheat on summer-fallowed land average between 18 and 20 bushels per acre. Grama grass forms the chief cover and the carrying capacity is between 20 and 25 acres per steer.

MORTON SANDY LOAMS

The surface 4 inches of the Morton sandy loams on the bench west of Conrad is a brown friable sandy loam, grading into a lighter brown columnar-structured sandy subsurface layer. The compact gray sandy carbonate zone below 11 inches grades into yellowish-brown fine sands at 34 inches or more. Disintegrated sandstones were found over the greater part of the bench to depths of 4 to 5 feet. Slabs of gray sandstone occur on the surface above the breaks of the bench.

The soils on the isolated tracts in the south-central part of the county have somewhat darker surface soils with carbonate zones below 12 to 15 inches. The lower soil depths consist chiefly of coarse sands.

The Morton sandy loams cover undulating sandstone-capped benches west of Conrad and also occur in basins in the south-central part of the county. On the land classification map, the 9 square miles of these sandy loams are classified as farming-grazing land. The sandy loams are rather droughty for dry-land soils, but fair yields are reported in seasons of average rainfall. After the root fiber has been destroyed, summer-fallowed land drifts, hence the summer-fallowed acreage is small. The tracts were nearly all under cultivation and devoted to spring wheat, the average yield of which has been between 15 and 18 bushels per acre. The surface acre-foot contains 4,000 to 5,000 pounds of nitrogen and 2,100 pounds of phosphorus. Grama grass and nigger wool predominate and the livestock carrying capacity of the land is around 20 acres per steer for a 10 months' grazing season.

MORTON GRAVELLY LOAMS[5]

Quartzite gravel derived from the erosion of the gravel-capped benches and buttes is distributed over the south-central part of the county. The gravel covering is not uniform and over the greater part of the area is underlain at comparatively shallow depths with residual material derived from sandstone. The soils developed over this gravelly wash have the same profile as the Morton loams, except for more or less gravel in the surface soils. The darker and deeper gravelly phases of the Morton gravelly loams are found on the slopes of St. Francis Bench and below the gravel-capped ridges southeast of Dupuyer. A more shallow phase occurs in the south-central part of the county and locally grades into the Bainville loams below the isolated sandstone-capped buttes and ridges.

The gravelly loams occur on the lower slopes of the gravel-capped benches and on rolling tracts in the south-central part of the county. The 64 square miles of these loams are classified as farming-grazing land on the land classification map. The tillable land is devoted chiefly to spring wheat, grown on summer-fallowed land and yielding between 18 and 20 bushels per acre on the darker-colored phase. The surface acre-foot, containing from 4,500 to 6,000 pounds of nitrogen and 1,800 to 2,400 pounds of phosphorus, indicates a fairly productive soil. Grama grass forms the chief cover and the forage on 18 to 20 acres would be sufficient to carry a steer through a normal 10 months' grazing season.

[5]Correlated with the Lowry gravelly loams in central Montana.

MORTON GRAVELLY LOAMS—SHALLOW PHASE

A shallow phase of the Morton gravelly loams covers isolated tracts below gravel-capped benches on the Blackfeet Indian Reservation in the northwestern part of the county. These soils differ from the Morton gravelly loams in having more shallow surface soils and heavier-textured gravelly subsoils underlain at various depths with fine sandy residual material. The tracts are dissected by alkali drainage courses, which do not carry much gravel on the surface and in the soils.

The shallow phase covers 8 square miles of undulating land, which is classified on the land classification map as grazing land. The Fisher unit of the Blackfeet reclamation project includes most of this area, but at the time of the survey the land was not under cultivation. The tracts are broken with shallow, seeped drainage courses and the acreage suitable for farming is small. The land has a fair cover of grama grass and 20 to 25 acres would carry a steer through a 10 months' grazing season.

LISMAS CLAY LOAMS

The Lismas clay loams have crusted non-calcareus grayish-brown fine grained silty clay mulches. Below the mulches, the soils are cloddy structureless non-calcareous olive-brown clays, grading into disintegrated dark-colored shales at 1 to 3 feet or more. These heavy loams cover less than a square mile of barren shaly breaks along Marias River in the north-central part of the county. A few shrubs, such as greasewood, are found on the lower slopes of the breaks.

PIERRE CLAY LOAMS

The Pierre clay loams have fine-grained silty clay surface mulches, which effervesce weakly with acid. The non-calcareous olive-brown cloddy humus-bearing layer is poorly defined and grades snto massive olive-brown clays, often flecked with alkali and rusty-brown spots at 12 to 15 inches. The lower soil depths usually have the platy structure of the parent shales below 3 to 5 feet. In the western part of the county, soils having a similar profile but developed over calcareous shales, such as Claggett, are grouped with the Bainville silty clay loams. These soils locally grade into the Pierre clay loams, where the shaly strata are non-calcareous.

The Pierre clay loams cover tracts of rather barren uplands and basins in the central and southwestern parts of the county. These

heavy loams, classified as non-tillable grazing land, cover 28 square miles, one-fourth of which is broken. The soils are too heavy and intractable for dry-land farming, and are used for grazing. A light stand of western wheat-grass and patches of grama grass form the chief cover. The livestock carrying capacity of the Pierre clay loams is low.

MARIAS CLAY LOAMS

The Marias clay loams are characterized by deep, calcareous fine-grained grayish-brown silty clay surface mulches. The humus-bearing layers are brown cloddy calcareous silty clay loams, which are rather shallow in Pondera County. The subsoils, also effervescing freely with acid, are deep massive olive-brown silty clays and clays, locally flecked with alkali.

The Marias clay loams cover 7.7 square miles of undulating land, classified as grazing land on the land classification map in the northwestern and southwestern parts of the county. In Pondera County these loams are rather heavy and intractable dry-land soils, hence the acreage under cultivation is small. A fair cover of western wheat-grass occurs on the surface and the forage on 20 to 25 acres would carry a steer through a 10 months' grazing season.

BURTON CLAY LOAMS

The Burton clay loams, grouped with the Marias clay loams in Chouteau County, have grayish-brown fine-grained silty clay surface mulches, which do not effervesce with acid. The humus-bearing layer is a brown non-calcareous silty clay loam 5 inches thick. This layer usually breaks into irregular clods, but locally it may have a slightly columnar structure. The lower soil depths, effervescing with acid, are deep olive-brown compact silty clays and clays sometimes flecked with alkali. The surfaces of the more undulating and eroded phases often effervesce with acid and grade into the Marias clay loams.

The Burton clay loams cover portions of several large basins in the eastern part of the county. The undulating slopes of these basins have fair surface drainage, but along some of the drainage courses the land often is in need of drainage. These loams cover 60 square miles of tillable land classified as farming-grazing and grazing-forage land on the land classification map. The soils are rather heavy for dry-land farming and are usually summer fallowed

for a season to accumulate moisture in the subsoils and to pulverize the clods. The cropped acreage, amounting to less than 20 per cent in 1928, was found largely on the more undulating slopes of the basins. The surface acre-foot contains 4,500 pounds of nitrogen and 2,000 pounds of phosphorus. The average yield of spring wheat on summer-fallowed land is between 12 and 15 bushels per acre, although in favorable seasons the yields are as high as 25 to 30 bushels per acre. Western wheat-grass forms the chief cover and the forage on 20 to 25 acres would carry a steer through a normal 10 months' grazing season.

ASHUELOT GRAVELLY LOAMS

The surface 3 inches of the Ashuelot gravelly loams on the low benches along Dupuyer Creek in Range 6 West is a dark-colored gravelly loam, underlain with a lighter-brown slightly columnar-structured gravelly sandy loam. The carbonate zone below 10 inches is a structureless sandy gravelly loam, underlain at 18 inches with semi-cemented gravels and at 26 inches or more with loose sand and gravel. In Ranges 7 and 8 West the surface soils are rather shallow and stony and the carbonate zone underlain with loose gravel and rock is somewhat more firmly cemented. Quartzite and argillite compose most of the gravel and rock and also form the cemented blocks, locally found on the surface.

The Ashuelot gravelly loams occur on gently sloping benches along Dupuyer Creek in the southwestern part of the county. The benches, covering 29 square miles, are classified as non-tillable grazing land on the land classification map. These gravelly loams produce fair crops, such as alfalfa, under irrigation but without irrigation are more important for grazing purposes. The large bench north of Dupuyer Creek was well broken out at the time of the settlement of the dry-land sections in the county, but the soils proved droughty for dry-land farming and a large acreage was abandoned. At the time of the survey the cropped acreage, devoted chiefly to spring wheat, was confined to the deeper soils in the northwestern and northern parts of the bench and to isolated tracts of alfalfa and sweet clover on the more stony and droughty sections. The surface acre-foot contains from 5,000 to 6,000 pounds of nitrogen and 2,400 pounds of phosphorus. The average yields of small grains and forage crops on the gravelly loams are low. Grama grass, giving way

to bunch grasses in the western part of the benches and to sedges in the poorly drained sloughs, forms the chief cover on the gravelly loams. A small shrub, known as cinquefoil, the flowers of which are economic range forage for sheep, is conspicuous on the more gravelly and stony phases. The livestock carrying capacity of these gravelly loams is between 15 and 20 acres per steer for a 10 months' grazing season.

FAIRFIELD LOAMS

The Fairfield loams, developed over a quartzite gravel deposit, exceeding 10 feet in thickness on the St. Francis bench, have shallow loose light-brown fine sandy surface mulches. The humus-bearing layer is a brown friable columnar-structured loam, containing more or less gravel. The gray silty gravelly carbonate zone below 9 inches is semiconsolidated and grades into stratified silts and gravels at 30 inches or more. The lime is often concretionary in the more silty phases. The eastern part of the St. Francis bench is broken with coulees and the surface soils are quite shallow and gravelly. On the isolated gravel-capped ridges and buttes in the south-central part of this county, the surface soils also are shallow and gravelly.

The Fairfield loams, covering 8 square miles, occur on gently sloping benches and ridges, which are classified as grazing land and grazing-forage land on the land classification map. The less shallow and gravelly phases are under cultivation and are considered among the better dry-land soils in the county. The surface acre-foot contains from 5,000 to 7,000 pounds of nitrogen and 2,100 to 2,400 pounds of phosphorus. Most of the land under cultivation is devoted to spring wheat, grown on summer-fallowed land and yielding between 15 and 20 bushels per acre on the less droughty phases. Grama grass and its associated species form the chief cover and the forage on 15 to 20 acres would support a steer through a 10-months' grazing season.

FAIRFIELD LOAMS—DARK PHASE

The dark phase of the Fairfield loams covering the gravel-capped ridges in the southwestern part of the county has shallow dark-colored silty to fine sandy surface mulches. The humus-bearing layer is a dark brown friable columnar-structured loam to gravelly loam, 5 to 7 inches thick. The surface soils on the higher ridges often grade into the Croffs stony loams, having a granular structure and horizontal cleavage. The subsurface layer is a lighter brown col-

umnar-structured gravelly loam. The carbonate zone below 15 to 20 inches consists largely of grayish-brown concretionary silts and lime-coated gravels grading into stratified yellowish-brown silts and gravels with depth. A fair amount of rock occurs on the surface of some of the higher benches, south of Dupuyer Creek.

The dark phase of the Fairfield loams, covering 11 square miles, is broken by deep coulees and on the land classification map is classified as grazing land and non-tillable grazing land. The lower benches are under cultivation locally. The surface acre-foot contains 8,000 to 10,000 pounds of nitrogen and 2,100 to 3,400 pounds of phosphorus. The average yields of spring wheat on the darker-colored phase probably do not greatly exceed those on the Fairfield loams, since the yields on the higher benches often are reduced by early fall frosts. The land covered with the tall bunch grasses has a high livestock carrying capacity during the time the area is open for grazing.

CROFFS STONY LOAMS

The Croffs stony loams, covering less than one square mile on the high bench along the county line, west of Dupuyer Creek, have dark-brown, almost black, organic surface mulches. The humus-bearing layer is a very dark brown granular blocky-structured stony loam 7 inches thick. The subsurface layer is also a brown blocky granular stony loam, characterized by gray veins, effervescing freely with acid. The carbonate zone below 30 inches or more is a structureless stony silt loam grading into more stony and gravelly material with depth. Argillite and quartzite compose most of the gravel and rock found on the bench.

Croffs stony loams, classified as non-tillable grazing land on the land classification map, occur on gravel-capped benches at elevations above 4,800 feet. The land is too stony and lies at too high an elevation for farming. The benches have a good cover of the tall bunch grasses and their livestock carrying capacity is high during the short grazing season.

BUFFALO STONY LOAMS

The Buffalo stony loams include an undifferentiated stony gravelly group, covering less than one square mile on eroded gravel-capped benches and ridges in the northwestern part of the county. These loams are characterized by dark-colored loose sandy surface mulches and by rich brown friable columnar-structured gravelly humus-bearing layers 4 to 6 inches thick. The gray gravelly carbonate

zone below 11 inches grades into yellowish-brown gravelly silts with depth. The area covered with these loams is not under cultivation and is classified as non-tillable grazing land on the land classification map. The land covered chiefly with grama grass has a fair grazing capacity.

ORMAN CLAY LOAMS

The Orman clay loams have shallow laminated fine-grained silty clay surface mulches. The humus-bearing layer, which is not well defined, is a dark-brown platy-structured clay loam, becoming lighter in color with depth. The carbonate zone below 10 to 14 inches is a structureless olive-brown clay, which often is flecked with lime and alkali below 34 inches. The more undulating phases on the slopes of the basins locally effervesce with acid below 6 inches and grade into the Burton clay loams.

The Orman clay loams, covering 19.1 square miles, occur chiefly in large basins in the eastern part of the county. These heavy loams, classified as grazing-forage land on the land classification map, are intractable dry-land soils, hence are not well under cultivation. The surface acre-foot contains 3,500 to 4,500 pounds of nitrogen and 3,300 pounds of phosphorus. The land has a fair cover of western wheat-grass and its carrying capacity for cattle is 20 to 25 acres per head.

ORMAN CLAY LOAMS—DEEP PHASE

The surface soils of the deep phase of the Orman clay loams below the grayish-brown fine-grained silty clay mulch are dark-colored cloddy clay loams, effervescing freely with acid below 14 to 20 inches. The subsoils are massive olive-brown clays, flecked with lime and alkali. These heavy loams, covering 7 square miles and classified as grazing-forage land on the land classification map, occur in the lower part of a large basin in the northeastern part of the county and on a poorly drained terrace above Birch Creek in Township 30 North, Range 7 West. The land above the irrigation canals is too heavy for dry-land farming and is not under cultivation. The small irrigated acreage is devoted chiefly to forage crops, such as alfalfa and the native wheat-grasses. The land is well covered with western wheat-grass and its livestock carrying capacity is somewhat higher than that of the Orman clay loams.

ORMAN CLAY LOAMS—SHALLOW PHASE

The shallow phase of the Orman clay loams, such as is found in poorly drained bottoms and on low terraces in ancient stream valleys in different parts of the county, has loose fine-grained silty clay surface mulches and shallow brown cloddy clay humus-bearing layers, often effervescing weakly with acid. The subsoils are stratified compact calcareous grayish-brown to olive-brown silty clays and clays, usually flecked with alkali at 5 to 8 inches. A small amount of gravel occurs in the soils on tracts along Pondera Coulee. This phase, classified as grazing-forage land and as non-tillable grazing land, covers 11 square miles. The soils are too heavy and intractable for dry-land farming and are therefore not under cultization above the ditch. Along Pondera Coulee a small acreage is under irrigation and is devoted largely to forage crops, such as alfalfa. The shallow phase, covered lightly with western wheat-grass, has a relatively low carrying capacity for livestock.

CHEYENNE GRAVELLY LOAMS

Cheyenne gravelly loams on the bench above Birch Creek in Township 30 North, Range 7 West are shallow brown gravelly loams underlain with semiconsolidated gravels at depths of 10 to 15 inches. The lower soil depths are largely loose limestone gravels, locally stratified with sand. Other tracts along Birch Creek range from stratified sands and gravels to loose gravels.

The Cheyenne gravelly loams on the low terraces along Dupuyer Creek vary from gravelly loams to sandy loams, underlain with stratified sands, silts, and gravels. West of this creek the soils are more stony and gravelly and the gravelly carbonate zone often is semicemented at depths of 10 to 15 inches. The deeper and more uniform soils occur east of the creek.

The Cheyenne gravelly loams, classified as grazing-forage land, grazing land, and non-tillable grazing land on the land classification map, depending upon the character of the terraces, cover 22 square miles, chiefly along Birch and Dupuyer creeks. The soils are rather gravelly and droughty for dry-land farming, but where the subsoils are deep stratified fine sands and silts the land is under cultivation. The yields of spring wheat on the bench east of Dupuyer Creek average above the ditch between 12 and 15 bushels per acre. Under irrigation these gravelly loams produce fair yields of forage crops, such as alfalfa. The amount of nitrogen and phosphorus of the surface

acre-foot varies with the different terraces. The land has a fair cover of grama grass and a livestock carrying capacity of 20 to 30 acres per steer for a 10 months' grazing season.

CHEYENNE GRAVELLY LOAMS—DARK PHASE

West of Francis Heights the terrace south of Dupuyer Creek is covered with wash from the high gravel-capped bench. The soils on the tract are deep dark-colored gravelly loams, underlain west of Lake Francis with semiconsolidated gravels at depths of 2 to 3 feet or more. Nearly all the tract, covering 6 square miles, is under cultivation and is devoted chiefly to spring wheat. The soils are well supplied with nitrogen and contain a fair amount of phosphorus. The average yield of spring wheat is more than 15 bushels per acre.

CHOUTEAU LOAMS

The Chouteau loams include a group of undifferentiated dark-colored stratified soils covering the first stream bottoms and lake basins below the high drift-covered tablelands east of the mountains. These soils range in texture from loams to stony loams and have no distinct horizons, except those locally produced by poor drainage. The soils effervesce with acid where the alluvium is derived largely from limestone and calcareous sedimentary formation.

The Chouteau loams cover many of the stream bottoms and lake basins in the western part of the county. The loams, classified as non-tillable grazing lands on the land classification map, cover 22 square miles. The lower levels along the mountain streams often are flooded during high water and the less stony and hummocky phases are among the more valuable wild hay lands in the area. The vegetation consists largely of sedges, wire grasses, and clumps of willows.

LAUREL LOAMS

The Laurel loams include another undifferentiated group of gray calcareous stratified soils covering the first stream bottoms in the central and eastern parts of the county. In this group also is included the stony river wash found along some of the larger streams, such as Birch Creek. The soils are without definite profile and the texture ranges from loose sands and gravels to intractable cloddy silty clays and clays. The bottoms of many of the upland streams often are highly impregnated with alkali and on the soil map these bottoms are shown as an alkali phase of the Laurel loams.

The Laurel loams, classified as non-tillable grazing land and as grazing land on the land classification map, cover 65 square miles. The stream bottoms are not under cultivation, except for small irrigated tracts lying on low terraces and gentle slopes above the high-water level. The subirrigated and less alkaline bottoms of the larger perennial streams locally have a dense growth of willows and cottonwoods and the higher levels often have a slight stand of grama grass and western wheat-grass. Sedges predominate in the sloughs and greasewood and other shrubs on the more alkaline phases. The livestock carrying capacity of the Laurel loams varies greatly in the different stream bottoms, but on the whole it is low.

LAUREL CLAY LOAMS

The more barren and intractable phases of the gray stream and lake bottoms, which do not effervesce freely with acid at the surface, are designated as Laurel clay loams. These soils are gray cloddy stratified silty clays and clays with subsoils highly impregnated with alkali.

The Laurel clay loams cover 10 square miles of non-tillable grazing land, and occur largely in a poorly drained lake basin in the northwestern part of the county. East of the alkali lakes there is a greasewood flat, characterized by low hummocks of wind-blown material about the shrubs. The Laurel clay loams are not well grassed and have a low carrying capacity for livestock.

BAD LANDS

Isolated tracts of barren, gullied clay hills and ridges, covering 3 square miles in the central part of the county, are classified as bad lands. The grass and shrub cover is very sparse and the land has a low carrying capacity for livestock.

MOUNTAINS

Mountains cover approximately four townships in the western part of the county. This rough, broken land consists largely of bald peaks, barren serrated ridges, talus-covered slopes, and inaccessible timbered and park areas.

Lodge-pole pine forms the chief cover on the mountain slopes and quaking aspen and willows in the poorly drained canyons and basins. Sedges predominate over grasses in the open parks and shrubs form most of the underbrush. The mountains have a rather low carrying capacity for cattle, but for sheep and goats it is fair during the 3 or 4 months the area is open for grazing.

SWAMPS AND OUTWASH GRAVELS

South of Birch Creek in Township 29 North lies a swampy tract covering less than 2 square miles. The borders of this tract, covered with sedges and wire grasses, are utilized for hay lands.

Outwash gravels cover approximately one square mile on a low terrace above Birch Creek, below the mouth of the Birch Creek canyon. This gravelly flat is not well covered with vegetation.

AGRICULTURE

Stock raising was the chief industry in this part of the state for many years after the Indians were confined to the reservations. Some of the early stockmen, who saw the need of supplementing their winter grazing land with native hay to prevent an occasional heavy winter loss of stock, took out ditches during the early nineties and irrigated small tracts along some of the perennial streams. The larger irrigation projects were not undertaken until after 1895. Dry-land farming in the more favored localities developed along with irrigation, but it did not become important until after the settlement of the dry-land areas about 1909.

The public range land in Pondera County was settled and fenced largely in tracts of 160 and 320 acres between 1909 and 1915. The larger stream bottoms and winter grazing lands were filed upon by the early stockmen, chiefly during the late eighties and early nineties. Crop yields have been fair on the dry lands, except for a few years of drought between 1917 and 1920.

The general trend of agriculture in the county is shown by a few statistics taken from the census reports for the years 1920, 1925, and 1930. In 1925, 77.4 per cent of the farm lands had a mortgage indebtedness of $13 on land valued at $26 per acre; and in 1930, 61.7 per cent had an indebtedness of $10 on land valued at $25.67 per acre. The farm tenancy for the respective years was 11.2, 30.6, and 27.4 per cent. In 1920, 59.4 per cent of the total area of the county was in farms and in 1930, 65.8 per cent. The number of farms decreased during the ten-year period from 1060 to 919, and the acreage composing a farm increased from 594.3 to 749.1 acres. Land values are nominal in most of the county. The better improved dry-land farms are held at $20 to $30, and the less improved farms from $15 to $20 per acre. The irrigated lands with paid-up construction charges range from $50 to $100 per acre depending upon location and improvements. Grazing lands are priced at less than $3 to $10 per

TABLE 4.—ACREAGE AND YIELD OF THE MORE IMPORTANT CROPS GROWN IN PONDERA COUNTY

	1919[a]		1922[b]		1923[b]		1924[a]	
	Acreage	Acre yield (bu. or tons)	Acreage	Acre yield (bu. or tons)	Acreage	Acre yield (bu. or tons)	Acreage	Acre yield (bu. or tons)
Cropped land harvested	65,726	—	141,650	—	134,900	—	131,963	—
Fallowed land	—	—	—	—	—	—	66,609	—
Cropped land, total	—	—	—	—	—	—	207,836	—
Barley	1,202	13.5	3,600	19.5	5,000	29.0	6,331	18.9
Corn, total	—	—	800	20.0	2,000	21.0	1,863	20.9
Flax	4,157	4.6	1,100	7.5	1,000	7.0	839	2.8
Hay, wild, total	3,498	.6	5,000	.7	5,000	.8	4,243	.7
Hay, tame, total[c]	11,936	—	14,000	1.8	16,100	1.7	15,507	1.9
Oats	3,743	18.7	10,000	35.5	10,000	22.0	7,446	20.8
Potatoes	229	85.8	550	111.0	500	130.0	442	47.3
Rye	936	3.3	1,600	20.0	1,400	13.6	85	15.0
Wheat, winter	31,584[d]	10.0[d]	3,000	17.0	2,000	13.0	93,050[d]	12.2[d]
Wheat, spring	([d])	([d])	102,000	15.7	91,000	19.0	([d])	([d])
Sugar beets	—	—	—	—	—	—	—	—

	1925[b]		1926[b]		1927[b]		1928[a]	
Cropped land harvested	159,900	—	158,700	—	183,600	—	179,850	—
Fallowed land	—	—	—	—	—	—	—	—
Cropped land, total	—	—	—	—	—	—	—	—
Barley	7,000	2.6	5,400	29.0	7,400	42.0	7,000	33.0
Corn, total	2,000	18.0	3,000	11.0	2,000	21.0	50	26.0
Flax	1,000	4.0	1,000	4.3	1,500	11.0	3,000	9.5
Hay, wild, total	5,000	0.5	4,200	0.5	9,600	1.0	6,600	0.9
Hay, tame, total[c]	17,000	1.9	17,000	1.7	15,000	1.6	14,200	1.7
Oats	11,000	31.0	11,000	30.0	9,000	48.0	7,000	35.0
Potatoes	700	127.0	800	105.0	700	120.0	200	130.0
Rye	200	15.0	300	17.0	400	22.0	—	—
Wheat, winter	—	—	1,000	16.0	2,000	25.0	2,000	18.0
Wheat, spring	116,000	12.0	115,000	19.0	136,000	24.0	140,000	23.0
Sugar beets	—	—	—	—	40	8.7	260	7.0

TABLE 4.—ACREAGE AND YIELD OF THE MORE IMPORTANT CROPS GROWN IN PONDERA COUNTY (continued)

	1929[a]		1930[b]		1931[b]	
	Acreage	Acre yield (bu. or tons)	Acreage	Acre yield (bu. or tons)	Acreage	Acre yield (bu. or tons)
Cropped land harvested	177,604	—	168,610	—	102,250	—
Fallowed land	125,533	—	—	—	—	—
Cropped land, total	308,533	—	—	—	—	—
Barley	8,059	18.2	7,300	17.0	4,000	17.0
Corn, total	61	5.0	70	11.0	50	15.0
Flax	7,110	4.4	8,000	6.9	5,000	3.2
Hay, wild, total	8,295	0.8	8,250	0.5	5,000	0.6
Hay, tame, total[c]	16,359	1.3	18,330	1.1	17,800	1.1
Oats	4,778	20.4	6,500	26.0	4,200	16.0
Potatoes	196	78.3	160	90.0	200	80.0
Rye	—	—	—	—	—	—
Wheat, winter	1,591	14.0	3,000	17.0	2,000	11.0
Wheat, spring	124,227	13.5	117,000	15.0	64,000	11.0
Sugar beets	205	6.6	150	13.6	600	8.9

[a]U. S. Census Reports.
[b]State reports—Department of Agriculture and Publicity.
[c]Includes grasses, legumes, and small grains cut for hay.
[d]Winter wheat and spring wheat reported together.

acre, depending upon the carrying capacity of the land for livestock, availability of water, and location. The gross agricultural income of Pondera County is derived chiefly from livestock, and products grown on the dry and irrigated farms.

STOCK-RAISING.—The western part of the county is primarily a grazing area. Stock is run on the open range during the grazing season and wintered on the ranches provided with hay or moved to the irrigated districts. The wild grasses covering the wet bottoms make a fair quality of hay, but for best results should be supplemented with other forage crops and commercial feeds. In the eastern part of the county the winter grazing lands are often supplemented with straw and small-grain hay. In the irrigated sections the beef breeds are usually run on the open range during the summer months and wintered on the irrigated farms. Dairy stock is usually run on tame pasture. Pondera County is well watered, but in some of the dry-land sections in the eastern part it is necessary to provide storage reservoirs to insure stock water during the drier part of the year.

Herefords and Shorthorns and their crosses are the more important beef breeds on the range. The total number of cattle in the county in 1920 was 10,776 and in 1930, 14,664. The number of milk cows for the same period increased from 1,746 to 3,283 head.

Sheep were brought into the area at an early date but their importance as a source of income did not rank with that of cattle until after the development of the irrigated projects. The number of farm flocks on the irrigated farms has increased rapidly during the past few years. In 1920 the total number of sheep in the county was 11,522 and in 1930, 63,409.

The number of horses has declined steadily with the increasing use of small tractors on the dry-land and irrigated farms. In 1920, 11,213 were reported and in 1930, 7313 head. The swine industry is not important as only 2,424 were reported in 1930.

DRY-LAND FARMING.—The assessed non-irrigated tillable land in 1930 was 434,757 acres. These figures do not include the tillable land on that part of the Blackfeet Indian Reservation lying within Pondera County. The average cropped acreage, including the irrigated lands, is 154,534 acres.

The crops grown above the ditch in Pondera County are the early and medium-early maturing varieties of small grains and forage crops. The more important small grains are wheat, flax, oats, barley, and

rye. Fall grains, except winter rye, winter-kill too frequently to be depended upon. The climate is too cool to mature the dent and semident varieties of corn in normal seasons. The small acreage devoted to corn is used chiefly for fodder and for hogging off. Flax usually produces satisfactory yields on new breaking and in some seasons a fair acreage is grown. Table 4 gives the acreage and yields of the more important crops grown in Pondera County since 1919.

Alfalfa, sweet clover, and brome grass are the chief forage crops grown on the dry-land farms. The yields of these legumes and grasses average rather low and the acreage devoted to these crops is small. The yields of root crops, such as potatoes, are fair in favorable seasons, but do not compare with those on the irrigated lands, except possibly for seed production.

On the larger grain farms, where 200 to 400 acres or more are annually in crops and an equal acreage is summer fallowed, the duckfoot cultivator and similar implements drawn by small tractors are used in preparing the land for spring seeding and for summer fallow. These implements are efficient in lowering the cost of production, destroying weeds, and producing a cloddy mulch. Small combines are used in harvesting the large grain fields.

Irrigation Farming.—The assessed irrigated acreage in Pondera County in 1930 was 85,625 acres, not including the irrigated land on the Blackfeet Indian Reservation. The small grains grown under the ditch are the medium late maturing varieties, except in the case of spring wheat. Alfalfa is the chief forage crop, with sweet clover grown on a small acreage for pasture and in short rotations. The soil and climatic conditions are favorable for the development of a type of agriculture in which grain, hay, and livestock are combined. Dairying is developing in a few localities and a small acreage of specialized crops, such as peas, is grown. Sugar beets produce fair yields on the lighter soils, but on the heavier soils the yields often are comparatively low. Small tractors and combine harvesters are found commonly on the irrigated farms.

SOIL PROBLEMS

Land utilization is one of the more important problems in Pondera County. The original homestead tracts are being consolidated slowly into larger and more economical farm units. On the large grain farms 2 to 3 sections or more often are under one operator, and

on the irrigated lands from 160 to 320 acres or more. The carrying capacity of the grazing lands requires from 5 to 10 sections to run 250 to 300 head of cattle.

DRY-LAND PROBLEMS.—A continuous rotation of spring wheat and summer fallow results in more or less soil drifting after the root fiber has been destroyed. All soils in the county are likely to drift when in the proper physical conditions. The drifting of the heavier loams usually occurs in the early spring before the surface of the land is crusted by the spring rains. Various cultural methods, such as ridging the land and leaving the stubble on the surface, are the chief means of controlling soil drifting at the present time. Strip farming and seeding the land to grasses and legumes are more effective in holding the soil in place and also increase the root fiber in the soils.

Variations of yields of small grains under similar cultural methods in different sections of the county are attributed usually to poor farming, low rainfall, and other uncontrollable factors. Analyzing the potential fertility of the different soil types indicates that soil fertility also may be a factor.

IRRIGATION PROBLEMS.—Irrigated crops grown on the heavier soils, such as the Scobey silty clay loams, often make a slow growth in the spring. Such soils probably would be benefitted by a rotation of small grains and legumes, which would induce better subsurface drainage and hasten the warming up of the soils in the spring. The physical condition of these heavy soils also would be improved by barnyard manures and the turning under of green manure crops. The phosphorus content of the soils is comparatively low for high average yields and the few tests that have been made indicate that such crops as sugar beets respond to phosphatic fertilizers. The maintenance of high average yields on irrigated land requires close attention to the fertility and physical condition of the soils.

Drainage is a problem on all the projects, and as irrigation develops, it will become more important. Some difficulty has been experienced in handling the heavier soil types and in irrigating the more level and poorly drained phases. Alkali is conspicuous in some of the seeped areas, especially where the soils are underlain at a comparatively shallow depth with shale. Other problems, such as the time of irrigating specialized crops like peas and sugar beets, are developing and will increase as the acreage of these crops is expanded on the different soil types.

IRRIGATION

The Valier irrigation project covers an irrigable area of 80,000 acres in the central part of Pondera County. A portion of this project was developed by the Conrad Brothers and in 1905 water was available for 44,000 acres. In 1908 Cargill and Withu organized an irrigation company to take over the Conrad holdings and also to reclaim an additional acreage under the Carey Act. The land on the reorganized project was opened for settlement in 1909 and at the present time the greater part of the acreage is improved. Water for the project is derived from the perennial flow of Dupuyer and Birch creeks, and from the flood waters of these streams stored in the Swift and St. Francis reservoirs. The more important soils on the project are the Scobey silt and silty clay loams and the Cut Bank loams, silty loams, and fine sandy loams. Most of these soils cover gently sloping areas, which are not difficult to irrigate.

The Badger-Fisher unit of the Blackfeet Indian reclamation project covers a large bench and a rolling area west of Birch Creek. The unit covers 30,000 acres, of which 16,000 are provided with canals and 9,000 acres with water. The Scobey silt and silty clay loams and the Joplin loams and sandy loams are the more important soils on the project. Serious drainage problems are likely to develop in the rolling area around the alkali lakes when the unit is developed.

The Birch Creek unit of the Blackfeet project covers a rolling area west of Birch Creek along the Glacier-Pondera county line. This unit covers 3,000 acres of which 2,200 acres are supplied with water. The Bainville loams predominate on the project and more or less difficulty will be experienced in irrigating and draining this rolling type.

The Bynum irrigation project, located in Teton County, supplies water for about 5,000 acres around Brady. The more important soils on the project are the Scobey silty clays, Joplin silty clays, and the Burton clay loams. These soils are heavy and rather low in organic matter and some difficulty has been experienced in their management. Nearly all the land has a smooth surface and is not difficult to irrigate. However, these soils have poor subsurface drainage and the lower levels are likely to become seeped with more intensive irrigation.

South of Dupuyer Creek and elsewhere in the western part of the county small tracts are also under irrigation along the perennial streams.

FUEL AND WATER RESOURCES

The agricultural development of some sections of Montana is influenced by the water and fuel resources. Most of Pondera County has a fair quality of water for domestic use, and coal and petroleum are available for fuel.

The Colorado shales underlie the drift in the eastern part of the county. Water from this formation usually is brackish and unfit for domestic use. In this part of the county water is obtained from the deeper deposits of drift and from flood water stored in small reservoirs. The glacial lake and stream deposits in the central part of the county are underlain with the Eagle and Two Medicine formations. Water from the shaly members of the Two Medicine formation is likely to be alkaline, but from the more massive sandstones an excellent quality of water for domestic use is obtained. Workable beds of coal are found in the upper part of this formation south of Valier. An excellent quality of water is found in the mountains and on the gravel-capped benches.

ACKNOWLEDGEMENT

The writer was assisted in the field work by Mr. Robert B. Tootell and Mr. Harry Noel, temporary assistants in the United States Bureau of Chemistry and Soils. The detailed survey of the Valier Irrigation Project was made in 1928 by Mr. Wm. De Young, assistant agronomist of the Montana Experiment Station, and others. The land classification map of the Northern Great Plains was obtained through the courtesy of the United States Geological Survey. Mr. Ralph O. Lund assisted in the preparation of the maps. The author wishes to express his appreciation of the cordial support accorded him by Mr. Blaine Ferguson, former county agent, officials of the Valier Montana Land and Water Company, bankers, business men, and county officials of Pondera County, and others who assisted in the preparation of the maps and manuscript.

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