

A Preliminary Report Upon
The Geography, Geology and Biology of Mellette,
Washabaugh, Bennett and Todd Counties,
South-Central South Dakota

State Geological and Biological Survey
Bulletin Number Five



ELLWOOD C. PERISHO, *State Geologist*
June, 1912



View down White River below the mouth of Pass Creek. Edge of a terrace in the foreground. Photo 1896 by Todd

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LETTER OF TRANSMITTAL

State Geological Survey,
University of South Dakota.

June 30th, 1912.

Hon. A. E. Hitchcock, President of the Board of Regents of
Education.

Dear Sir:

I herewith submit the accompanying articles for publication as Bulletin 5 of the State Survey. This bulletin treats of the Geology and Biology of four Counties situated in the South Central portion of the State. Two of them, Mellette and Bennett were opened for settlement last fall. Todd County is to be opened in 1912, and Washabaugh a little later. The State Survey considers this an opportune time to issue this report for the benefit of the new settlers in that portion of the State.

Very respectfully,

ELLWOOD C. PERISHO,
State Geologist.

TABLE OF CONTENTS

	Page
Title Page	1
Regents of Education	3
Letter of Transmittal	5
Table of Contents	7
List of Illustrations and Maps	9
A Preliminary report on the Geography of Mellette, Washa- baugh, Bennett and Todd Counties	11
A Preliminary report on the Geology of this area by the State Geologist and S. S. VISHER.....	31
A Preliminary Report on the Biology of this area, by STEPHEN SARGENT VISHER	60
The Biennial report, 1910-1912, By the State Geologist.....	131
Index	137
Advertisement of Bulletins of the Survey.....	153

LIST OF ILLUSTRATIONS AND MAPS

Plate 1	White River below Pass Creek	Frontispiece
Plate 2.	Indian Ranch in Bear Creek	opp. p. 11
Plate 3.	"A Good Ranch Country."	opp. p. 11
Plate 4.	Claim Shanty near Inlay	opp. p. 13
Plate 5.	Indian Buildings, Bennett County	opp. p. 13
Plate 6.	A Flat Topped Butte	opp. p. 15
Plate 7.	A Talus Block	opp. p. 15
Plate 8.	Blow-outs near Norris	opp. p. 17
Plate 9.	Valley Water Holes	opp. p. 17
Plate 10.	White River at Low Water	opp. p. 18
Plate 11.	White River at High Water	opp. p. 18
Plate 12.	Rolling, Sage-decked Land	opp. p. 20
Plate 13.	Incipient Badlands	opp. p. 20
Plate 14.	A Good Cattle Country (Bear Creek)	opp. p. 22
Plate 15.	Badlands of Cottonwood Creek	opp. p. 22
Plate 16.	Brule Beds showing Banding	opp. p. 45
Plate 17.	Flats in the Badlands	opp. p. 45
Plate 18-19.	Badland Erosion	opp. p. 47
Plate 20.	Dyke in Badlands	opp. p. 48
Plate 21	Vein in Badlands	opp. p. 48
Plate 22-23.	Exposures of Badland Shales	opp. p. 49
Plate 24-25.	Reworked Badland Materials	opp. p. 50
Plate 26-27.	Harder Layers in Badland Beds	opp. p. 51
Plate 28-29.	Peculiarities of Surface of Badlands	opp. p. 52
Plate 30.	View across Cottonwood Creek showing Terraces	opp. p. 53
Plate 31.	A Butte, showing both Pierre Shale and Tertiary	opp. p. 53
Plate 32.	Skulls of common fossils	opp. p. 55
Plate 33.	Cottonwood grove	opp. p. 61
Plate 34-36.	Seven conspicuous plants of this region	opp. p. 66, 70
Plate 37.	Succession from grassland to woodland	opp. p. 74
Plate 38-40.	Two abundant composites and two bad- land plants	opp. p. 74, 76
Plate 39, 41, 42	Views in the Sandhills of Bennett County	opp. p. 76, 80

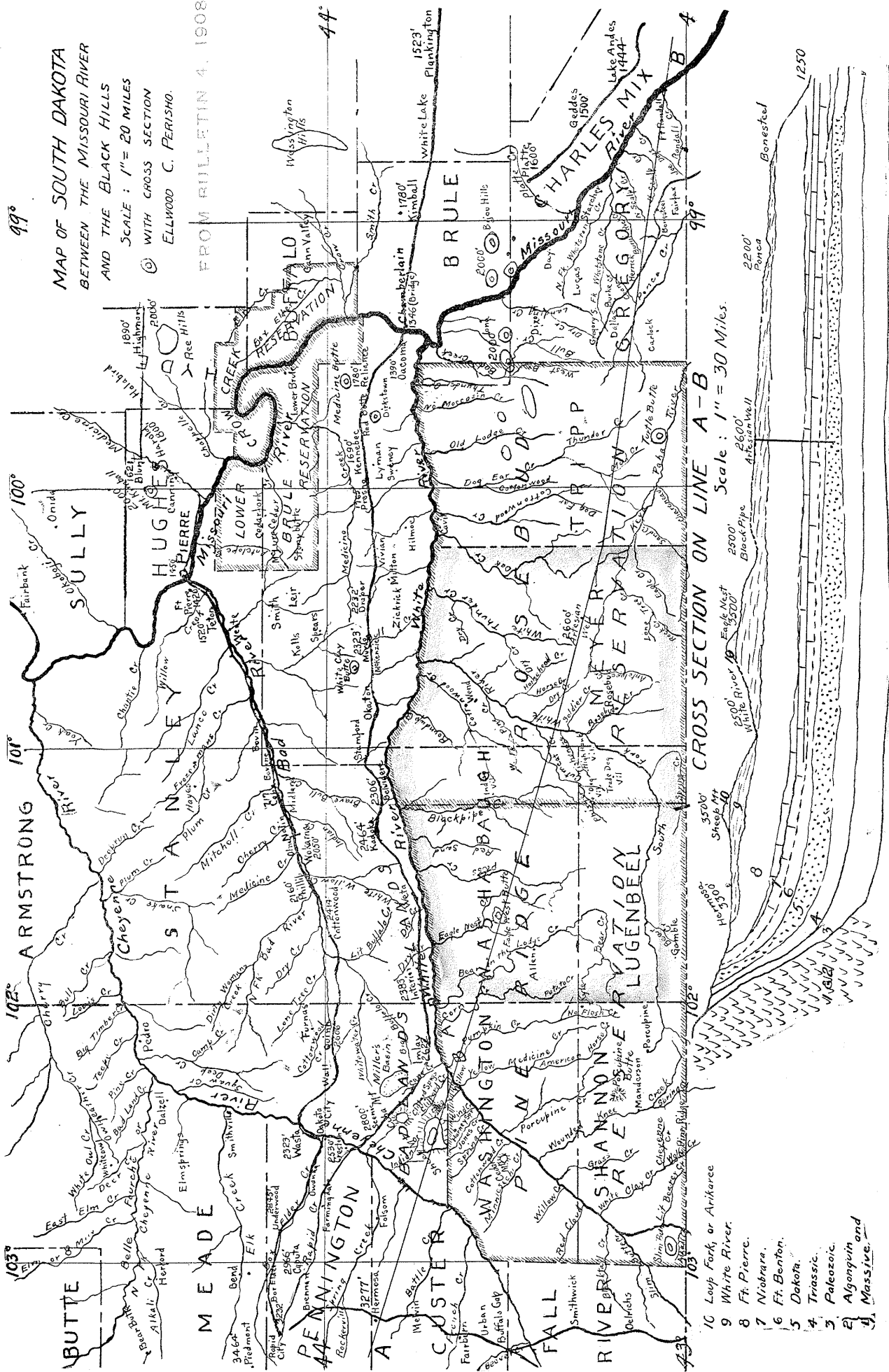
List of Illustrations and Maps—Continued

- Plate 43. Cottonwood Canyonopp. p. 78
Plate 44. Nests of a colony of badland Cliff Swallowsopp. p. 78
-
1. General Mapopp. p. 10
2. Local Mapopp. p. 14
3. Soil Mapopp. p. 31
4. Geological Map p. 43
5. Map of Pine Ridge Reservation p. 110
Chart of Geological formations p. 58

MAP OF SOUTH DAKOTA
AND THE BLACK HILLS
WITH CROSS SECTION

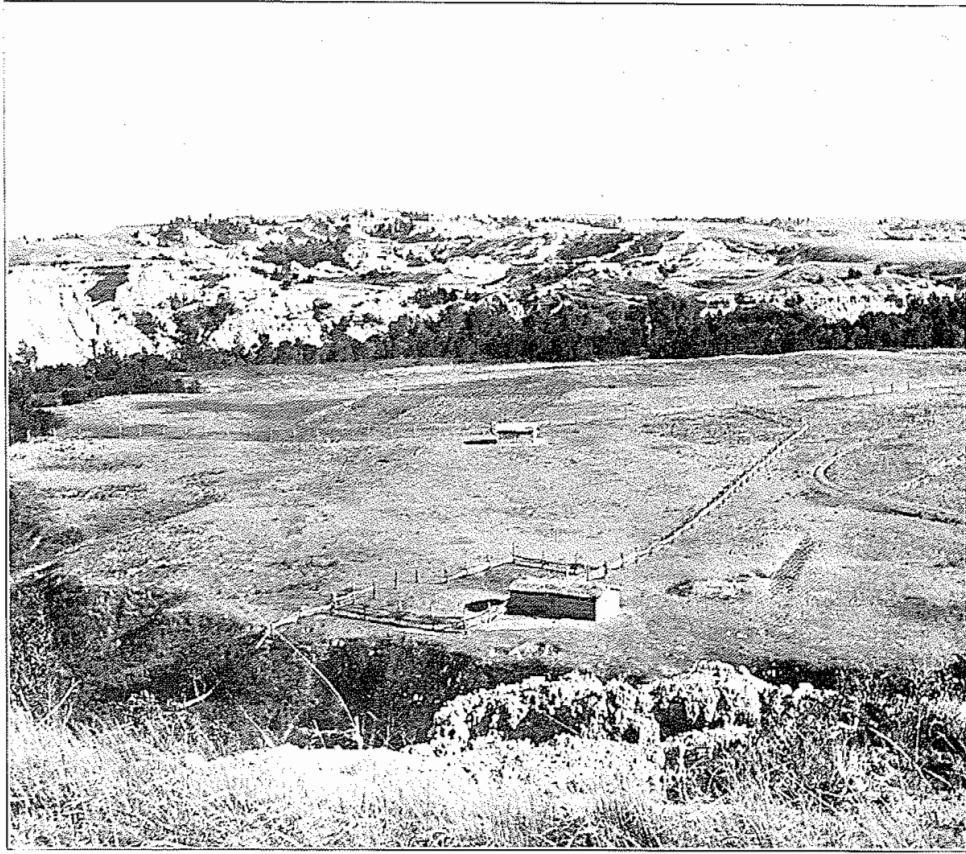
SCALE : 1" = 20 MILES
WITH CROSS SECTION
ELLWOOD C. PERISHO.

FROM BULLETIN 4, 1908.



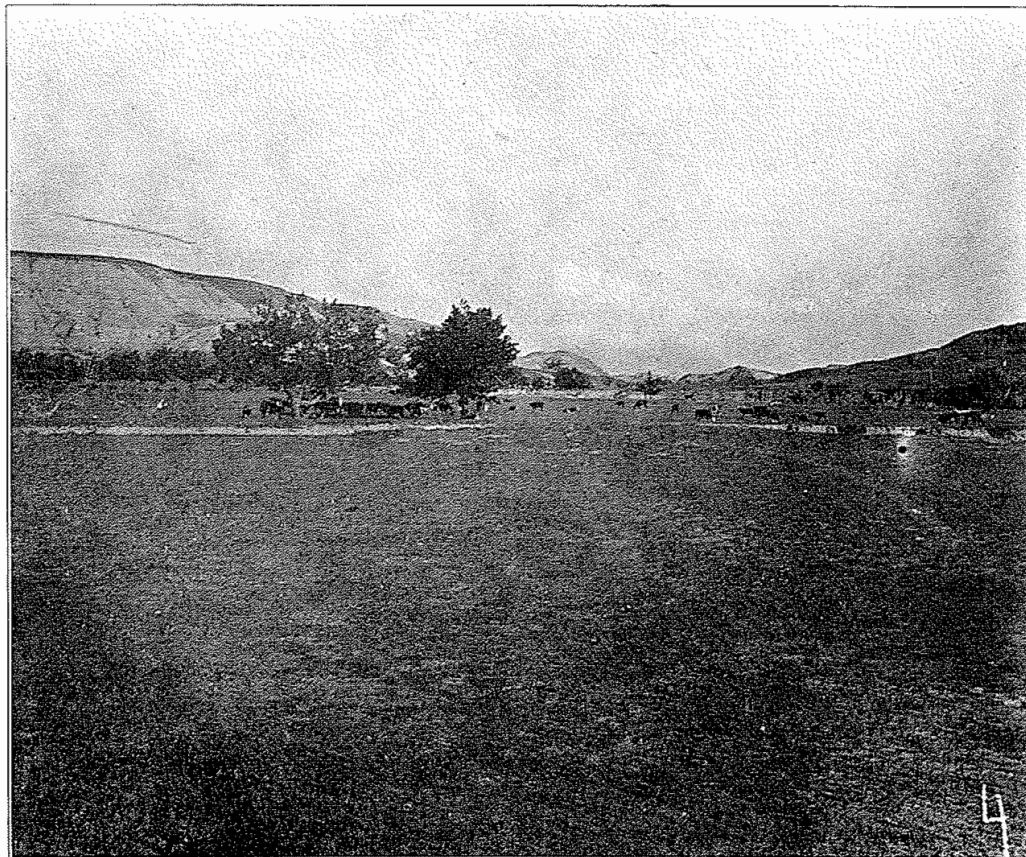
CROSS SECTION ON LINE A-B
Scale : 1" = 30 Miles.

- 10 Loop Fork, or Arikaree
- 9 White River.
- 8 Ft. Pierre.
- 7 Niobrara.
- 6 Ft. Benton.
- 5 Dakota.
- 4 Triassic.
- 3 Paleozoic.
- 2 Algonquin and
- 1 Massive.



A portion of Bear Creek valley showing an Indian ranch.

Plate 3



A good cattle county. A view of a small Badland valley.

A Preliminary Report Upon the Geography, Geology and Biology of Mellette, Todd, Bennett and Washa- baugh Counties, South-Central South Dakota.

INTRODUCTION

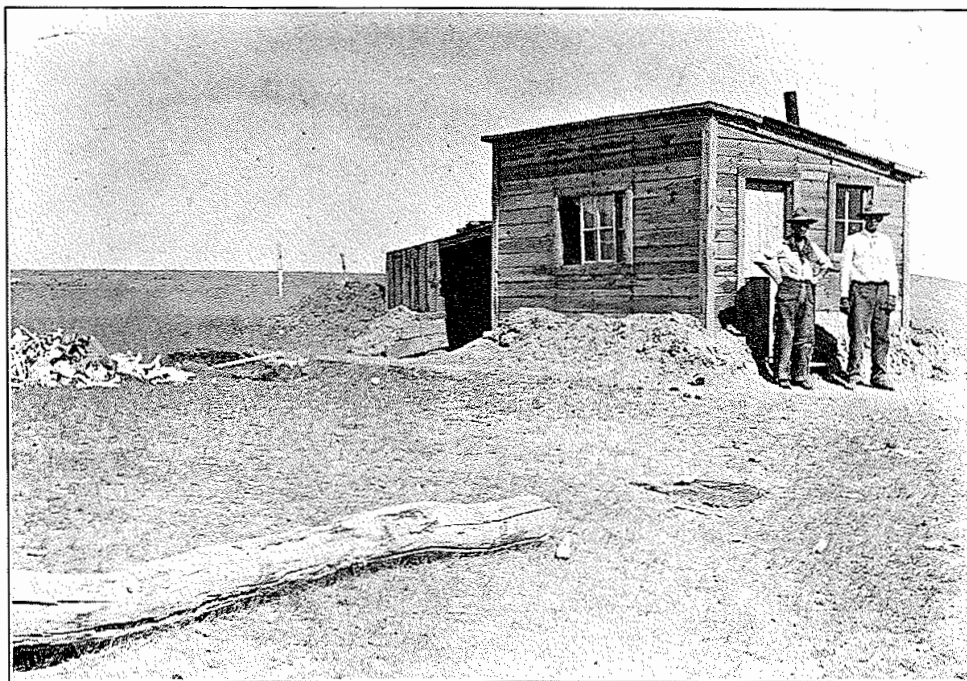
The Geography of the Area

	Page
I. Location, Size, etc	14
II. General Topographic Features	14
1. The Plains, their Elevations	14
2. The Buttes, their Origin	15
3. The Streams and their Valleys	17
(a) <i>Drainage</i>	17
(b) <i>Waterholes</i>	19
(c) <i>Chief Valleys</i>	18
4. Badlands	19
5. The Sandhills	20
III. Climatic Conditions	20
1. Comparative	20
2. Data for Precipitation, Temperature, Wind and Cloudiness	22

The Geology of This Area

I. The Soils—Distribution of, Agricultural Description of and Derivation of	31
1. Rosebud Loam	31
2. Rosebud Sandy Loam	34
3. Pierre Clay	35
4. Dunesand	38
5. River Bottom Soils	39
II. The Subsoils, Brief Description and Derivation of....	39
III. The Country Rock of this Area	41
1. Shale, Sandstone, Limestone	41
Characteristics and Mode of Formation	42
IV. The Rock Formations	42
1. Sections	42

2.	Pierre Shale	43
	(a) <i>Distribution</i>	43
	(b) <i>Physical description</i>	43
	(c) <i>Fossil content</i>	44
	(d) <i>Structure</i>	44
	(e) <i>Thickness</i>	44
	(f) <i>Manner of deposition</i>	45
	(g) <i>Age</i>	45
3.	White River Formation—Chadron, Brule.....	45
	Introductory	45
	<i>a to g</i> as under Pierre Shale	46
4.	The Rosebud Beds	49
	<i>a to g</i> as under Pierre Shale	49
5.	More recent deposits, Harrison and Equus Beds ...	53
V.	The Geological History of this area	54
	1. Cretaceous Period	54
	(a) <i>Dakota Epoch</i>	54
	(b) Benton and Niobrara.....	54
	(c) <i>Pierre</i>	55
	(d) <i>Fox Hills to Eocene</i>	55
	2. Oligocene Period.....	55
	3. Miocene Period	55
	(a) <i>Lower</i>	55
	(b) <i>Middle</i>	56
	(c) <i>Upper</i>	56
	4. Pliocene Period	57
	5. Pleistocene Period	57
	6. Recent	58
	7. The development of the present topography	56
VI.	Notes on the Mineral Resources	58
	1. Underground water supply	58
	(a) <i>Artesian wells</i>	58
	(b) <i>Shallow Wells</i>	59
	(c) <i>Springs</i>	59
	2. Clay	60
	3. Building Stone	60
	4. Fuller's earth, Barite, Sapphire, etc.	60



A claim shanty. Dried bones are sold as a fertilizer, hence the pile.



A rather typical reservation view: two Indian houses, the old one, sod covered; two pony sheds, a corral and woodpile, located on the grassy margin of a wooded valley where there is no danger from floods and where the breeze will tend to keep away the mosquitos. The arched sticks in the right foreground are the frame work of an Indian style of Russian bath. Churches erected for the Indian are almost always placed on the hilltops and one or more are visible from each group of settlements.

INTRODUCTION

Mellette and Todd Counties were the Rosebud Reservation until 1911 when Mellette County was opened for homesteading. Washabaugh and Bennett Counties formed the eastern half of Pine Ridge reservation until 1911 when Bennett County was opened. Todd County is scheduled to be opened in 1912 and Washabaugh County in 1913 or 1914. The Rosebud and Pine Ridge reservations were created by the treaty of 1875. Before that date they were parts of a larger reservation.

Exploration in this region commenced at an early date. By 1803 the White River had been ascended. From 1853 for many years military parties from Fort Kearney in Nebraska and other forts to the southward crossed this region in going to Fort Pierre, Fort Lincoln and other northern forts.

The badlands of this general region have attracted many scientific parties during the past half century, but these counties were studied but little.

In 1896 Professor J. E. Todd, then state geologist, passed through Todd and Bennett Counties and made some notes on the geology which were published in Bulletin 2 of the South Dakota State Survey.

A. B. Reagen taught one of the Rosebud Indian schools during 1904-5. An account of his geological observations was published in the October, 1905 "American Geologist."

In 1909 this portion of the state was mapped by the Bureau of Soils. The accompanying soil map is based largely upon their work. Their report is now "out of print."

During July and August, 1911, a state survey party under the direction of the state geologist visited most of the area under consideration. The members of this party were Prof. S. S. Visser, R. W. Chaney and A. B. Helms.

The State Geologist has done field work in several adjacent counties. In 1900 and 1905 what are now Gregory and Tripp counties were visited.* In 1907 and 1911 the Bad Lands in the vicinity of Sheep Mountain were studied. Mr. Visser spent a month in the badlands of south-western Stanley County and visited Mellette County in 1908. In 1911 he made a reconnois-

*See the paper in Bulletin 4. S. D. Geol. Survey on a preliminary report on the Geology of Gregory and Tripp Counties, S. D.

sance trip across Washington, Shannon and Fall River Counties and saw something of Tripp and Gregory Counties.

Geography of the Area

1 THE LOCATION AND SIZE

These four adjacent counties are located in the south-central part of South Dakota between the White River, (the north boundary) and the Nebraska line, (the south boundary) just west of Tripp County and east of Washington and Shannon Counties. They extend from slightly west of the 100th. meridian west to slightly beyond the 102d a distance of nearly one hundred miles. The south boundary is the 43° parallel and north approximately $43^{\circ} 45'$, giving a width of about fifty miles. The adjacent counties to the north are Lyman, Stanley and Pennington. Cherry County, Nebraska, lies to the south.

Bennett and Todd Counties are at the northern edge of the "high plateau" part of the great plains. Mellette and Washabaugh Counties are on the slope from this plain to the White River valley.

With regard to *railroads* these counties lie between the C. M. & St. Paul, to the north just across the White River, and the C. & N. W. R. R. in Nebraska to the south. The nearest railroad to the west is over fifty miles distant. A branch of the C. & N. W. is expected to soon enter Mellette County from the east and a spur from Cody, Nebraska into Bennett County is rumored.

Size—These four counties have a length of nearly one hundred miles and an average width of over fifty miles, giving a total area of about 5,000 square miles, or about the size of Connecticut, and twice the size of Delaware or four times that of Rhode Island. Five thousand square miles is equivalent to over 3,000,000 acres or 20,000 quarter sections.

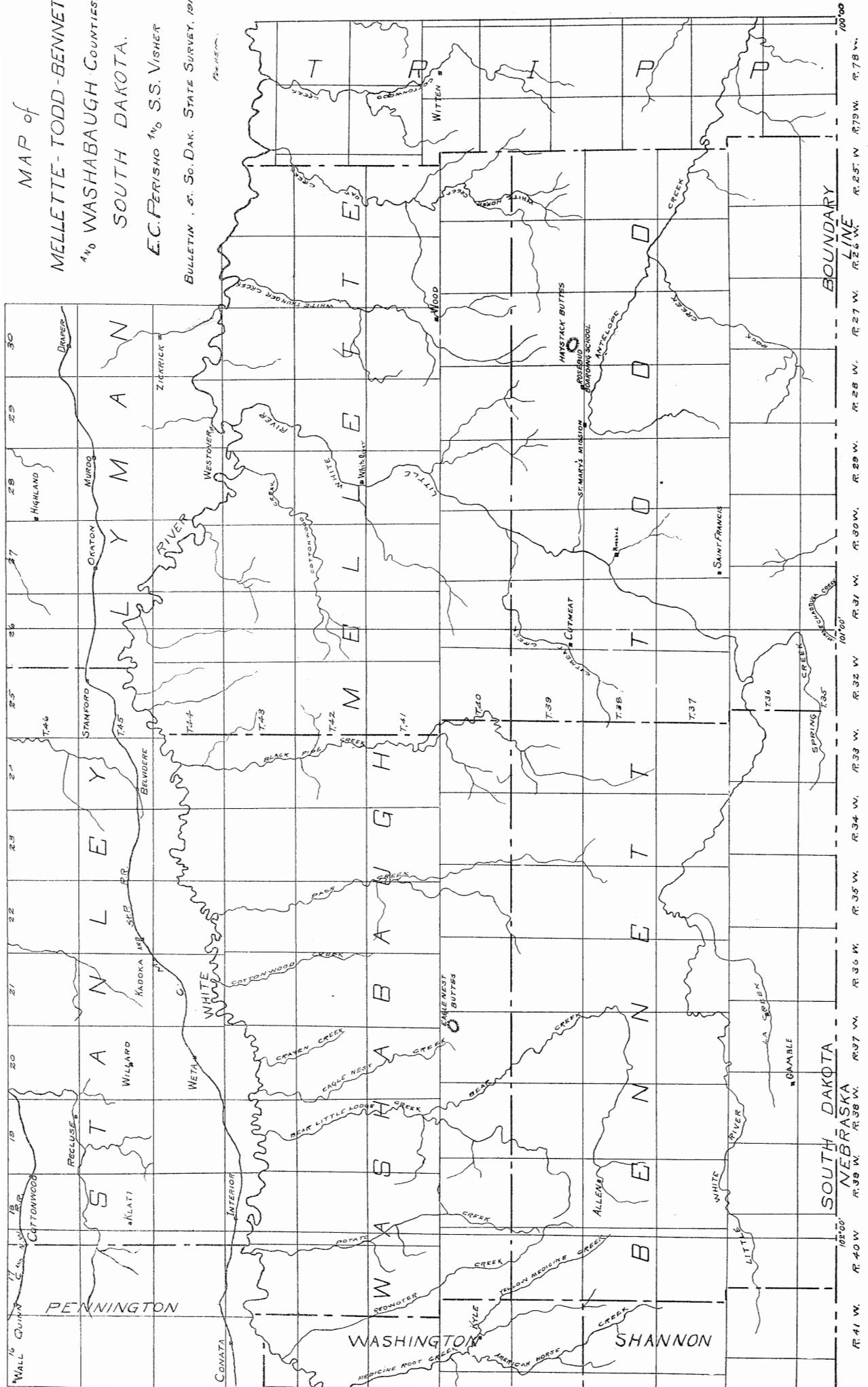
II. GENERAL TOPOGRAPHIC FEATURES

1. THE PLAINS. The higher parts of the counties are portions of the great plateau which extends southward across western Nebraska and Kansas. This plain slopes from the Rocky Mountains towards the Missouri and Mississippi rivers. In South Dakota this plateau has been largely destroyed by erosion of active streams, the White River, the Cheyenne, the Moreau and the Grand. Except in the two more southern counties now considered it is represent-

MAP of
 MELLETTE-TODD-BENNETT
 1/40 WASHABAUGH COUNTIES,
 SOUTH DAKOTA.

E.C. PERISHO 1/10 S.S. VISHAY

BULLETIN, ST. SO. DAK. STATE SURVEY, 1912.



BOUNDARY

SOUTH DAKOTA

NEBRASKA

103°00' R. 40 W. 102°00' R. 41 W.

101°00' R. 39 W. 100°00' R. 38 W.

R. 37 W.

R. 36 W.

R. 35 W.

R. 34 W.

R. 33 W.

R. 32 W.

R. 31 W.

R. 30 W.

R. 29 W.

R. 28 W.

R. 27 W.

R. 26 W.

R. 25 W.

R. 24 W.

R. 23 W.

R. 22 W.

R. 21 W.

R. 20 W.

R. 19 W.

R. 18 W.

R. 17 W.

R. 16 W.

R. 15 W.

R. 14 W.

R. 13 W.

R. 12 W.

R. 11 W.

R. 10 W.

R. 9 W.

R. 8 W.

R. 7 W.

R. 6 W.

R. 5 W.

R. 4 W.

R. 3 W.

R. 2 W.

R. 1 W.

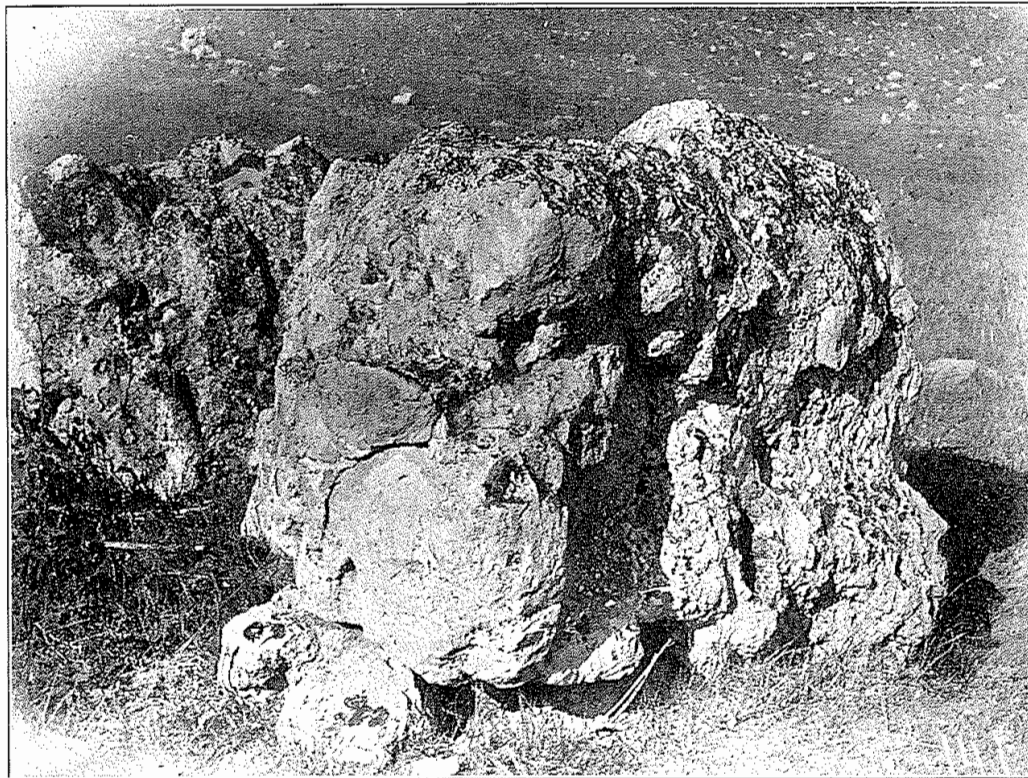
R. 0 W.

R. 0 W.

R. 0 W.



A flat topped butte: The harder layers and splendid talus slopes are evident.
The trees are bull pines. Plate 7



A large talus block, a portion of the hard cap rock of a disappearing butte, which has rolled well down the slope. The rock is limestone. The dark patches are various lichens.

ed only by the tops of the higher buttes such as Eagles Nest, Two Top, and Turtle. Bennett and Todd Counties are on the northern edge of this plateau and have large approximately level areas. Only relatively small portions have been yet so cut up by streams as to be rough enough to prevent agriculture. Aside from this highest plain there are large tracts in the two northern counties which slope quite gently from the edge of this plateau towards the White River. This slope is now being vigorously attacked by the tributaries of the White River, so that it is here and there rather rough.

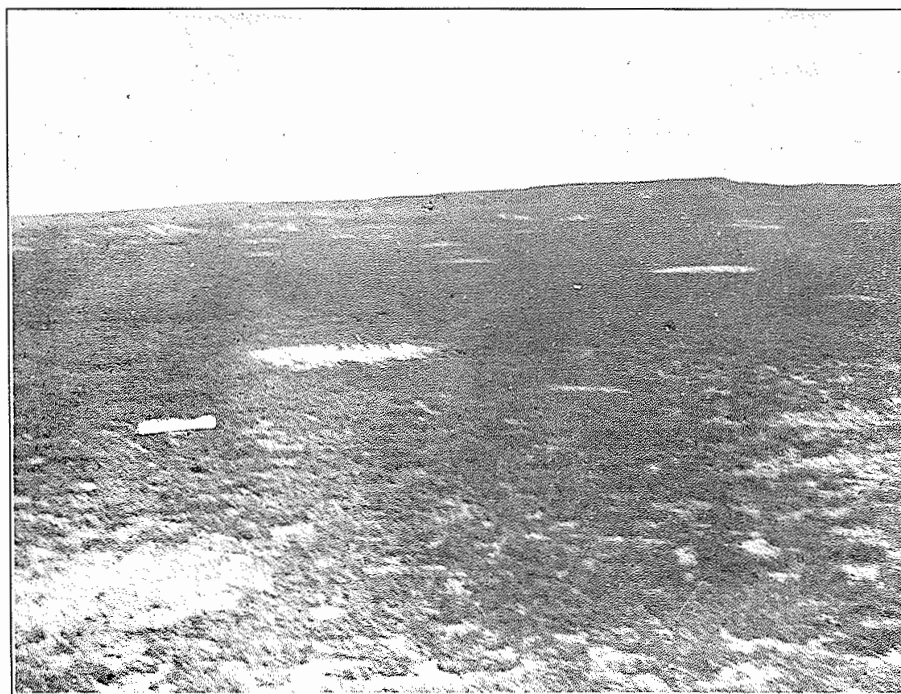
Five *penneplains* or partial plains are in evidence in this region. The oldest and highest is represented by the highest hills standing on the second or great plain mentioned in the preceding paragraph. The third is the higher slope towards the White River. The tops of Sheep Mt., Cedar Butte, Bigfoot Butte etc. belong to this penneplain. The fourth is the broad flat along the tributaries of the White River, and the terrace a hundred feet or so above the White River on which Kadoka and other railroad towns are located. The fifth is the flood plain of the White River and its tributaries. For a fuller discussion of this topic see "The Development of the Present Topography."

2. THE BUTTES. As mentioned above the buttes are remnants or outliners of the high plateau. To one looking southward from the far north toward Eagles Nest and other buttes this is not very evident because the eye is deceived by the slope from their base towards the White River. We unconsciously fail to realize how much slope there is and assume that these buttes are standing upon an almost level plain. If from the plateau one looks north beyond the buttes the true relationship of the buttes to the plain is readily discernible. From the plain are noted ridges or "divides" which extend out between the valleys. One can readily see that these ridges are frequently cut partly across giving rise to a series of hills which after they have become somewhat isolated from the rest of the upland by the carrying away by the streams and the wind of the soil and rock around them become more or less conspicuous and are called buttes. Hence Eagles Nest and other buttes in this region are not of volcanic origin, nor made by a great earthquake, or upheaval as is locally believed, but by the gradual wearing away of surrounding regions.

Why the spots which are now buttes should have worn away less rapidly than the surrounding areas is due to one of two reasons or combination of the two. (1) Between valleys there are ridges. Why the valleys should have been cut just where they are instead of where the ridges now are may have been due to chance. Side valleys cut into the ridges and form hills. Valleys are not all equally effective in their work, so some small valleys grow larger and faster than others, and as a result between these more effective valleys are left portions of the original divide or "spur" which may come to stand out conspicuously enough to be known as a butte. Ordinarily before the surrounding locality is brought relatively low, such an ordinary hill as the one considered will have also been greatly eroded.

(2) If a portion of the plain should have a layer of rock beneath its surface, which is notably more resistant to erosion than the nearby surrounding portions, this hard layer would act as a protection to the underlying layers and as a result the surrounding portions would be eroded before the protected part, which might then form a butte. In this region most of the larger buttes are topped or capped with horizontal harder layers or "cap rock," usually a layer of firm sandstone or a layer of quartzite often called flint. It is believed that when the clay was being laid down over this region there were streams with sandy stretches in their channels. This sand in some cases was cemented into sandstone. Occasionally there were pools in which lived minute plants and animals and also larger plants such as the pond weeds, *Chara*, *Equestium*, etc. all of which had silica for their shells and supports. In some cases beds of flint were thus formed. Since these sand pockets and flint-forming-pools were in the lowlands of that ancient surface it is evident that the surrounding higher areas had to wear more than the protected layers in order to have the buttes stand out a couple hundred feet higher than the surrounding plains as they do now. What was once relatively the highest areas are now the lowlands, and the butte tops which were once the lowlands are now, by the great erosion of the surrounding areas the highlands.

Everyone who has climbed the side of a butte will have noticed that the cap rock is being undermined and great slabs of it are rolling or sliding down the sides, forming talus slopes.



The white patches are small, dry blowouts on the Rosebud formation in central Mellette Co. Similar blowouts are frequent.



Photo in Gregory County, 1905, by Perisho.

Valley waterholes, made in even such gentle valleys as this, in times of "cloudbursts."



White River near the mouth of Bear Creek at low water.

Plate 11



Crossing the White River southeast of Kadoka "when the river is up."
The trees on the further bank are cottonwoods.

This causes the flat on top to become progressively smaller. Finally all of the cap rock will be broken up and a pointed butte will result. After the disappearance of the cap rock the butte is soon largely worn away and in this way even our most prominent buttes are rapidly (geologically considered) being destroyed.

III. THE STREAMS AND THEIR VALLEYS.

(a) *Drainage.* By far the greater part of this area is drained by tributaries of the White River. The Little White River is the most important and drains nearly one-third of the area. Other large tributaries of the White River here are, named from east to west, Oak Creek, Black Pipe Creek, Pass Creek, and Bear Creek. For the names of smaller tributaries see the map.

Most of Todd County is drained by tributaries of the Keya Paha River which is itself a tributary of the Niobrara River. A small part of this county is drained by another tributary of the Niobrara, the Minnechaddusa creek.

These streams and many smaller ones quite thoroughly drain these four counties. The water after a rain runs off very rapidly. The tributaries of the White River are therefore subject to frequent floods and are often unfordable. Except in extremely high floods, ordinary bridges would entirely do away with this difficulty. All of the larger streams flow permanently and except during and just after rainstorms their water is very clear and of excellent quality.

(b). *Water Holes* are quite numerous in these counties and except during the severest droughts there is plenty of rain water available for range stock. The water holes are of three sorts. The most abundant are small depressions that have been blown out by the wind. These are usually only a few yards across and a few inches deep, though sometimes attaining to an extent of several acres or more and a couple of feet deep. Sometimes the larger ones are locally called lakes. The prevalent direction of their longer axis is northwest-southeast, from which directions come the stronger and more frequent winds during the seasons when the surface is dry and most easily excavated. Valley water holes are also very abundant, especially in the upper, shallower, parts of valleys. During times of very heavy rains or "cloud bursts" even these gentle valleys are filled with a torrent

which locally cuts out pockets. These pockets contain water for quite a while after a shower.

Several "lakes" have been formed in Bennett County by the damming of valleys by deposits which were once wind blown.

(c). *Valleys Proper*. 1. The Big White. The flood plain of the "Big White" is about a mile wide and has a good growth of cottonwoods which indicates an abundant supply of ground water not far from the surface. This is also shown by the crops grown. About a hundred feet above the flood plain there is a terrace or bench, sometimes several miles wide which frequently is quite even and as far as topography is concerned, excellent farming land.

2. The Little White. The lower, middle and upper sections of the valley of the Little White River differ greatly. In Bennett County the valley is quite shallow and relatively wide and free from groves. In the middle portion it is canyon-like; almost vertical cliffs of a height of three hundred feet or more occur; the bottom is narrow and the stream very swift; oak, pine, elm, as well as cottonwood grow in the narrow bottom, and the bluffs are more or less covered with pine and oak. The lower course of the river flows through a valley about a mile wide, a hundred feet above which is a terrace often a couple miles wide.

The valleys of Oak, Black Pipe, Pass, Bear Creek and many others have in their lower courses a broad level stretch through which the stream has cut a narrow, deep channel. Where the streams cross the badland formations the valley is more canyon-like and there are typical badlands. Throughout the greater portion of their course the valleys are quite broad and even and the channel occupied by the stream is usually shallow.

Elevations

BENNETT COUNTY.

Average 3300 Feet.

Highest (Central West) 3500 feet.

Lowest (Along Pass Creek and Little White) 3,000 feet.

WASHABAUGH COUNTY.

Average 2,800 feet.

Highest (Southern) 3,300 feet.

Lowest (North east corner) 2,100 feet.

TODD COUNTY.

Average 2,600 feet.

Highest (Western and South-Western) 3,000 feet.

Lowest (N. W. on Little White, S. E. on Oak Crk.) 2,200 feet.

MELLETT COUNTY.

Average 2,200 feet.

Highest (Black Pipe—Little White Divide, Little White-White Thunder) 2,700 feet.

Lowest (White River in N. E. part) 1,700 feet.

Badlands are locally well represented in the two northern counties especially in Washabaugh. The tributaries of the White River in this area all cross the White River (Oligocene) formation, the erosion of which frequently gives rise to badlands. Badlands are not worthless lands; this is illustrated by plate 17 and proved by many farms and ranches. They were so-called because they were found by the early explorers to be hard to cross. This is due to three main characteristics. (1). The slopes are usually very steep, too steep to ascend or descend with a wagon so that "the walls" and "jump offs" offer great obstacles to travelers unfamiliar with the region. (2). The small gulleys frequently have vertical banks, and in the absence of bridges it is often necessary to go considerable distance in order to cross these valleys. (3). Surface water in the badlands is usually scant and uninviting to say the least, though not harmful. Shallow wells generally have good water.

The topography of the badlands—and South Dakota badlands are type badlands—is very interesting. The sculpturing is fascinating and suggests cathedrals, towers, statuary, the billows of an ocean and what not. The accompanying views of Mellette and Washabaugh County badlands will show several types of erosion. The series (plates 13-17) showing the developmental history of badlands is especially illuminating.

Badlands are developed when certain conditions are combined. The rainfall must occasionally come in heavy showers or cloudbursts. The beds of a badland area are usually clays or shales with only relatively thin layers of sandstone or limestones. The Tertiary clays, especially the Oligocene clays, seem to be the most favorable, though the badland type of topography

is developed in semi-arid regions in representatives of many formations.

Upon the steeper slopes of the badlands there is but little vegetation. This is due to (1) the rapid drying up and severe crumbling of the clay following a shower, thus preventing the growth of seedlings. (See plate 29) (2) During the occasionally severe rain storms the slopes are worn away so quickly that those plants which have obtained a start are undermined and usually killed.

The lack of vegetable cover expose to view clays etc. which are often gayly colored. These varied tints usually reds, salmons or yellows, but often purples or whites, add greatly to the attractiveness of our badlands.

The Sandhills. The area along the Nebraska line shown on the soil map as Dunesand is popularly called "the sandhill country." This district, as also that considerable portion of western Nebraska which is covered with sand hills, is less adapted to farming than to grazing. For stock raising it is excellent, the grasses being varied and abundant, and water and shelter plentiful.

The sand of which these hills are composed is derived from the sandy or sandstone layers in the upper portions of the Rosebud beds. At present only in regions which have been over pastured, burned over or wrongly cultivated is there much moving sand. Elsewhere the hills are held somewhat stationary by the vegetation.

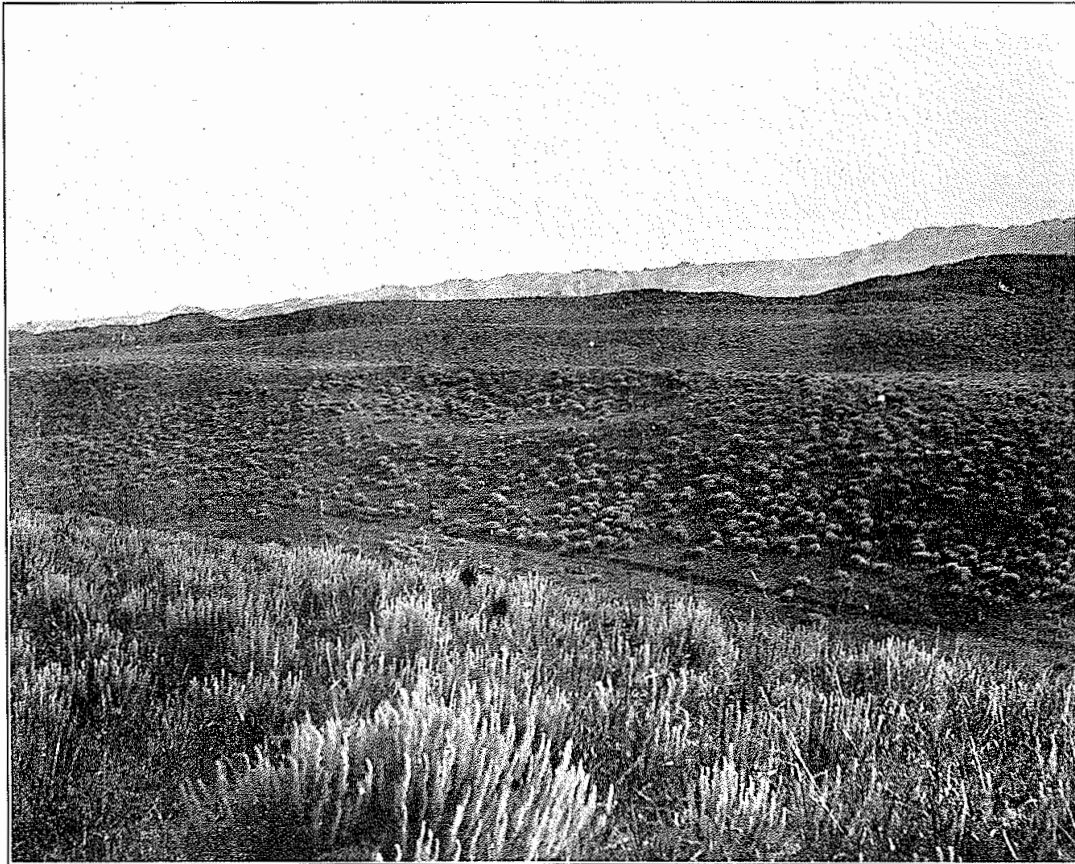
The topographic relief is slight except about its borders where valleys having a depth of a hundred feet or so occur.

V. CLIMATIC CONDITIONS

1. COMPARATIVE. Climatic Conditions are usually expressed in the terms of precipitation, temperature, wind and cloudiness.

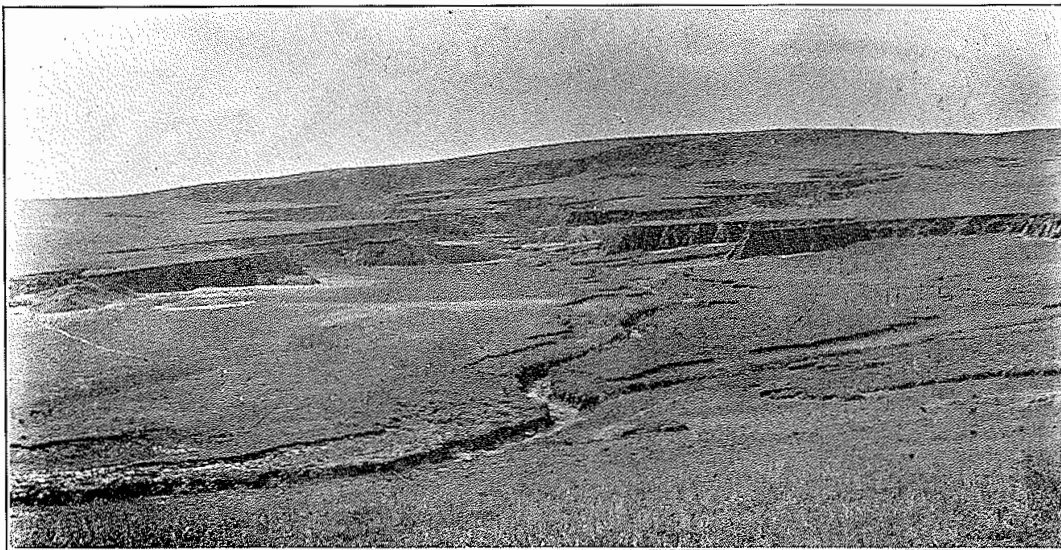
We usually think of the annual amount of precipitation as the important thing agriculturally, but the amount is not nearly as important as the distribution. Many areas have a greater total amount of rainfall than western South Dakota. The average total rainfall of these counties is about eighteen inches a year.

Even twelve inches a year is an abundance of rainfall if it comes at just the right times. The precipitation which falls during the autumn and winter is only of comparatively slight



A good grazing country. Rolling land near the badlands. The clumps of vegetation is mainly herbaceous sage (*Artemisia frigida*.)

Plate 13



Beginning the development of a badland topography. This slope has just recently been thus cut up.

value when there is a normal amount of rain in the growing season. The reason why most farmers are so pleased to have heavy rains in the fall is that they realize if the rainfall in the spring should be deficient the moist condition of the soil would enable the crops to start.

The amount of rainfall during the five growing months is almost always considered to be indicative of the agricultural practicability of an area. These counties receive on an average a good share of their precipitation during these five months.

Ten inches of rain during the growing season is usually believed to be sufficient, but again, almost everything depends on its distribution. This amount of rainfall to be sufficient must fall in several well distributed showers. Ten inches of rainfall would obviously be insufficient if it fell as two or three down pours of say three inches each and there were several weeks without rain.

Even if two inches of rainfall fell each fortnight for the five growing months its effectiveness would depend to a large degree on whether it fell as one heavy shower most of which ran off, as many slight showers which scarcely soaked in and consequently were soon evaporated or in one steady shower of an inch of precipitation each week of the fortnight.

So we see that favorable statistics showing the average total rainfall or even the average rainfall for the five growing months are very apt to be deceiving. In this area though the total amount of rainfall is almost always quite abundant the distribution of the rainfall is often not what we could wish. However, there is very little doubt but that in regard to effectiveness of the precipitation this region is more fortunate than the nearby counties to the west or north.

2. DATA FOR PRECIPITATION, TEMPERATURE, WIND AND CLOUDINESS.

TAKEN FROM REPORTS OF U. S. WEATHER BUREAU.

ROSEBUD, TODD COUNTY, S. DAK.

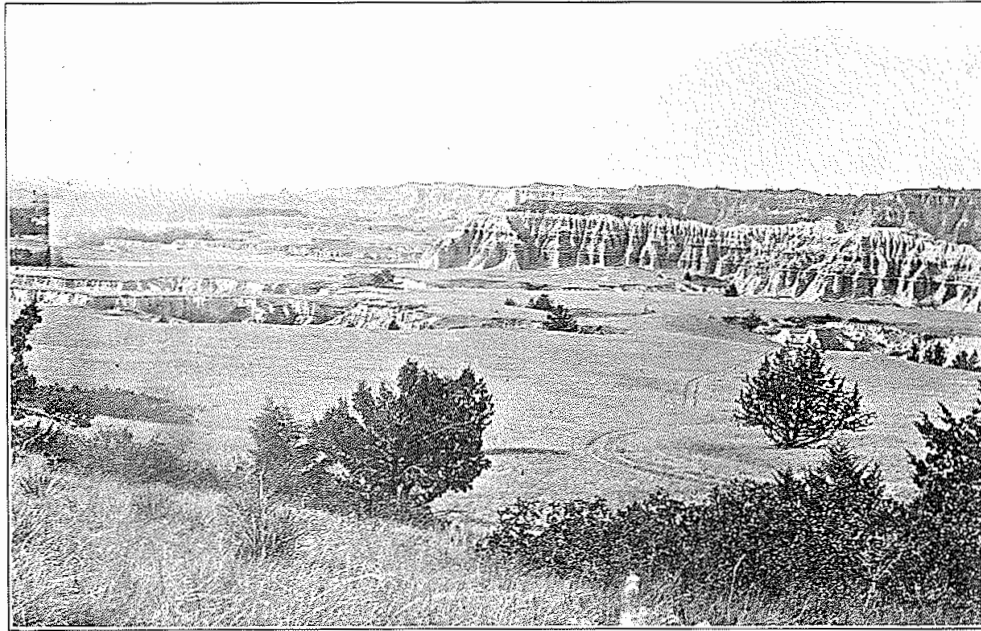
(Elevation, 2600 feet)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1892	.....	.....	.....	4.18	5.10	4.48	1.38	4.19	0.19	3.24	0.40	0.80	.....
1893	1.00	0.75	1.50	1.94	2.40	1.69	1.84	0.95	0.08	0.34	1.20	1.97	15.66
1894	1.50	0.80	2.46	4.33	0.27	2.50	0.89	1.30	0.44	0.44	0.18	0.10	15.21
1895	1.20	0.40	0.92	2.74	1.28	3.99	0.59	0.86	0.67	T.	0.60	0.30	13.55
1896	0.50	0.50	2.40	3.04	0.53	4.00	6.03	1.61	2.98	0.40	1.60	0.85	25.04
1897	2.30	1.12	1.50	2.87	3.02	1.47	2.50	2.90	0.47	0.50	0.85	2.40	21.90
1898	1.20	0.15	1.20	1.41	3.98	0.60	2.77	0.98	0.35	0.08	0.30	0.20	13.22
1899	0.96	0.60	1.90	1.31	1.74	2.00	1.45	0.77	0.20	0.76	0.20	1.30	13.19
1900	0.20	0.90	0.60	2.69	1.03	2.35	6.10	2.32	1.50	1.00	0.60	0.60	19.89
1901	0.10	1.10	2.60	2.66	1.54	7.52	1.84	2.75	1.23	1.07	0.04	0.33	22.78
1902	0.20	0.43	0.48	1.12	1.87	2.51	1.44	3.08	0.58	0.76	0.31	1.90	14.68
1903	0.20	0.50	0.53	2.10	2.41	1.17	3.80	3.00	1.00	0.15	0.45	1.55	16.86
1904	.....	0.70	0.30	0.60	1.65	4.26	5.30	0.51	.....	T.	.....	.....	.....
1905	.....	.....	.....	.....	.....	.....	.....	.....	1.46	1.60	0.47	T.	.....
1906	0.58	0.29	0.90	2.84	4.56	1.66	1.01	3.47	.....	.....	.....	.....	.....
1907	.....	.....	.....	.....	.....	.....	5.46	1.07	0.77	0.10	0.05	0.59	.....
1908	0.57	0.20	1.05	0.86	6.50	3.57	2.31	1.85	0.01	3.55	0.96	1.05	22.48
1909	.....	.....	.....	1.45	3.58	2.60	2.04	1.28	.....	.....	.....	.....	20.35
1910	.....	.....	.....	.92	.91	2.33	2.32	1.09	.....	.....	.....	.....	15.40
1911	.....	.....	.....	.34	1.35	.....	1.05	3.52	.....	.....	.....	.....	.....
Means	0.81	0.60	1.31	2.31	2.53	2.92	2.83	1.98	0.80	0.87	0.55	0.93	18.44

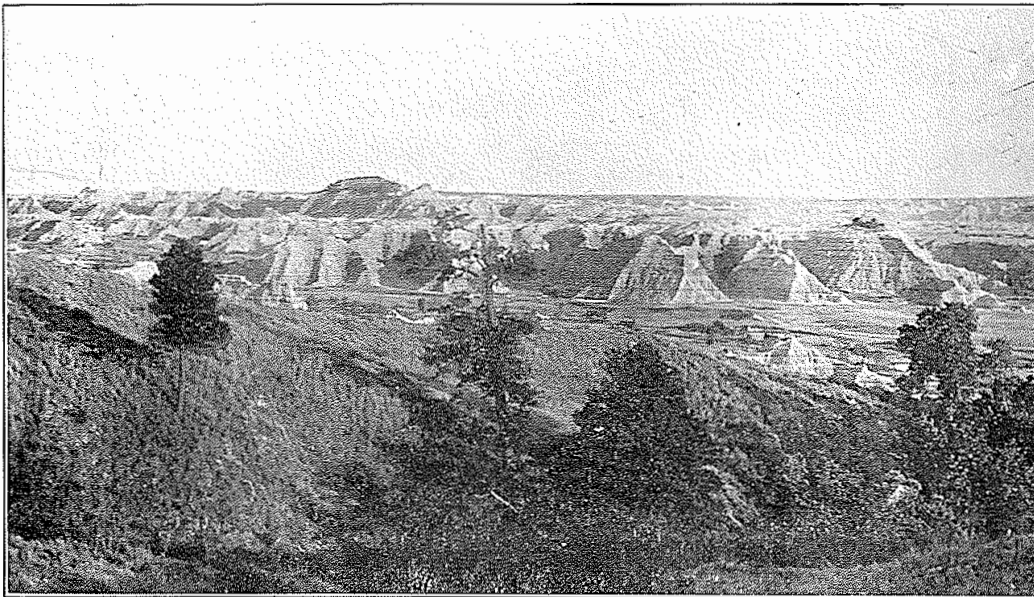
VALENTINE, NEBRASKA—CHERRY COUNTY.

Elevation, 2850 feet.

1889	1.27	0.15	1.05	3.87	2.05	2.99	2.60	0.34	1.71	2.12	0.56	0.84	19.55
1890	0.69	1.19	2.28	1.33	1.31	3.09	1.79	2.01	0.68	0.37	0.37	0.37	17.79
1891	0.61	1.55	2.58	3.12	1.33	6.36	4.29	4.68	0.40	1.65	0.78	0.42	27.77
1892	0.57	0.47	1.99	7.03	4.66	4.32	1.67	4.82	0.86	0.90	0.27	0.45	27.92
1893	.....	.....	2.41	2.76	2.07	4.39	1.19	1.20	0.08	0.23	0.51	0.83	.....
1894	1.09	0.53	1.08	2.00	0.17	2.36	0.97	0.33	0.36	1.01	0.19	0.05	10.14
1895	0.62	0.95	1.36	3.34	0.83	2.53	0.54	0.48	1.25	0.88	0.00	0.15	12.93
1896	0.36	0.26	1.81	3.08	0.67	4.48	4.25	0.77	2.73	0.35	2.57	0.46	21.79
1897	1.22	1.94	1.50	2.19	3.71	1.69	4.71	2.09	0.67	2.01	0.93	1.03	23.69
1898	0.44	0.28	0.57	1.33	5.98	2.11	2.28	3.62	0.64	0.11	0.54	0.37	18.27
1899	0.47	0.45	1.28	0.74	2.84	2.69	1.34	2.59	0.10	0.98	0.14	0.40	14.02
1900	0.04	0.26	0.47	4.70	1.23	1.24	7.97	4.67	0.85	0.38	0.26	0.15	22.23
1901	0.04	1.19	1.70	1.46	0.90	7.85	2.38	2.49	4.06	1.79	0.05	0.93	24.84
1902	0.34	0.20	1.07	0.77	2.17	1.89	1.79	2.93	0.25	0.39	0.53	1.28	13.61
1903	0.22	0.73	0.28	1.81	2.41	1.43	3.95	4.21	1.70	0.22	0.04	0.15	17.15
1904	0.53	0.22	0.64	0.40	2.93	4.67	6.08	3.08	1.17	0.54	0.19	0.16	20.61
1905	1.01	0.51	1.18	2.27	5.12	8.18	4.31	0.85	1.45	1.61	1.35	0.03	28.37
1906	0.52	0.33	2.50	2.68	4.14	1.56	1.88	5.02	3.17	3.42	0.92	0.40	26.54
1907	0.36	0.30	0.70	0.91	2.35	2.74	5.52	1.19	1.24	0.30	0.03	0.57	16.21
1908	0.16	0.40	1.19	0.96	4.78	2.91	2.33	1.97	0.11	2.64	0.68	1.38	19.51
Mean	0.56	0.64	1.38	2.36	2.61	3.42	3.22	2.42	1.17	1.11	0.58	0.52	19.99



A good cattle country: Badlands along Bear Creek.
Three cycles of erosion shown.



A typical view of the badlands. Excellent grazing land in the foreground.
Badlands of Cottonwood Creek, Mellette County.

PINE RIDGE, SHANNON COUNTY, S. DAK.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1901	T.	0.42	0.71	1.54	1.96	5.36	1.54	0.80	1.14	2.63	0.07	0.27	16.44
1902	0.03	0.57	1.48	0.68	1.13	4.68	1.78	1.60	0.60	0.58	0.08	0.88	14.09
1903	0.42	0.19	0.20	1.64	4.72	1.41	4.48	2.20	1.59	0.73	0.07	0.09	17.74
1904	0.16	0.09	0.32	0.20	2.52	3.49	0.98	1.70	2.10	1.00	T.	0.20	12.76
1905	0.36	0.05	0.81	1.72	4.33	2.63	5.00	2.05	0.79	0.60	0.30	0.25	18.89
1906	0.18	0.40	0.97	2.97	3.63	2.59	1.13	3.45	2.93	1.53	0.51	1.40	21.69
1907	0.67	0.01	0.70	0.28	3.76	.....	.....	.....	.....	.....	.....	.....	.....
1908	.....	.....	.....	.....	.....	1.82	1.85	0.99	0.40	3.60	0.18	0.85	.....
Means	0.26	0.39	0.74	1.29	3.15	3.14	2.39	1.83	1.36	1.52	0.17	0.56	16.80

Note—The monthly values from June to December, inclusive, 1908, are for Manderson, 13 miles northeast of Pine Ridge.

HAY SPRINGS, NEBRASKA—SHERIDAN COUNTY

Elevation 3821 feet

1876	.....	.....	.....	.....	.....	.....	.....	0.98	1.60	1.22	1.95	0.20	.....
1877	0.15	T.	0.65	0.33	3.59	2.09	0.41	0.66	1.32	1.98	0.91	0.37	12.46
1878	0.21	0.31	3.69	1.80	6.53	5.05	6.75	2.59	0.46	0.72	0.42	0.48	28.92
1879	0.62	0.68	0.42	3.39	2.24	3.70	2.78	0.79	0.30	0.92	0.05	0.43	16.32
1880	0.22	0.42	0.50	1.02	1.06	3.14	1.95	2.66	0.84	0.50	0.30	1.00	13.61
1881	0.42	1.14	1.78	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1886	0.55	0.93	1.51	1.83	1.80	2.66	3.09	2.32	0.37	0.37	2.19	0.60	18.22
1887	0.81	0.41	1.22	2.30	5.87	3.60	1.48	3.14	0.78	1.45	0.23	1.61	22.90
1888	0.44	1.22	0.94	0.88	7.25	3.26	3.09	3.38	0.00	0.15	0.33	0.32	21.26
1889	0.46	0.94	0.82	2.27	3.66	3.41	1.86	3.55	0.64	0.60	0.28	0.67	19.16
1890	0.61	0.40	1.01	1.73	2.24	4.55	2.75	1.27	0.00	0.43	0.61	0.35	15.95
1891	1.49	1.38	2.76	2.07	2.33	2.70	4.90	1.12	1.90	0.75	1.21	0.65	23.26
1892	1.61	0.20	.....	.....	.....	.....	.....	.....	0.72	5.80	0.05	0.66	.....
1893	0.20	0.85	2.36	1.43	.....	.....	1.00	1.06	0.10	0.61	0.29	1.16	.....
1894	0.71	0.66	1.73	2.88	1.20	1.93	1.24	0.43	0.81	0.55	0.75	0.10	12.99
1895	1.00	0.30	1.32	4.33	1.96	3.49	0.72	0.90	0.54	0.14	0.69	0.30	15.69
1896	0.49	0.81	2.30	3.22	1.79	4.85	1.64	0.86	1.73	0.80	1.37	.....	.....
1897	2.45	0.50	2.68	1.65	2.27	1.52	3.62	3.10	0.18	1.20	1.60	1.12	21.80
1898	0.40	0.55	0.88	1.11	6.91	0.43	2.74	0.31	1.31	0.25	0.48	0.62	15.99
1899	0.41	0.50	2.94	1.56	2.82	1.97	1.60	1.47	0.41	0.78	0.53	0.85	15.84
1900	0.29	0.20	0.59	3.91	0.59	3.82	3.19	1.22	2.39	1.22	T.	0.65	18.07
1901	T.	0.92	2.09	2.90	3.99	5.13	1.66	3.30	0.85	3.04	T.	0.98	24.65
1902	0.20	2.01	3.09	1.26	2.00	5.25	1.71	1.98	1.62	0.78	0.15	1.98	22.03
1903	0.48	1.20	0.92	2.19	3.91	2.16	8.92	2.22	1.92	0.98	0.21	T.	25.11
1904	0.49	0.13	0.12	0.85	2.26	3.68	2.16	1.92	3.14	3.17	.....	.....	.....
1905	1.00	0.35	2.56	3.07	5.04	4.85	4.81	1.78	0.63	0.92	0.70	0.20	25.91
1906	0.35	0.01	1.70	3.08	3.02	2.47	2.08	3.42	2.37	2.40	0.41	1.05	23.26
1907	0.30	0.70	0.41	0.20	4.42	3.29	2.75	0.99	1.05	T.	0.10	0.55	14.76
1908	0.20	0.10	0.82	1.93	4.99	3.22	2.78	3.30	T.	3.71	0.35	0.90	22.30
Mean	0.59	0.67	1.55	2.05	3.35	3.29	2.76	1.88	1.00	1.27	0.60	0.68	19.69

GEOGRAPHY OF SOUTH CENTRAL S. DAKOTA

PIERRE, HUGHES COUNTY, S. DAK.

(Elevation, 1,572 feet)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1891	.....	.....	.....	.....	.....	.....	1.21	1.50	0.70	1.10	0.47	0.56	.....
1892	0.10	1.15	0.68	3.86	4.65	3.79	1.43	0.63	1.32	0.56	0.25	0.39	18.81
1893	0.77	0.46	1.46	2.19	1.94	1.73	2.29	0.34	0.78	1.57	0.40	0.03	14.56
1894	0.46	0.04	1.60	1.56	0.46	1.14	0.81	0.21	0.73	0.58	0.15	0.08	7.82
1895	0.71	0.53	1.85	2.87	1.20	6.09	0.90	1.88	0.36	T.	0.45	0.01	16.85
1896	0.62	0.37	0.85	3.70	0.30	2.76	3.39	0.85	1.76	0.55	1.92	0.28	17.35
1897	1.66	0.29	2.49	3.51	0.45	3.11	3.79	2.12	0.14	0.40	0.41	0.47	18.84
1898	0.01	0.13	0.60	0.90	3.55	0.77	3.05	0.78	0.26	0.15	0.17	0.28	10.65
1899	0.47	0.58	2.06	1.67	4.15	3.18	2.88	2.02	1.51	0.75	0.32	0.41	20.00
1900	0.04	0.36	1.69	1.98	0.24	3.39	3.38	1.90	2.09	0.50	0.33	0.31	16.81
1901	0.08	0.53	1.09	1.26	0.63	4.45	1.76	3.23	1.20	1.77	0.18	0.86	17.04
1902	0.37	0.83	1.38	1.47	0.81	5.60	1.18	4.82	0.70	0.50	0.17	2.21	20.04
1903	0.26	0.36	1.03	1.65	1.72	2.14	4.99	3.98	1.97	0.25	0.52	0.66	19.53
1904	0.63	0.83	0.33	0.87	0.62	2.48	1.46	1.09	0.20	0.16	0.14	0.34	9.15
1905	0.35	0.17	1.32	1.42	4.34	3.36	4.81	2.09	0.34	1.64	0.62	T.	20.46
1906	0.37	0.10	0.52	2.62	4.28	1.66	1.02	5.16	1.99	3.05	0.45	0.84	22.06
1907	0.85	0.45	0.10	0.62	3.42	1.22	2.74	1.76	1.96	0.56	T.	0.34	14.02
1908	0.22	0.46	1.23	1.41	3.98	1.88	3.04	2.32	0.26	3.21	0.49	0.60	19.10
Means	0.47	0.45	1.19	1.97	2.16	2.87	2.45	2.04	1.05	0.96	0.41	0.48	16.50

LESLIE, STANLEY COUNTY, S. DAK.

1895	.....	.....	0.08	0.04	0.16	3.67	0.50	0.55	0.40	0.00	0.02	T.	.....
1896	0.03	0.03	0.19	2.15	0.06	3.75	5.27	2.23	0.85	0.10	1.90	T.	16.56
1897	0.50	0.15	1.80	1.40	T.	3.44	0.53	2.35	T.	T.	T.	0.08	10.25
1898	T.	T.	0.26	1.75	3.84	1.92	1.09	1.84	0.00	T.	0.40	T.	11.70
1899	0.10	0.25	0.86	0.65	2.84	2.53	1.05	2.50	0.80	0.43	0.06	T.	12.07
1900	0.00	T.	0.27	0.87	1.32	2.55	1.16	0.95	3.60	1.75	0.10	T.	12.57
1901	T.	0.08	0.71	1.23	0.56	4.03	1.90	1.78	3.16	0.49	0.30	0.40	14.64
1902	T.	T.	2.60	1.96	1.95	3.27	0.05	5.73	0.35	0.95	0.05	1.97	18.88
1903	0.05	0.05	0.65	1.02	2.44	4.09	3.86	3.12	1.57	0.24	0.43	0.30	17.82
1904	0.31	0.45	0.07	0.10	1.37	3.75	2.64	1.91	0.58	0.34	T.	0.10	11.62
1905	0.40	T.	0.20	1.10	3.63	5.20	.....	.....	.....	.....	.....	.....	.....
1906	0.10	T.	0.40	0.69	5.01	0.13	0.46	6.53	2.71	1.40	0.10	0.93	18.46
1907	0.64	0.53	0.19	0.75	3.10	0.85	4.97	0.91	1.00	0.72	T.	0.45	14.11
1908	0.23	0.20	1.69	0.50	2.26	3.74	1.10	1.35	0.85	2.85	0.20	0.20	15.17
Means	0.18	0.13	0.71	1.02	2.04	3.07	1.94	2.44	1.22	0.71	0.27	0.34	14.07

INTERIOR, STANLEY COUNTY, S. DAK.

1897	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.10	0.10	.....
1898	0.50	0.00	0.10	0.50	3.90	T.	4.09	T.	0.70	0.15	0.20	0.05	10.10
1899	0.10	0.20	1.40	2.50	5.00	1.00	1.10	2.00	0.50	2.05	T.	0.30	16.15
1900	6.05	0.65	0.20	2.50	0.65	4.50	2.30	0.90	1.80	1.50	0.20	0.10	14.75
1901	T.	0.95	1.36	0.87	0.08	.....	.....	.....	.....	2.23	0.09	0.56	.....
1902	0.45	0.23	3.03	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1903	.....	.....	0.40	2.00	.....	.....	.....	.....	.....	.....	.....	.....	.....
Means	0.22	0.29	1.08	1.67	2.43	1.83	2.47	0.77	1.00	1.48	0.32	0.22	13.78

TABLES OF PRECIPITATION

FORT MEADE, MEADE COUNTY, S. DAK.

(Elevation 3,624 feet)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1879	.....	.....	.....	.....	.....	.....	0.78	1.40	0.14	1.60	0.04	0.89	.....
1880	0.38	1.00	0.92	0.75	.....	4.68	1.62	3.91	T.	0.54	0.44	0.39	.....
1881	0.56	1.30	0.95	1.10	3.33	2.66	1.50	1.57	1.00	0.63	0.46	T.	15.06
1882	0.10	0.10	0.60	4.77	3.87	5.47	3.05	0.44	0.26	0.49	0.05	0.12	19.32
1883	2.90	0.30	2.16	4.50	9.61	1.56	2.80	0.18	1.60	0.67	0.05	0.72	27.05
1884	0.37	0.33	2.26	5.04	8.58	0.48	1.20	2.30	0.23	0.75	0.53	0.90	22.97
1885	0.32	0.23	0.52	1.30	0.64	3.38	1.52	3.22	0.28	0.74	0.93	0.17	13.25
1886	0.32	0.67	0.88	2.17	0.57	0.90	3.38	1.50	0.40	0.40	1.60	0.72	13.51
1887	0.56	0.20	0.76	2.12	2.72	1.76	4.46	4.25	1.10	0.40	0.24	0.36	18.93
1888	1.65	1.29	0.75	0.20	3.94	5.50	2.64	3.54	0.02	0.14	0.16	0.17	20.00
1889	0.27	0.85	0.12	2.64	2.02	1.60	6.38	0.00	0.67	1.71	0.88	0.86	18.00
1890	0.55	0.46	1.24	1.65	2.31	6.30	0.16	1.64	0.76	0.38	0.40	0.38	16.23
1891	0.78	0.83	1.63	2.29	6.60	4.29	1.75	1.50	0.87	0.41	0.52	0.32	21.79
1892	1.36	0.27	0.67	5.70	3.30	3.09	1.04	2.93	0.32	2.46	0.51	1.54	24.09
1893	0.40	0.74	2.41	3.45	2.01	1.63	1.14	0.70	0.00	3.48	1.48	1.68	19.12
1894	0.55	0.12	3.08	3.48	1.15	3.80	0.57	0.42	0.62	1.24	1.03	0.72	16.78
1895	0.85	1.05	2.26	2.91	3.35	5.05	0.55	0.95	0.80	0.23	2.36	0.40	20.76
1896	0.66	1.14	3.43	2.51	2.09	2.62	0.72	0.05	2.46	T.	1.27	0.06	17.61
1897	1.33	0.05	1.36	1.80	1.07	5.32	2.05	3.11	0.01	0.02	0.50	T.	16.62
1898	1.20	0.15	0.83	1.20	9.60	2.70	1.20	1.50	1.80	1.54	0.33	1.10	23.13
1899	0.91	0.46	1.42	4.15	6.75	2.35	0.29	0.30	1.10	1.94	0.14	0.56	20.37
1900	0.50	0.34	1.14	0.95	0.35	3.00	2.05	1.90	2.03	0.46	0.50	0.70	13.92
1901	0.47	0.99	1.71	1.68	2.83	6.78	2.83	2.75	1.35	0.83	0.17	0.89	23.28
1902	1.53	2.30	5.53	3.80	3.35	3.57	1.11	0.07	0.70	0.10	0.01	0.07	22.19
1903	0.50	0.90	1.70	2.55	3.36	2.16	4.25	3.56	2.90	0.40	0.80	0.81	23.89
1904	0.26	1.22	0.31	0.96	4.52	5.76	0.40	2.35	0.45	1.86	0.16	0.72	18.97
1905	0.97	0.21	1.14	0.49	5.94	4.84	10.33	0.62	0.12	4.95	0.64	0.12	30.37
1906	0.30	1.42	2.25	0.25	5.37	1.85	1.45	5.55	0.12	1.20	0.92	1.30	21.98
1907	0.60	0.40	0.30	0.85	19.95	8.10	6.23	0.04	1.40	0.00	0.00	0.33	29.20
1908	0.10	1.00	1.15	2.80	3.98	1.87	0.50	0.80	0.58	2.20	0.32	1.70	17.00
Means	0.73	0.70	1.50	2.35	4.10	3.59	2.26	1.77	0.80	1.06	0.58	0.62	20.06

OELRICUS, FALL RIVER, COUNTY, S. DAK.

(Elevation, 3,339 feet)

1890	0.40	0.60	1.12	1.47	2.59	3.70	1.07	0.10	0.13	0.09	0.45	0.10	11.82
1891	1.35	2.80	4.20	0.40	1.75	2.00	2.90	1.66	2.32	0.90	0.58	1.19	22.05
1892	2.55	1.15	1.60	7.83	2.67	8.71	1.77	2.25	0.60	3.10	0.20	1.15	33.58
1893	T.	1.75	2.48	3.30	T.	1.80	2.78	0.75	T.	0.71	0.95	2.30	16.82
1894	1.70	2.25	4.31	2.85	1.00	1.83	2.90	0.22	0.80	0.65	0.60	0.20	19.31
1895	1.50	1.80	2.21	T.	3.72	5.30	0.50	0.85	0.44	T.	1.50	1.10	18.92
1896	1.10	0.30	1.70	3.00	4.15	1.32	1.90	0.19	0.80	0.65	2.45	0.10	17.57
1897	1.75	0.60	2.20	2.20	0.30	0.70	2.40	2.20	0.40	0.40	2.70	1.00	16.85
1898	1.50	0.25	0.90	0.36	5.50	1.00	2.20	0.02	0.90	0.20	0.43	0.55	13.81
1899	1.00	1.05	2.80	1.20	6.00	1.40	2.30	0.80	1.00	2.05	0.35	0.70	20.65
1900	0.20	1.03	0.45	2.30	0.45	1.50	1.90	1.55	2.20	0.60	0.40	0.35	12.93
1901	0.00	1.40	1.35	2.95	1.55	8.50	0.70	0.30	1.64	4.70	0.05	1.20	24.34
1902	0.60	1.00	2.30	1.19	2.60	5.30	2.10	1.30	1.30	0.47	0.22	1.41	19.79
1903	0.60	0.65	1.25	2.35	5.25	1.00	3.15	1.05	1.75	1.07	0.20	0.25	18.57
1904	0.70	0.45	0.90	0.41	3.30	2.92	1.30	T.	1.00	1.30	T.	0.55	12.83
1905	0.90	0.40	0.50	2.20	4.09	3.61	5.45	2.46	0.30	0.92	0.60	0.30	21.73
1906	0.75	1.70	1.00	2.90	3.66	2.43	1.10	3.45	3.33	0.80	0.28	0.85	22.25
1907	1.00	0.70	1.20	0.30	5.95	3.85	2.32	0.33	0.62	0.06	0.07	0.80	17.20
1908	0.30	0.10	0.40	0.90	5.02	4.05	3.40	1.55	0.20	2.70	0.00	0.38	19.00
Means	0.94	1.05	1.73	2.01	3.13	3.21	2.22	1.10	1.04	1.12	0.63	0.76	18.94

GEOGRAPHY OF SOUTH CENTRAL S. DAKOTA

RAPID CITY, PENNINGTON COUNTY, S. DAK.

(Elevation, 3,251 feet)

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1888	0.33	1.62	1.76	0.41	6.01	4.74	1.69	4.76	0.02	0.43	0.47	0.51	22.75
1889	0.52	1.39	0.56	4.22	2.19	2.97	4.52	0.11	0.37	0.43	0.32	0.33	17.93
1890	0.47	0.66	1.40	1.55	2.46	3.77	0.13	1.83	0.75	0.56	0.27	0.37	14.02
1891	0.27	0.87	1.96	2.74	1.72	3.25	2.09	1.97	1.32	0.34	0.17	0.05	16.75
1892	0.63	0.24	1.18	4.04	4.49	3.80	0.67	2.00	0.13	2.29	0.08	0.48	20.03
1893	0.30	0.45	0.92	1.05	1.73	1.21	1.51	0.63	0.06	1.01	0.35	0.39	9.61
1894	0.41	0.17	1.18	4.24	0.72	4.17	1.31	0.35	0.65	0.16	0.34	0.05	13.75
1895	0.23	0.27	1.95	1.53	2.66	6.22	0.39	0.09	0.36	0.02	1.03	0.11	15.48
1896	0.27	0.22	1.35	1.67	0.60	3.35	1.73	0.13	2.58	0.68	1.09	0.01	13.68
1897	0.62	0.46	1.09	0.69	1.82	2.67	0.71	2.15	0.08	0.15	1.16	0.11	12.32
1898	0.56	0.24	0.51	1.66	3.26	0.50	1.50	0.72	1.27	0.51	0.06	0.19	10.98
1899	0.33	0.41	0.94	0.43	6.76	2.95	0.96	0.52	0.83	1.58	0.19	0.81	16.71
1900	0.31	0.17	0.45	3.81	0.53	2.13	1.45	1.64	2.09	0.26	0.34	0.14	13.32
1901	0.07	0.53	0.40	1.86	2.53	7.53	4.83	2.52	1.30	1.16	0.14	0.38	23.25
1902	0.18	0.14	3.34	2.49	2.97	2.96	3.59	0.72	0.43	0.21	0.68	0.80	18.51
1903	0.23	0.47	1.10	3.51	2.94	3.79	3.37	2.47	2.79	0.30	T.	0.31	21.28
1904	0.46	1.09	0.40	0.43	3.50	5.07	1.84	1.36	0.43	1.18	0.19	0.54	16.40
1905	0.52	0.02	1.00	1.95	6.25	3.05	9.66	1.66	0.85	1.08	0.40	0.02	27.06
1906	0.06	0.32	1.15	0.65	4.67	1.97	1.08	5.67	1.16	1.79	0.40	0.93	19.85
1907	0.31	0.47	0.14	0.79	8.09	3.24	2.64	0.72	1.75	0.04	0.01	0.20	18.40
1908	0.22	0.12	1.14	0.78	5.46	4.28	1.26	0.87	2.67	2.09	0.01	0.73	19.63
Means	0.34	0.48	1.17	1.93	3.49	3.50	2.24	1.47	1.04	0.77	0.37	0.35	17.15

ANNUAL DEPTH OF SNOWFALL

(Inches and tenths)

Stations	Length of record years	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Fort Meade	24	6.1	6.8	12.0	5.9	1.6	0	0	0	T.	1.9	4.5	5.5	44.3
Leslie	13	1.7	4.0	4.0	1.1	T.	0	0	0	0	0.1	3.1	3.0	17.0
Oelrichs	18	9.5	9.9	14.9	2.8	0.1	0	0	0	0.5	1.3	8.0	6.2	53.2
Pierre	17	5.0	4.3	8.0	2.4	0.1	0	0	0	T.	0.9	3.4	4.6	28.7
Rapid City	21	3.7	4.9	7.2	3.1	2.1	T.	0	0	0.2	1.0	2.9	3.6	28.7
Rosebud	14	8.3	5.9	10.2	6.5	0.1	0	0	0	0.1	0.6	5.4	9.5	46.4
Spearfish	18	9.4	10.2	14.3	12.2	2.2	0	0	0	0.6	2.8	5.3	7.4	64.4

AVERAGE NO. OF DAYS WITH 0.01 INCH OR MORE OF PRECIPITATION

Fort Meade	28	4	4	6	6	8	8	6	5	3	3	3	4	60
Leslie	13	2	2	3	4	5	6	4	5	2	2	2	1	38
Oelrichs	18	3	5	6	4	6	6	3	3	2	2	3	3	48
Pierre	17	6	6	8	9	9	12	9	8	6	4	5	6	88
Rapid City	21	6	7	10	9	13	13	9	9	5	5	5	6	97
Rosebud	15	4	4	4	7	8	7	6	6	3	2	2	4	57
Valentine	20	6	7	9	9	11	12	10	10	6	4	5	6	95

PRECIPITATION AT ROSEBUD DURING THE FIVE SEEDING AND GROWING MONTHS, WITH TOTAL FOR FIVE MONTHS

Year	April	May	June	July	Aug.	Total for 5 Mo.
	inches	inches	inches	inches	inches	
1892	4.18	5.10	4.48	1.38	4.19	19.33
1893	1.94	2.40	1.69	1.84	0.95	8.82
1894	4.33	0.27	2.50	0.89	1.30	9.29
1895	2.74	1.28	3.99	0.59	0.86	9.46
1896	3.04	0.53		6.63	1.61	11.81
1897	2.87	3.02	1.47	2.50	2.90	12.76
1898	1.41	3.98	0.60	2.77	0.98	9.74
1899	1.31	1.74		1.45	0.77	5.27
1900	2.69	1.03	2.35	6.10	2.32	14.49
1901	2.66	1.54	7.52	1.84	2.75	16.31
1902	1.12	1.87	2.51	1.44	3.08	10.02
1903	2.10	2.41	1.17			5.68
1904	0.60	1.65	4.26	5.30	0.51	12.32
1905	0.68	6.41	6.99	2.86	0.72	17.66
1906	2.84	4.56	1.66	1.01	3.47	13.54
1907				5.46	1.07	
1908	.86	6.50	3.57	2.31	1.85	15.09
1909	1.45	3.58	2.60	2.04	1.23	10.90
1910	.92	.91	2.33	2.32	1.09	7.57
1911	.34	1.35		1.05	3.52	

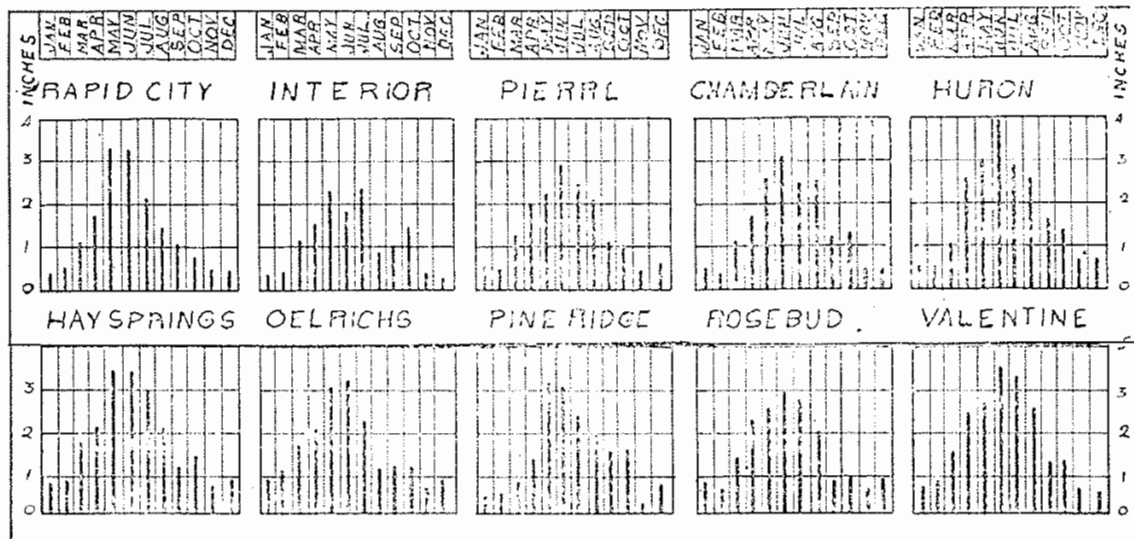
PRECIPITATION AT KIMBALL, BRULE COUNTY FOR THE FIVE GROWING MONTHS

	inches	inches	inches	inches	inches	
1886	3.29	0.70	2.55	1.05	2.95	10.45
1887	2.75	0.60	2.05	3.40	10.15	18.95
1888	1.00	4.00	1.77	0.90	2.15	9.82
1889	2.40	1.56	0.72	3.93	1.76	10.37
1890	1.45	2.03	3.07	1.98	2.21	10.74
1891	3.25	0.56	9.28	2.53	2.91	18.53
1892	6.64	4.22	3.58	0.38	2.74	17.56
1893	3.15	3.56	2.65	2.17	0.57	12.10
1894	1.91	0.75	1.36	0.42	0.43	4.87
1895	1.52	1.42	3.49	1.32	1.54	9.29
1896	5.40	1.23	5.60	5.43	2.01	19.67
1897	4.20	1.00	2.52	2.26	2.75	12.73
1898	2.58	3.96	2.26	4.98	1.37	15.06
1899	1.32	2.46	3.13	3.19	1.59	11.69
1900	2.91	1.50	2.40	5.83	4.53	17.17
1901	0.98	1.35	8.42	0.66	4.00	15.41
1902	1.85	1.75	2.39	1.14	3.77	10.90
1903	1.20	2.34	1.73	4.29	1.76	11.32
1904	1.51	1.20	2.16	1.78	2.28	8.93
1905	0.68	6.41	6.99	2.86	0.72	17.66
1906	2.57	6.11	5.07	1.26	6.68	21.69
1907	1.24	2.72	1.85	6.47	1.18	13.46
1908	1.98	4.97	5.36	3.58	3.97	19.86
1909	.76	4.47	1.27	2.54	4.44	13.48
1910	.81	.91	2.70	4.52	1.24	10.18
1911	1.80	2.53	2.93	4.43	3.39	15.08

AVERAGE PRECIPITATION FOR MANY YEARS DURING THE FIVE GROWING MONTHS

Place	County	April	May	June	July	Aug.	Year
		inches	inches	inches	inches	inches	
Aberdeen	Brown	3.70	2.85	4.38	3.06	3.14	15
Ashcroft	Harding	1.13	2.20	2.24	1.54	1.28	12
Faulkton	Faulk	3.10	1.66	3.75	2.39	2.14	12
Greenwood	Charles Mix	1.14	2.94	3.88	3.52	2.90	11
Huron	Beadle	2.73	2.66	3.67	2.80	2.60	23
Kimball	Brule	2.59	1.90	3.22	2.53	2.71	18
Leslie	Stanley	1.12	1.45	3.30	1.86	2.30	10
Oelrichs	Fall River	2.12	2.72	3.09	1.99	0.97	14
Pierre	Hughes	2.11	1.59	3.19	2.32	1.81	13
Rapid City	Pennington	2.14	2.76	3.59	1.90	1.45	16
Rosebud	Todd	2.32	2.06	2.96	2.73	1.85	12
Sioux Falls	Minnehaha	2.89	4.27	4.05	2.81	2.77	14
Spearfish	Lawrence	2.85	2.99	4.40	2.02	1.71	15
Yankton	Yankton	3.07	3.84	3.98	3.76	3.06	30

SHOWING THE AVERAGE MONTHLY PRECIPITATION



(b) *Temperature.* The average annual temperature for southern South Dakota is about 44 degrees F. Because of the greater elevation found in these counties, on the principle that an increase in elevation gives a decrease in temperature, these counties are cooler than the lower counties which surround them. The lower temperature causes a decrease in the rate of evaporation so that cultivated crops lose less water from their leaves and consequently require less moisture. The lower average temperature will also decrease the amount of evaporation from the soil.

MEAN TEMPERATURE (Fahrenheit)

Stations	Length record years.	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Fort Meade	27	13.4	14.5	29.4	45.1	55.1	64.3	71.7	70.6	60.5	48.2	34.4	27.7	44.6
Leslie	14	18.9	18.4	30.3	48.6	58.6	67.7	74.9	72.9	62.4	49.5	31.7	21.8	46.3
Oelrichs	18	22.1	21.0	31.8	46.0	55.7	55.4	72.0	71.0	60.6	48.2	33.8	25.7	46.1
Pierre	17	17.9	18.1	30.8	47.8	58.1	68.2	74.8	73.4	63.6	50.7	33.3	23.8	46.7
Rapid City	21	22.9	22.2	31.1	45.6	54.0	63.7	70.7	70.0	61.2	49.2	35.4	29.4	46.3
Rosebud	15	22.6	21.1	31.2	47.0	58.1	66.7	73.8	71.7	62.2	48.3	34.6	25.3	46.9
Valentine	20	22.0	21.4	32.4	46.8	56.5	66.0	72.2	71.1	62.3	54.9	34.6	26.9	47.3

HIGHEST TEMPERATURES BY MONTHS (Fahrenheit)

Stations	Length record years.	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Fort Meade	27	79	71	78	90	94	105	108	109	104	96	77	73	109
Leslie	13	67	69	83	95	100	108	114	115	108	96	88	64	115
Oelrichs	18	63	78	83	102	99	110	108	107	108	96	87	64	110
Pierre	17	60	70	84	94	98	103	108	110	104	98	80	67	110
Rapid City	21	69	72	78	89	92	103	102	106	102	96	79	75	106
Rosebud	15	63	72	86	92	98	106	109	104	103	92	76	66	109
Valentine	20	68	69	84	91	97	102	106	103	102	94	78	72	106

LOWEST TEMPERATURE BY MONTHS (Fahrenheit)

Stations	Length record years.	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Ft. Meade	27	-34	-37	-22	1	20	33	34	32	20	-11	-25	-32	-37
Leslie	13	-28	-41	-29	3	23	30	36	36	18	-4	-25	-35	-41
Oelrichs	18	-28	-41	-28	7	19	33	38	35	20	6	-18	-32	-42
Pierre	17	-30	-40	-15	5	25	38	45	39	26	4	-16	-19	-40
Rapid City	21	-30	-34	-17	2	22	35	45	41	23	10	-9	-24	-34
Rosebud	15	-33	-35	-17	0	19	33	38	33	18	-1	-23	-24	-35
Valentine	20	-38	-37	-36	0	23	32	41	36	21	6	-18	-34	-38

FROST DATA

Stations	Length record years.	Average date of—		Date of—				
		First killing in autumn	Last killing in spring	Earliest killing in autumn	Latest killing in spring			
Fort Meade	24	September	23 May	7	September	6	May	28
Leslie	10	September	21 May	18	September	7	June	26
Oelrichs	18	September	23 May	10	September	2	May	30
Pierre	17	September	30 April	30	September	12	May	19
Rapid City	21	September	26 May	6	September	13	May	21
Rosebud	14	September	25 May	10	September	10	May	30
Valentine	22	September	18 May	9	September	12	June	21

DIRECTION OF PREVAILING WIND

Stations.	Length rec- ord years.	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Pierre.....	17	nw	nw	nw	se nw	se	se	se	se	se	nw	nw	nw	nw
Rapid City.....	21	w	w	nw	nw	se	w	w	w	w	w	nw	w	w
Valentine.....	16	nw	nw	nw	nw	nw	s	s	s	s	nw	nw	w	nw

AVERAGE HOURLY WIND VELOCITY (Miles)

Pierre	18	7.9	8.8	10.6	12.1	10.9	10.1	9.6	9.2	8.9	8.3	8.0	7.2	9.3
Rapid City	21	7.8	7.5	8.7	9.3	8.5	7.9	7.5	7.2	8.0	8.5	8.0	7.8	8.1
Valentine	15	10.	10.	12.	13.	12.	11.	10.	10.	11.	10.	10.	10.	11.

MEAN RELATIVE HUMIDITY (Per cent)

Pierre.....	8 a.m.	18	69	72	63	49	49	75	73	75	72	73	75	78	75
	8 p.m.	18	81	81	80	71	83	48	44	44	44	51	61	72	55
Rapid City	8 a.m.	20	68	69	63	51	49	71	67	65	63	63	70	72	70
	8 p.m.	20	73	77	77	71	71	51	43	39	42	50	62	66	54
Valentine..	6 a.m.	17	70	70	62	47	44	78	78	80	76	78	77	80	79
	6 p.m.	17	77	78	78	74	73	82	47	48	46	51	58	70	56

The Geology of Mellette, Todd, Bennett and Washabaugh Counties.

THE SOILS.

There are three chief types of soil in this area. These are: The Rosebud Loam, the Rosebud Sandy Loam, and the Pierre Clay. The loam covers about two-thirds of Bennett and Washabaugh Counties, one-third of Todd and perhaps one-fourth of Mellette. The sandy loam is almost confined to Bennett and Todd Counties, and covers about one-fifth of the former and one-third of the latter. The clay covers about three-fourths of Mellette County and extends slightly into Todd and Washabaugh Counties. A fourth "soil" is the dunesand of the southern one-fifth of Bennett and about one-seventh of Todd Counties.

The following descriptions of the soils are in the main taken from the Reconnaissance Soil Survey of western South Dakota by the U. S. Bureau of Soils, G. N. Coffey in charge of party

1. ROSEBUD SILT LOAM.

(a) *Description*--The soil of the Rosebud silt loam to an average depth of ten inches is a very silty loam. The sand in the soil is composed of the very finest grades. In color it ranges in different localities from a light ashy gray to a dark brown, depending upon the quantity and character of the organic matter present. The sub-soil, to a depth of two feet or more, is a light gray or brown silty loam, containing in most localities more clay than the soil. Below this is a white, light pink, or buff material that extends to a depth of several feet. In all parts of the area covered by this type there are beds of white partly calcareous concretions at a depth of several feet below the surface, and often fragments of fossil bones are found embedded within the concretions.

The Rosebud silt loam is loose and friable and is easily brought into a good condition for tillage. The principal difficulty in handling this type is due to its tendency to wash. The silty material melts away rapidly under running water and on slopes

and hillsides the erosion is excessive, so that eroded spots and incipient badland topography are a feature of the hilly areas. The areas of this type may be distinguished from a long distance by the white spots that fleck the hillsides. The badlands, which have been mapped as a separate type, represent badly eroded country once covered by the Rosebud silt loam. On the broad level or gently rolling flats and valleys it will not be difficult with a little care to prevent gullying, but where there is any considerable slope, washes must never be allowed to start.

The following table gives the average results of mechanical analyses of samples of the soil and subsoil of the Rosebud silt loam:

MECHANICAL ANALYSIS OF ROSEBUD SILT LOAM

Description	gravel Fine	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Soil	0.4	0.5	1.0	4.9	28.2	55.3	14.6
Subsoil .....	.2	.5	1.0	1.6	16.5	62.5	17.4

(b) *Origin.* This type is the partly weathered product of the White River beds and some of the Arikaree or Rosebud formation. It is not easy to separate the soils derived from the White River group from those weathered from the more silty members of the Arikaree formation, and the agricultural values of the two are so similar as to make a separation of little importance. The changes which have taken place since the formations have been exposed to weathering have chiefly affected the lime content by the breaking down of the lime nodules and the removal of much of the calcareous matter.

(c) *Location.* The Rosebud silt loam is one of the most uniform and extensive soils of the State. It covers the greater part of the Pine Ridge Indian Reservation. In this region it is broken only by the Bad Lands along White River and the Dunesand and their associated types along the southeast border. There are also considerable areas west of the White River along the western side of the reservation and some patches outside. On the Rosebud Reservation this soil is found in a number of large areas in the southern parts of Tripp and Todd counties and in the western part of Todd extending into the southern and southeastern part of Gregory County.

(d) *Topography.* The topography occupied by the Rosebud silt loam varies from the almost level plains north of Little White River to rough hills and broken country closely approaching the Bad Lands. East of Pine Ridge Agency the valley of the Little White River is a broad, level, very gently rolling plain capable of being made into a beautiful farming country. Several large flats also occur on the divide to the north. The slope toward White River is a plain broken by parallel northward-flowing streams several miles apart which have a rapid fall toward White River. The usual configuration between these streams is first a gentle slope from the streams having a width of one-fourth mile to two miles, all good farming land; then a more rolling topography with broken steplike patches where the hillside surface has given way; then an abrupt rise, sometimes as a cliff, to the highest altitude of the divides. Patches of badland traverse the country usually at a distance of several miles from the river where the streams are cutting most rapidly.

(e) *Native Vegetation.* In the highest hill slopes and in the sheltered valleys of the hills there is usually a sparse growth of pine and cedar, the pine predominating on the hills. On some of the ranges the timber is commercially valuable and is being removed for public use. Except in the recently eroded spots, the entire surface of the uncultivated land has a thick covering of native grasses. Blue grama grass (*Bouteloua oligostachya*) usually predominates. This soil is not so well adapted to wheat grass (*Agropyron tenerum*) as the soils of the Pierre series, but it grows to some extent in all parts of the area and in many places it may be cut for hay.

(e) *Utilization.* A large area of this type is yet held by the Indians and utilized only for grazing and the cultivated portion has been farmed for so short a time that the value of the soil is not yet fully determined. Only a small area is cultivated in the reservation, but recently settled portions of Tripp County have been farmed with good results, and in Gregory nearly all of the type is under cultivation. The principal crops grown are wheat, oats, corn, and flax, with a little rye, barley, and emmer. Yields necessarily depend largely on the season and rainfall. In ordinary seasons wheat will average between twelve and fifteen bushels to the acre, oats thirty to forty, and corn twenty to thirty bushels.

In very dry seasons the best farmers can not secure these yields, while in the most favorable seasons good farmers may get yields of thirty bushels of wheat or more to the acre. Apples, plums, grapes, and cherries grow well, but are often prevented from bearing by climatic conditions. Potatoes and other vegetables do well and are grown for home needs. This type should prove one of the best in the area for general farming.

2. ROSEBUD SANDY LOAM.

(a) *Description.* The Rosebud sandy loam, to a depth of twelve to eighteen inches, is a dark-gray or brown loamy fine sand to fine sandy loam, sometimes containing a large percentage of silt. The subsoil is usually lighter in color with an equal or greater amount of silt than the soil.

The following table gives the average results of mechanical analyses of samples of the soil and subsoil of this type:

MECHANICAL ANALYSIS OF ROSEBUD FINE SANDY LOAM

Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Soil	0.0	0.8	7.1	54.2	22.4	8.4	7.1
Subsoil .....	.0	2.1	9.4	48.3	23.1	7.7	9.0

(b) *Origin.* The soil is derived by weathering from sandy strata of the Arikaree or Rosebud formation, with probable accessions of wind-blown sand.

(c) *Location.* The type is found in areas of several square miles on the border between the Dunesand and the Rosebud silt loam, and it merges so gradually into these types that it is difficult to draw a sharp boundary. Considerable areas of the type are found in Tripp and Todd Counties and in smaller patches in Gregory. In the Pine Ridge Reservation it occurs principally along Little White River north of LaCreek.

(d) *Topography.* The Rosebud fine sandy loam has a gently undulating to steeply-rolling topography in some places covering very broken and buttelike formations.

(e) *Native Vegetation.* The native vegetation varies according to the amount of sand in the soil. In the more silty portions of the type the grasses are of the same varieties as those of the Rosebud silt loam, but on the more rolling sand areas sand grass,

needle grass, and blue-joint predominate with some yucca, though the latter is not so common as on the Dunesand.

(f). *Utilization.* This type has not been cultivated to any extent in the Indian reservations, but in the settled counties some of it is farmed. When first farmed, it produces good crops of corn and vegetables, and in favorable seasons the small grains do well. It is held by some that this soil will withstand drought better than the Pierre clays. After a number of years of steady cultivation the type will doubtless become less productive unless some effort is made by the farmer to maintain the supply of organic matter in the surface soil. Where it is not too sandy the soil is adapted to general farming, but corn, potatoes, and vegetables will be more successful than the small grains.

3. THE PIERRE CLAYS

(a). *Description.* The most distinguishing characteristic of the Pierre clays is their heavy sticky nature, which has given to them the local name of "gumbo." The soil varies considerably in texture as well as in color, but this sticky nature is a constant feature. In texture the material ranges from a silty clay loam through a silty clay to a heavy clay.

The color is usually a yellowish brown to a dark brown, but varies from a decided yellow on the one extreme to a black on the other, the difference being sufficient to justify a separation in a more detailed survey. Frequently a thin surface covering of ashy gray to white is found.

The subsoil, which is encountered at a depth of six to ten inches is a silty clay to heavy clay of a gray to yellowish brown color. In some areas it is almost black. It is often mottled with white spots of lime, making these areas quite calcareous. Soft shale is usually encountered at three to six feet below the surface and on some of the badly eroded areas comes to the surface.

A very characteristic feature throughout the area of the Pierre clays is the cracking of the soil upon drying. In general the heavier the texture the larger the cracks which will be formed. In some instances these extend to a depth of several feet. This tendency to crack or granulate causes the surface soil to become very loose and is a valuable property, as it enables the farmer to secure a proper seed bed much more readily than could be done otherwise. It also permits the rains to enter much more easily.

A thin covering of light material is sometimes found over the clay in almost all sections of the area. As this does not granulate itself and prevents the cracking of the underlying clay, the rainfall runs off instead of entering the soil, and cactus and other arid vegetation are common. This furnishes a striking illustration of the necessity for having the surface loose and open in order that the rainfall may enter.

Where the topography is very broken erosion has been very active and the soil here is quite variable. Much of the surface soil has been removed and the subsoil or, where the washing has been most pronounced, the soft shales are exposed.

The following table gives the average results of mechanical analysis of samples of the soil and subsoil of Pierre clays.

MECHANICAL ANALYSIS OF PIERRE CLAYS

Description	Fine gravel	Coarse sand	Medium Fine	Fine sand	Very fine sand	Silt	Clay
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Soil	0.1	0.8	3.0	8.9	6.4	44.8	35.8
Subsoil .....	.1	.9	3.3	8.6	7.7	42.6	36.7

(b). *Location.* The Pierre clays are the most extensive soils in western South Dakota. The country for many miles west of the Missouri River consisting almost entirely of the "gumbo" soils. Nearly all of Stanley and Lyman counties, northern Gregory and Tripp Counties, and the southern and eastern parts of the Cheyenne Indian Reservation are occupied by these heavy types. Northeast of Belle Fourche a wide area extends northwest and southeast through Butte County, covering a very large percentage of the county. Another extensive development is found in Fall River County, in the southwestern part of the state. Many smaller tracts occur where-ever the clayey Cretaceous shales form the surface.

(c). *Utilization.* At the present time nearly all of the Pierre clays are used for pasture or hay. The growth of grass is not generally as good as upon the loams, but varies in different sections both in quantity and in the species, depending very largely upon the texture of the soil. The predominating and characteristic grass upon the gumbo areas is the western wheat-grass (*Agropyron tenerum*). Where the soil is very heavy and cakes very badly, or where erosion has been pronounced, as upon the steeper

slopes, this grass is practically the only species present, and the growth there is nearly always very sparse and in some places bare spots are found. Where the soil becomes more silty in texture grama and buffalo grasses are mixed with the wheat-grass, the growth is dense and heavy, and the grass tall enough to cut for hay, yielding from one-fourth to one-half ton per acre.

The character of the grass furnishes a very safe index as to the relative value of the lands for agricultural purposes. Where the growth of grass is heavy and a large proportion of grama and buffalo grass is present the soil is much more tractable and desirable for agriculture.

The Pierre clays are naturally strong soils, but their sticky nature makes them less desirable than those of lighter texture. If plowed when too wet, the soil bakes into hard clods, which are difficult to pulverize. If allowed to get dry, it becomes too hard to cultivate. The soil is, however, very retentive of moisture, and if a mulch is provided after rains it can be conserved. Unless this is done the moisture is lost very rapidly and crops suffer during periods of insufficient rainfall. The silty clay loam is more easily pulverized than the heavier clay and the natural granulation aids greatly in securing a mulch.

The careful and observant farmer will plow and cultivate when the soil has dried out just enough not to adhere to the implements, for under this condition the soil breaks up into small granules, thus allowing the formation of a good mulch. When tilled properly the gumbo becomes surprisingly mellow, especially when a good supply of humus is present. A great deal of power is required for its cultivation. Only a small percentage of the areas occupied by these soils have been put under cultivation, and nearly all of this has been broken within the last two or three years. Definite statements as to yields were therefore difficult to secure, especially since these vary so much with the season. The crops that are being grown are wheat, oats, corn, flax, rye, barley, and emmer, or speltz. During good seasons wheat yields from twelve to twenty bushels, oats 35 to 50, corn 20 to 25, barley about the same, and speltz 30 to 40. Most of the farming so far has been upon sod and better and surer yields may be expected after the soil has been gotten into a good physical condition. The government experiment farm near Belle-

Fourche is located upon the garabo, and the results secured here indicate that dry farming can be made a success. Owing to its sticky nature, the cost of preparing and cultivating the land is considerably greater than on the lighter type of soil.

4. DUNESAND

The dunesand consists of eight to twelve inches of fine sand having a dark gray color due to organic matter. The subsoil is a fine sand of the same texture, but lighter in color to a depth of thirty inches. Below this it may pass in some places into light colored silty material, but more often the sand continues to a depth of many feet. The surface soil is loose and incoherent and liable to be drifted where it is exposed to full sweep of the winds and conditions are favorable. The sand grains consist largely of quartz, but a much larger proportion of other materials is present than in the Dunesand in more humid regions.

According to topography, this type may be divided into two phases; the most extensive, comprising what is commonly known as the Sand Hills, extends for many miles over the southern part of South Dakota and covers a large area in Nebraska. There is also a large area of these hills in the northern part of the Pine Ridge Reservation north of White River and southeast of Sheep Mountain. The Dunesand areas consist of steeply rolling hills and ridges which owe their origin to wind action. The material thus accumulated was probably derived by weathering from sandy beds of the Arikaree or Rosebud formation. In most places the sand is heaped up to a great height; in others a covering of sand has been distributed over more silty materials. A very small proportion of the surface sand is now drifting as vegetation soon obtains a foothold. The occasional drifting hills are small in extent and having a slow movement.

The native vegetation consists of a heavy growth of coarse grasses, of which the most common are "sand grass" (*Calamovilfa longifolia*) and blue joint *Andropogon furcatus*. Weeds and wild roses are common and the yucca is characteristic of this type of soil. These grasses make good grazing and with the grasses of the plains give the variety which the stockman thinks beneficial to his cattle. It is probable that these grasses on more droughty land are more certain to be cured on the ground

before frost than the grasses on the heavier soils. At present the sand hills in South Dakota are used only for grazing. Numerous valleys traverse the sand hills, furnishing hay and in many places grain to carry cattle through the winter. All water that falls on these hills sinks into the ground and issues as springs at the foot of the hills, furnishing an abundant supply of pure water.

The second phase of the Dunesand has a level of gently rolling topography. In texture the soil does not differ greatly from that of the sand hills, but the more level topography makes it more retentive of moisture and greatly enhances its agricultural value.

The native vegetation is more like that of the silty soils, with occasional patches of sand grass and some yucca. Very little of it is cultivated and farming will always be somewhat precarious on the loose sandy areas, though on the better areas corn, potatoes, and oats may be grown and good yields secured in seasons of adequate rainfall.

5. THE RIVER BOTTOM SOILS.

See soil map for their location. As is the case with alluvial soils in all parts of the world these are highly desirable.

II. THE SUBSOILS

The soil of any area is derived chiefly from the subsoil (frequently clay) which underlies it. To the materials of the subsoil are added humus and other organic compounds resulting from the partial decay of vegetable and animal matter. The black soil has a considerable amount of unoxidized humus. Soils which are not black have less humus, but are not necessarily less fertile. Soils of the drier parts, as well as those of the hotter parts of the world, are normally not black in color and consequently are frequently not conspicuously differentiated from the subsoil. Though unoxidized humus is a desirable feature, its absence is often more than recompensed for by the presence of other compounds. In the soils of dry regions certain salts quite essential to plant growth (nitrates, phosphates and potash) accumulate near the surface, have been drawn up from the subsoil by the ascending, capillary, water and are not leached out and carried away by the streams as these salts often are in more humid regions.

Soils differ from subsoils also because of wind action. An examination of the mechanical analysis of the soils of this area given under "Soils" shows that the percentage of the coarser grades of particles is larger in the soil than in the subsoil. This is certainly due to the fact that the wind has blown away more finer particles than it has added to this soil. It has done this, obviously, because the smaller particles are more readily blown than the the coarser ones. Although the wind has here carried away from any square foot more fine particles than it has brought to that area, it has certainly brought very many (perhaps millions) of fine particles from widely separated points. As a result soils are more similar than the subsoils, and no soil is entirely lacking in certain desirable constituents.

Another agent which helps convert subsoil into soil is chemical activity. In the subsoil there are various substances which when exposed to the air will combine with oxygen. Some of these subsoil constituents are harmful to plant growth; but after their oxidation they are no longer harmful and may be the opposite.

The process by which subsoil is converted into soil is therefore quite complex. The wind replaces some of the finer particles by fine particles from different places. Plants and animals add organic compounds to it. Burrowing animals, such as ants, beetles and gophers bring to the surface unoxidized materials, and also allow air to enter the subsoil along their burrows. Cracks due to excessive drying or to frost also permit the entrance of the air. Moving underground water transports soluble salts.

The subsoil, in turn, is usually derived from the underlying formations. In glaciated regions, such as north-eastern United States, the subsoil has not been so derived, but was brought down by the glaciers and spread over the underlying rock as a thick layer called variously glacial or boulder clay, till or drift. In mountain valleys and other large valleys, and in many other places the subsoil is also of the "transported" type, carried there not by glaciers, but chiefly by streams. However in the area under consideration the subsoil is generally of the residual type. It has resulted from the weathering, that is the breaking up of and partial decay, of the underlying rock formations. The break-

ing up has been accomplished by the roots of plants, by cracking due to freezing or to excessive drying, and to the dissolving out of soluble substances which have tended to hold the rock particles together. The decay is chiefly due to the combining of oxygen, of carbonic acid gas, or of water with certain of the rock materials. The resulting compounds are more bulky than the original and consequently disrupt the rock; they are usually more soluble and are therefore frequently transported by circulating waters.

Origin. The Rosebud silty loam subsoil is derived from marshy or calcareous formations of Tertiary age, especially the White River and Rosebud formations.

The Rosebud sandy loam subsoil comes from the sandy strata of the Rosebud beds.

The Pierre clay subsoil is from the underlying Pierre shale and other Cretaceous formations.

III. THE COUNTRY ROCK.

In this part of South Dakota the sort of rock which is most extensive is shale. Because shale disintegrates so rapidly into clay it is exposed in its natural condition as shale only at points of unusual rapid stream erosion or in artificial cuts. Marl is likewise very extensively developed in this section, but it is so soft that it seldom has the appearance of "rock." Impure layers of sandstone and of limestone are exposed on the sides of buttes and valleys. Flint layers occur on top of some of the buttes and are there quite conspicuous because of the large slabs of firm rock which are scattered on the sides of the butte.

(1). *These commoner rocks may be described as follows:*

Sandstone is composed of sand grains cemented together. Shale is compact clay, earthy, readily scratched with the finger nail and is usually black or red. Marl is also earthy and soft, but is usually whitish. Limestone is usually white, is less easily scratched than shale. It is firmer and consequently ledges, large slabs and boulders of limestone are found while such occurrences of shale or marl are very infrequent. Flint and chert are very firm and very hard. They can not be scratched with a knife. In fact sharp edges will cut glass. In color the flint of this area is usually a dirty yellow. The chert is often black.

(2). *The history of the formation of sandstone, shale and limestone:* The materials of stratified rocks are derived from the decay of massive rocks. Massive rocks are solidified plastic ("molten" rock. When granite (the type massive rock) decays the small particles of quartz are set free and form sand grains. The substances, mainly feldspar, which had surrounded the quartz grains, mostly becomes shale. Moving water and the wind sorts these products of the disintegration of massive rock so that frequently almost pure beds of sand, are laid down in one place, and of shale are laid down in another. The decay of massive rocks furnish a small amount of limestone material which is soluble in water. Various shell forming animals and certain plants extract these from the water. Beds of limestone are precipitated or are formed from consolidated layers of such shells. Commonly the larger shells have been crushed; and the very small ones are too small to be seen without the aid of a microscope.

IV. THE ROCK FORMATIONS.

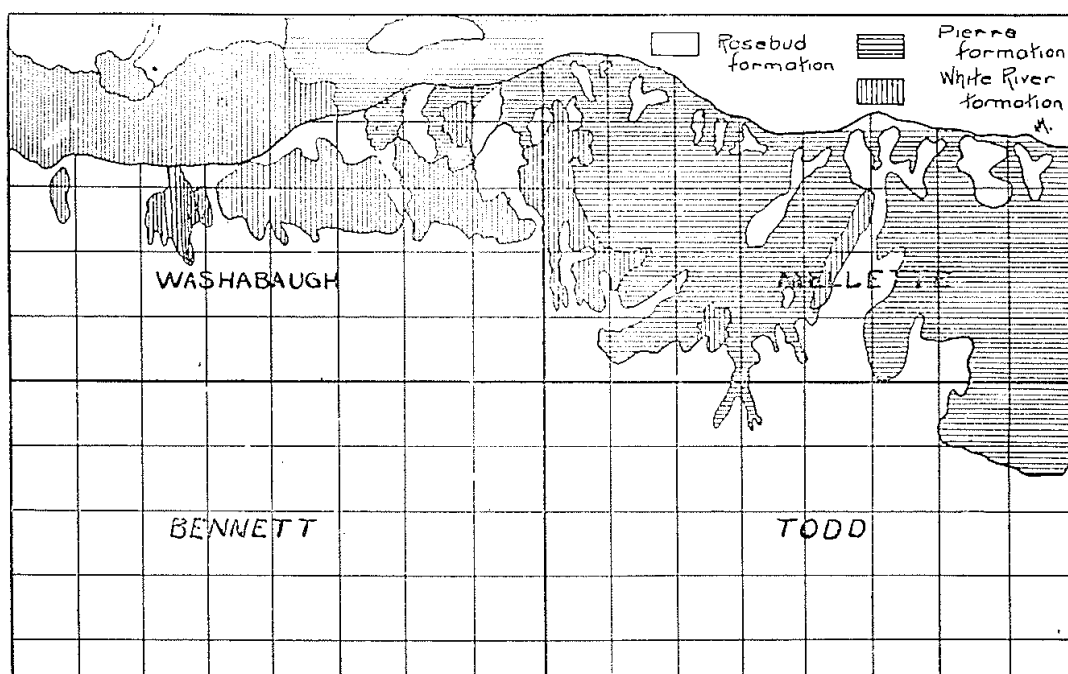
I. SECTIONS.

(a.) *Summarized Section of the Rosebud Artesian Well,* situated about twenty-five miles northeast of the Rosebud agency in township 40 north and range 27 west. This well was drilled by the government in 1895-6-7. Water rises to within about five hundred feet of the surface which is here 2626 feet. Most of the water comes from the depth of about 2300 feet.

Depth	Thickness.	Character	Age	Divisions
FEET				
0- 350	350	Sand, Clays, &c.	Tertiary ..	{ 3 Rosebud 2 Brule 1 Chadron
350-1550	1200	Shales	Cretaceous	{ Pierre Niobrara Benton Dak. Sandstone
1550-1750	200	Chalk, Shale		
1750-2100	350	Shales, dark with sand		
2100-2500	400	Sandstone with shale layers		

(b). *Section by Reagan (revised) of Three Points Buttes at the head of Oak Creek, one mile east of artesian well.*

Depth	Thickness.	Character	Division
FEET	FEET		
0- 8	8	Firm Sandstone	Rosebud
8- 18	10	Sand and sandstone of dune origin	Rosebud
18- 26	8	Sand and sandstone of stream origin	Rosebud
26- 66	40	Sand	Rosebud
66-300	234	Light colored shales	White River
300-000	000	Dark shales	Pierre



Geological map of the four counties. Upper Miocene, Pleistocene and recent materials not shown.

2. THE PIERRE SHALE.

(a). *Distribution.* The Pierre formation outcrops in many thousands of square miles of the Great Plains region. It is widely exposed in Mellette County and other areas covered with Pierre soils.

(b). *Physical Description.* It is a very uniform, irregularly jointed shale, bluish to dark gray, which rapidly weathers into flaky fragments that are usually light brown in color; yellowish spots or stains of iron oxide are common and nodules of iron

pyrites are far from rare. The uppermost beds, especially, contain numerous concretions or nodules, composed either of impure limestone or of carbonate of iron, which vary in size from a couple of inches to several feet across and in shape from lenticular to spherical. These lenses or balls have not infrequently been cracked vertically into polygonical columns and the cracks wholly or partially filled with calcite of various colors of which yellow is the most general.

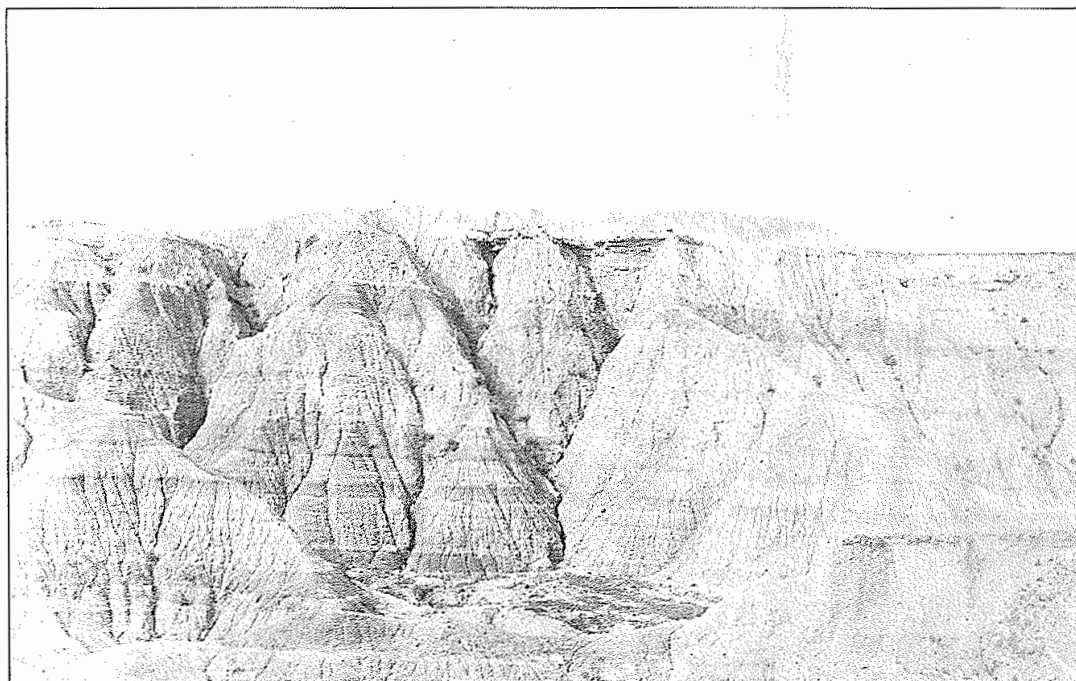
(c). *Fossil Content.* Fossils are not rare in this formation and many forms of great interest have been discovered. Fossils of marine "shellfish" are frequently found in the concretions. The commoner ones are the coiled "ammonites" ("petrified snakes")* and the straight slender cone-like *Baculites*. Both are related to the nautilus and octopus. Several kinds of mussel or "clam" shells are met with; *Inoceramous* a large mussel, four to eight inches long, with well developed "ribs" occurs widely. Locally near the top of the formation a small roundish mussel, less than an inch across, known as *Lucina* is abundant in concretions.

Fossils of marine reptiles of several kinds have been found, usually only fragments. Complete skeletons or even only well preserved skulls are valuable.

(d). *Structure.* The Pierre Shale is approximately horizontal in this region. However several slight and local departures from the horizontal were noted. In southeastern Mellette County slight dips to the west occur. There is some evidence of a slight doming of the Pierre in the White River Valley near Kadoka. The distinct anticline along the upper White River valley (western Shannon County) doubtless results in an eastward dip of the Pierre in Bennett County.

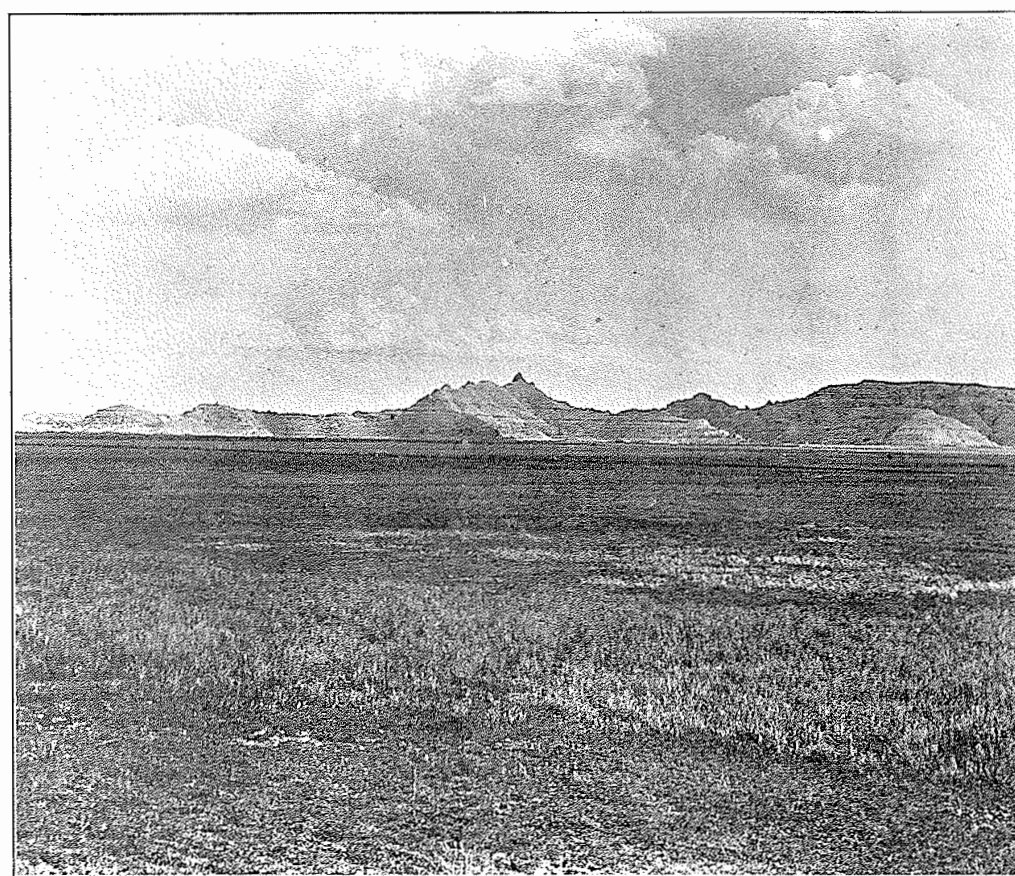
(e). *Thickness.* The Rosebud artesian well indicated a thickness of about 1200 feet and data from surrounding areas point to

*There are in the South Dakota Pierre Shales three genera popularly called ammonites. *Scaphites* is the most common. Some of its species are partially, and others irregularly coiled in a single plane. The ordinary fossil is a disc from two to five inches across and an inch thick. The large end of the coiled shell is squarish. A row of protuberances are arranged along each of the sides. *Platoniceras* has only a couple of coils, also in single plane, and the outer edge is sharp, giving a triangular shape to the end of the shell. *Nautilus* has a shell which increases very rapidly in size so that though there are only a couple of coils, the end is commonly larger than in the case of the two preceding genera. The shell, and hence the end and the edge, are roundish. The sutures are straight; in the other two genera they are quite complex.



Showing banding in the Brule division of the White River formation. View taken in northeastern Washabaugh County.

Plate 17



Disappearing badlands. The flat, fertile plain of the foreground is constantly enlarging at the expense of the badlands which are in the Brule formation.

that as approximately the thickness of this formation in this region.

(f). *Manner of Deposition.* The fossil content, physical characteristics, etc. are quite conclusive in indicating the marine nature of this shale. A shallow sea extended from the present Gulf of Mexico to the Arctic Ocean. The material was supplied by sluggish muddy streams from the west and partially also from streams from the east.

(g). *Age.* The Pierre formation belongs to the Montanan division (the third of four divisions) of the (Upper) Cretaceous Period which is the fourth and last great period of the Mesozoic Era. The term Mesozoic means "mid-life." The abundant fossils of the preceding era (the Paleozoic) are relatively much more ancient; and these of the succeeding (the Cenozoic) are recent in aspect.

3. THE WHITE RIVER FORMATION AND ITS SUBDIVISIONS.

Introductory. The Cenozoic Formations. The uppermost Mesozoic formations (Fox Hills and Laramie) are not represented here nor is the lowest (Eocene) of the Cenozoic. During the interval between the depositions of the Pierre Shale and of the White River Formation this region was probably land and being eroded. At any rate the succeeding formation was deposited upon an uneven surface. In contrast to the Pierre shale the other outcropping formations are not of marine origin, but are believed to have been deposited along their channels by streams. The sediment came from the growing Rockies and its outliers (including the Black Hills). These streams instead of carrying material away from this particular district (as we popularly consider it a stream's mission to do) deposited here much sediment secured in higher regions to the west along their channels. The Platte River in Nebraska and many smaller streams locally are carrying on somewhat extensive similar depositions.

There are two chief divisions of the Cenozoic formation exposed. The lower is the White River formation which is divided into two mainly on the basis of its fossil content, a lower, the Chadron, and an upper, the Brule. The second great division is the Rosebud formation. The recent deposits, alluvium for example, are inconsiderable.

(a). *Distribution.* The White River formation has been eroded away from those areas where the Pierre Shale outcrops. It is exposed in an irregular belt which extends from Tripp County westward nearly to the Cheyenne River, and thence south and west. To the east the outcrops are frequently narrow and badlands are not developed. Westward from central Mellette County this formation is eroded into badlands in or along the sides of the several valleys. Badlands are splendidly developed in the middle or lower portions of the valleys (see soil map), of Cottonwood, Craven, Eaglesnest, Bear, Medicineroot and other creeks. The portion of this area covered by the White River formation is indicated on the geological map.

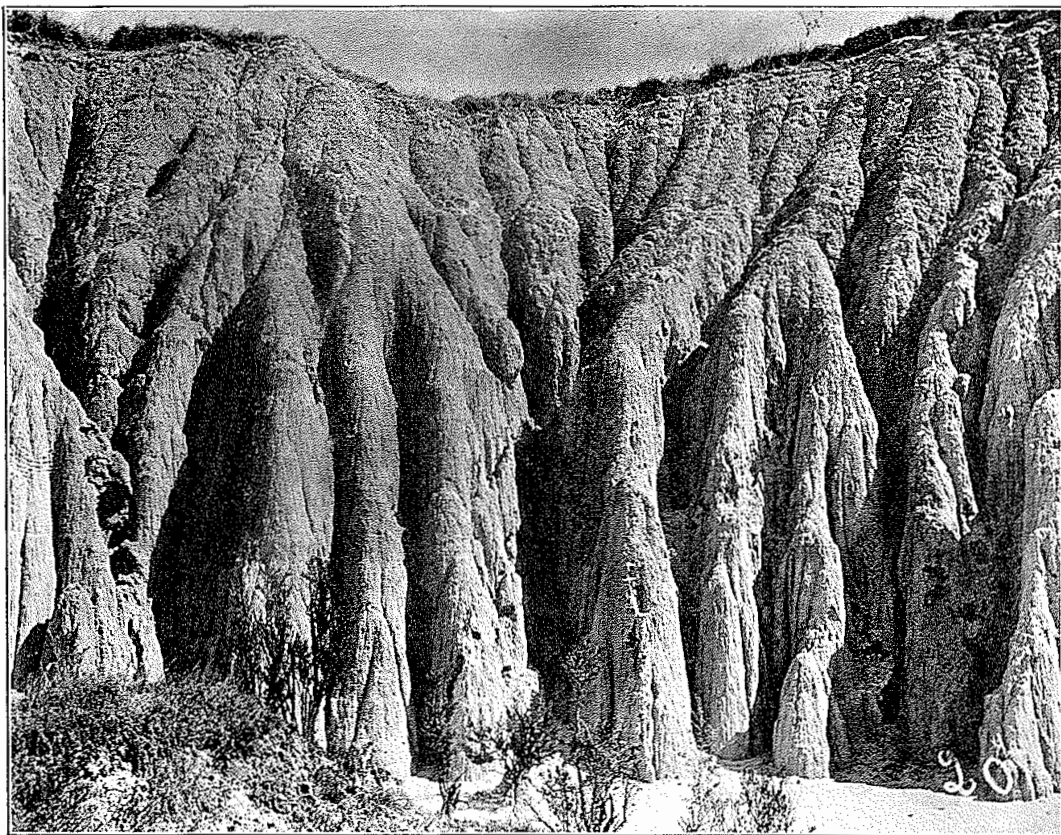
(b). *Physical Description.* The White River formation is mainly light colored clays and shale though sandy or sandstone strata, conglomeratic zones and impure limestones or marls are all represented. "The sandstones are never entirely continuous and never more than a few feet thick. They present every degree of compactness from loose beds of sand to most solid sandstones. The cementing material, where present, is carbonate of lime. The sand is composed of quartz, feldspar and mica and is evidently of granitic origin" (Hatcher) "Occasionally thin persistent bands of knotty grayish limestone or lime clay concretions are found. These weather to a chalky white and although seldom prominent, individual bands may sometimes be traced over considerable areas." (O'Harra.) "A section of the beds taken at any point and showing the relative position and thickness of the sandstones, clays and conglomerates is of little value since these vary much at different and quite adjacent localities." (Hatcher.)

THE SUBDIVISIONS OF THE WHITE RIVER FORMATION.

The Chadron beds, so named from Chadron in Northwestern Nebraska, have frequently been called the "Titanotherium beds" from the name of the large extinct mammals whose bones occur somewhat abundantly. The formation is made up chiefly of a sandy clay of light greenish-gray color with generally coarser sandy materials at or near the bottom, including sometimes deposits of gravel or conglomerate several feet thick. The beds immediately above the gravels are often of a yellowish, pinkish, reddish or brownish color.



Erosion of homogeneous materials. Grooves, pillars and alluvial slopes formed,
Cottonwood Canyon. Plate 18



A portion of a "badland wall." Cottonwood Canyon.

The clay of the Chadron beds where exposed on bare slopes, has a rather striking manner of drying so that the surface is loose with a gradual increase in compactness for a few inches within. As a result cattle or men can obtain sure footing and can and do clamber about surprisingly steep slopes with safety. The clay of the Brule beds, although it sometimes is loose at the surface, is always hard at a shallow depth and footing can not be obtained. The Chadron clay also erodes into rounder, distinctly smoother hills than does the Brule.

(c). In regard to the fossil content the Chadron is notable for its remains of the gigantic Titanotheres. Several kinds are somewhat numerous and eighteen species belonging to five genera have been described from this formation in South Dakota. One member of each of the dog and the cat family, four species belonging to three genera of the Rhinoceros family; three species of the primitive three-toed horse (*Meshippus*); six species representing four genera and four families belonging to the Artiodactyla (cow-sheep etc. division) comprise the other mammals known from this formation. In addition three species and genera of turtles and one species of crocodile have been described. Without doubt there are many undescribed additional forms.

The Brule Formation. This formation has two main subdivisions, the lower or Oreodon Beds (Middle White River) and the upper or Protoceras Beds (Upper White River). The following generalized section of the Brule is modified from O'Harra.

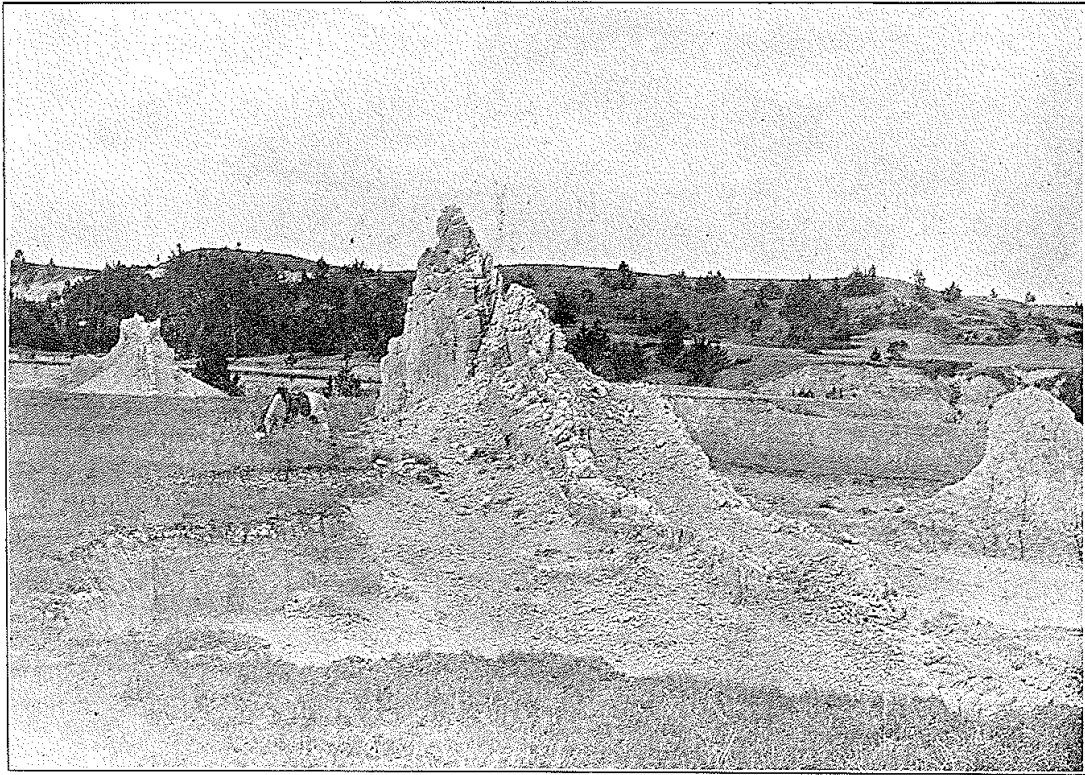
Approximate thickness of beds		Dominant Fossils and General Character of Beds
Protoceras Beds.	100 ft. {	<i>Leplauchenia</i> layer; nodule-bearing, pink colored clays widely distributed.
	50- 75 ft. {	Coarse sandstone occupying different levels, not continuous.
Oreodon Beds.	100 ft. }	Light colored clays, barren.
	75-100 ft. {	Nodulous clay stratum. Bones white. Sandstones and clays. Bones rusty colored.
	10- 30 ft. {	Oreodon layer: nodule-bearing, very constant and widely distributed. Numerous <i>Oreodons</i> and turtles imbedded in nodules. Bones always rusty. "Red layer" of collections.
	50 ft. {	<i>Metamynodon</i> layer; sandstones, sometimes replaced by light colored barren clays. Reddish or bluish gritty clay. Bones white.
	20 ft. {	Mingled remains of Titanotheres, <i>Mesohippus</i> and <i>Aceratherum</i> .

The fossil fauna of the Brule formation is very rich—about 100 species belonging to 40 genera arranged in 25 families of mammals, and three species (2 genera) of turtles, and a couple species of lizards, being already known. The most abundant forms are turtles and Oreodons. The latter resembles sheep somewhat. For an excellent treatment of the fossils of the White River formation see O'Harra, Bulletin 9, South Dakota School of Mines and the references therein given.

(d). *Structure*: The White River formation in these counties is horizontal though cross bedding is sometimes locally deceiving.

(e). *Thickness*. The White River formation in this general region has a maximum thickness of approximately 600 feet of which over 400 feet is Brule and less than 200 feet is Chadron. It thins out to the east and sections of the formation in Mellette County indicate a total thickness of less than 300 feet.

(f). *Manner of Deposition*. These beds were considered by some of the earlier geologists to have been laid down in a large lake which was believed to have covered this region. Fuller studies have disproved this theory, and it is now considered that most of the material was laid down in and along the channels

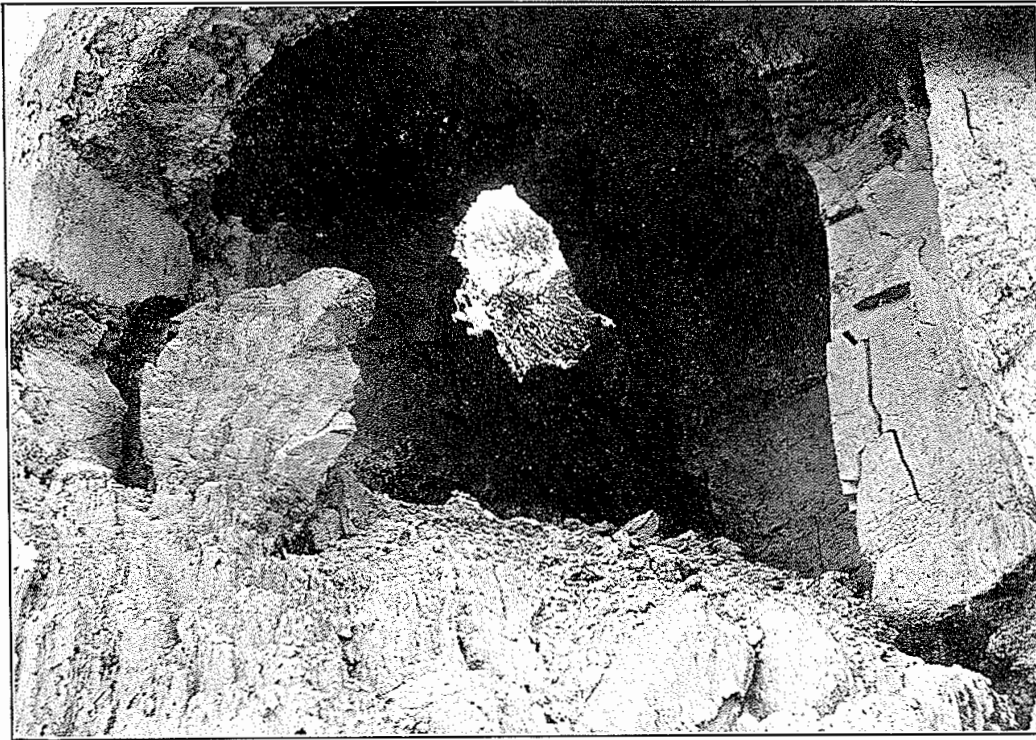


A view in the badland (Brule) portion of Bear Creek valley showing a prominent dyke of calcarious material. It is sufficiently hard to give rise to a series of pinnacles. Note the depression surrounding the pinnacle. Such blowouts almost always accompany small, sharp buttes.

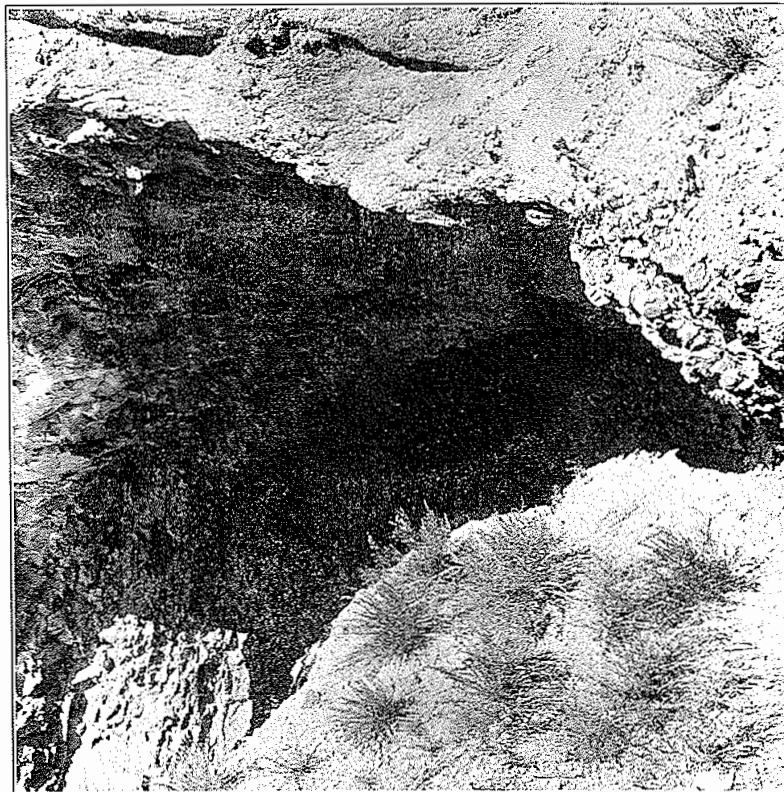
Plate 21



A vein of calcarious material in the badlands.
(Brule formation)



A natural bridge resulting from undercutting and a "cave off." The Brule shale is well exposed here. Plate 23



A portion of the Brule formation being rapidly eroded. The character of the rock can be discovered, with difficulty, in the shadow.

of overloaded streams. The streams meandered and there were cut-offs. Oxbows and bayou lakes were formed in which at times sediment was deposited in a true lacustrine fashion. At seasons of low water the mud flats and sand bars furnished fine material to the wind which produced in certain localities typical aeolian deposits. Thus through lacustrine and aeolian deposits occur fluvial or stream deposits predominate.

(g). *Age.* In the oldest reports on this region (including Bulletin One, (1894) of the South Dakota Geological Survey) the White River Formation is included in the Miocene. Its position in the Oligocene has been recognized for over a decade and the most recent workers (Osborn and Matthew Bull. 361, U. S. Geol. Survey, 1909) states that it represents practically the entire Oligocene.

4. THE ROSEBUD FORMATION.

(a). *Distribution.* Nearly three fourths (See geological map) of this area is underlain by this formation which overlies the upper White River (Brule) unconformably. It is probable that the Rosebud formerly covered the entire area.

(b). *Physical Description.* The material of this formation is but rarely lithified or solidified; as a result, the conventional type of rock is almost lacking. Shallow wells and cuts usually expose a light colored very soft sandstone which rapidly breaks down into sand. Locally a layer of the sand may be cemented to form firm sandstone. Such strata are the cause of waterfalls in the Sandhills (See plate 42). Other firm layers are exposed on the sides of such buttes as Rattle Snake and Three Point Butte. On the former the sandstone, which is near the top, approaches quartzite and the latter has a cap rock of calcareous sandstone. Layers of volcanic ash are frequently noted where sections of this formation are exposed to view. They are usually uncemented, but on Porcupine Peak (in eastern Shannon County) such a stratum is rather firmly cemented and forms, with some overlying quartzite, the cap rock.

The following statement is (altered) from W. D. Matthew: "The base is taken at a heavy white stratum which appears to be identical with the stratum capping the White River formation on Sheep mountain in the Big Badlands. This stratum can be seen extending interruptedly across the river to Sheep Moun-

tain, about twenty miles distant, capping several intervening buttes and projecting points. At the bottom the Rosebud beds approximate the rather hard clays of the upper Leptauchenia beds of the Brule, but becomes progressively softer and sandier towards the top, and are capped at Porcupine Butte by a layer of hard quartzite sandstone. Several white flinty, calcareous layers occur, one of which, about half way up, was used to divide them into Upper and Lower. The stratification is very variable and inconstant, lenses and beds of soft fine-grained sandstone and harder and softer clayey layers alternating with frequent channels filled with sandstone and mud conglomerates, all very irregular and of limited extent. The hard calcareous layers are more constant. A bed of volcanic ash lies near the top of the formation, and there often is a considerable percentage of volcanic material in the other layers.*"

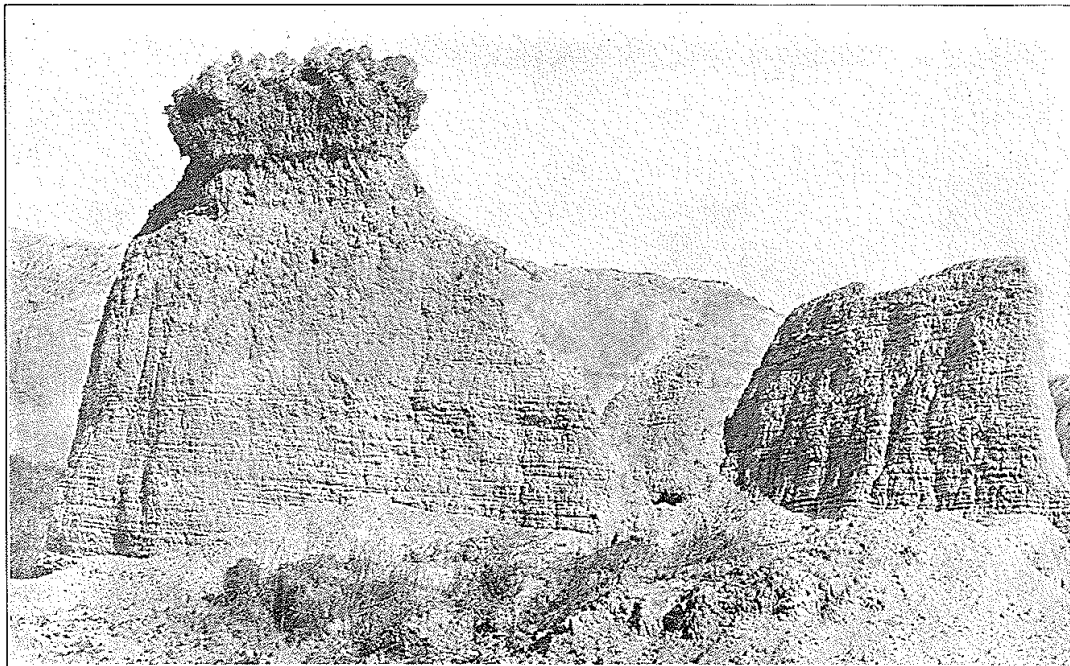
Two peculiar and remarkable forms or arrangements of mineral matter occur locally in the Rosebud beds. These are *Calcite-sand Crystals* and *Devil's Cork Screws* or *Daemonelix*.

The *Calcite Sand-Crystals* are made up of approximately sixty per cent of sand and about forty per cent of calcium carbonate. The sand is an impurity in the calcite crystal. The size varies from a quarter of an inch up to fifteen inches. The best known locality is Devil's Hill located in the extreme south western corner of Washabaugh County. The following account by Professor Barbour is of their occurrence there: "The mode of occurrence of these crystals seems most unusual and remarkable. In a bed of sand scarcely three feet thick, and so soft as to resemble the sand on the seashore, occur these crystals in numbers which can best be figured in tons. We dug them out with our bare hands. They are mostly single crystals, with numerous doublets, and triplets, quadruplets, and multiplets. In other words, every form from solitary crystals to crowded bunches and perfect radiating concretions were obtained. It was a matter of special interest in the field to note that at the bottom of the layer the bulk of these sand-line crystals are solitary; one foot higher there is an evident doubling of the crystals, until within another foot they are in loosely crowded clusters, a little high-

*"A lower Miocene Fauna from South Dakota." Am. Mus. Nat. Hist. Bull., Vol. 23, 1907, pp. 169-219.



Re-worked White River formation material. Note the tiny natural bridge.

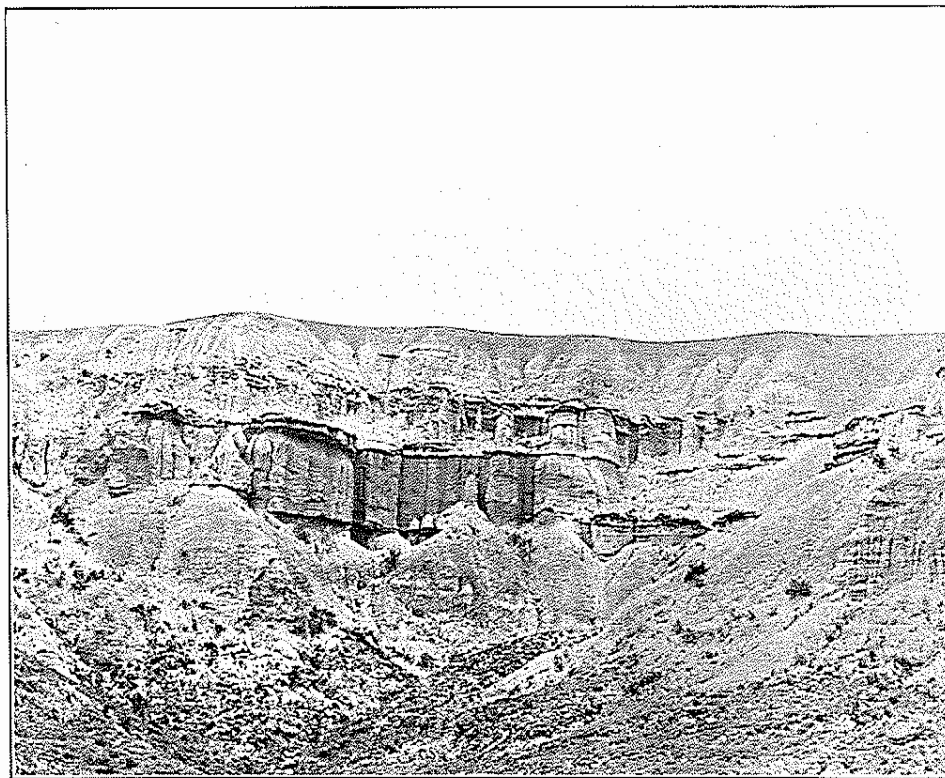


Re-worked White River beds. Along many of the larger valleys there is abundant evidence that there has been a recent re-juvenation which has followed a period of deposition.



Badland erosion especially as influenced by harder, ferruginous, layers. "Toadstools" are present in the foreground. The trees are cedars.

Plate 27



The thin layers of sandstone are often firm and greatly affect the topography developed by erosion. A portion of the Titanotheres beds of the Chadron.

er in closely crowded continuous clusters, pried out in blocks with difficulty; still higher they occur in crowded concretions in contact with one another, making nearly a solid rock. A little higher this mineralizing process culminates in pipes, compound pipes, and solid rocks, composed wholly of crystals, but so solidified that their identity is lost, and is detected only by a certain reflection of light, which differentiates the otherwise invisible units by showing glistening hexagonal sections. There could not have been a more gradual and beautiful transition, and all confined to a bed six or eight feet in thickness.”*

The *corkscrews* are reported by Reagan from near the top of Three Points Butte in Mellette County, but are there small. It is quite likely that larger and more striking specimens will be disclosed in the more south-westerly counties. At any rate the following clipping from O’Harra is of interest.

“Among the interesting materials of the badlands formations few have given rise to more speculations as to their origin than what are known as the Devil’s Corkscrews of the Harrison (Upper Rosebud) beds. Devil’s Corkscrews, or Daemonelix, as they are technically called, have been known by the early residents of northwestern Nebraska for many years but it was not until 1891 when Prof. Barbour made a collecting trip to Harrison and the badlands that these strange objects were brought to the attention of scientific men. What they really represent or how they were formed is still a matter of conjecture. The more typical forms are upright tapering spirals and they twist to the right or to the left indiscriminately. The spiral sometimes encloses a cylindrical body known as the axis but it is more often without the axis. Sometimes the spiral ends abruptly below but more often there projects from the lower part one or two obliquely ascending bodies placed much as the rhizomes of certain plants. The size of the well developed form varies considerably. The height of the corkscrew portion is ordinarily about the size of one’s body.

“They are known to occur especially between the head waters of White and Niobrara rivers chiefly in Sioux County, Nebraska. The vertical range of strata carrying them is approximately 200 feet. Concerning their abundance prof. Barbour says: ‘It

*Barbour, E. H. Calcite—Sand crystals and their relations to certain concretionary forms. Bull. Geol. Soc. Am. 1901 pp. 13-18.

intrudes itself upon you at every turn. On lands laid bare by erosion the half exposed and weathered tops of countless Dæmonelix projects. There they stand, bolt upright, till overthrown by the elements. We have picked our way through acres of these fallen spirals. The walls, bluffs, and buttes they are particularly accessible to the collector.

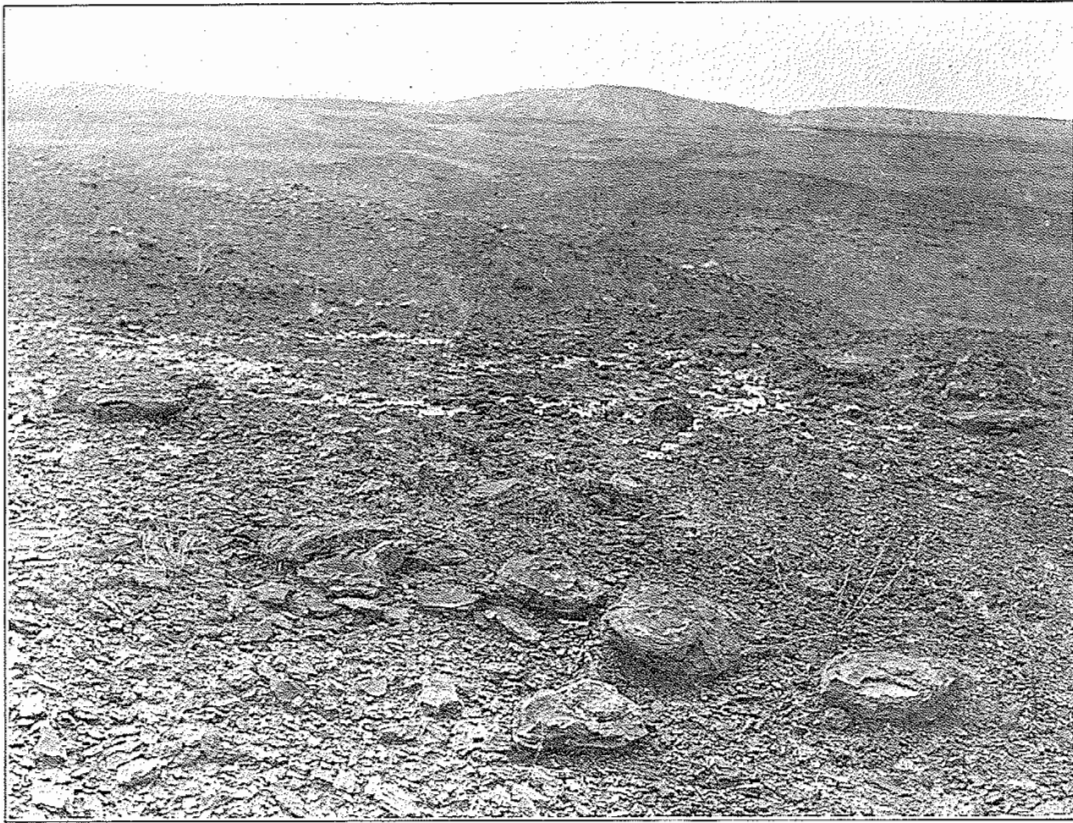
“It is apparent at a glance that they flourished in numbers of which one can form no conception. Growing closely packed side by side, they are often inextricably entangled and fused together. We have counted as many as twenty or thirty in a space occupied by an ordinary dwelling house. We have often destroyed several while digging one out.’

“Prof. Barbour who has given these interesting fossils most study considers them as representing some form of plant life and has apparently found much to corroborate this view. The surface of all forms shows as a mass of fossil vegetable fibre much resembling ‘fine excelsior in a matrix of hydraulic cement.’ Microscopic study of thin sections shows abundant vegetable cells in the peripheral portion but the inner portion is usually structureless at least so far as plant development is concerned. Prof. Barbour has furthermore found that in going from lower to higher beds there is a gradual change in forms ranging from simple fibers and masses to those of ever increasing diversity and complexity. This resembles steps in phylogeny, but it is not at all sure that it really does represent phylogeny, for it may develop, as some believe, that the forms have only some indirect connection with organic life.

“Some have considered that they represent low plant organisms such as algæ, others that they may be remains of higher plants, in which all has decayed away except the cortical layer. Still others and these with much reason have considered them as casts of well preserved burrows of animals, which theory has been emphasized by the finding of burrowing rodents within the corkscrew.*

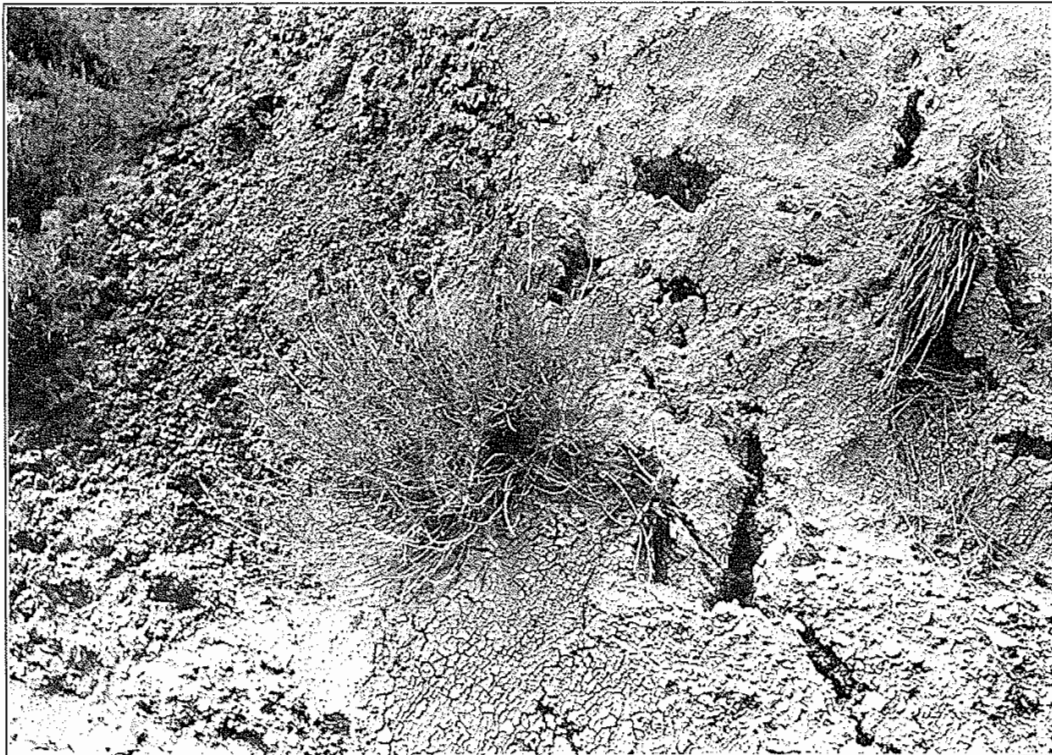
(c). *Fossil Content.* The Rosebud beds have yielded a considerable mammalian fauna as the result of their study by Matthew of the American Museum, especially near Porcupine Peak, Peterson of the Carnegie Museum mainly in north-western Ne-

*O’Harra Bull. South Dakota State School of Mines, pp. 51-52.

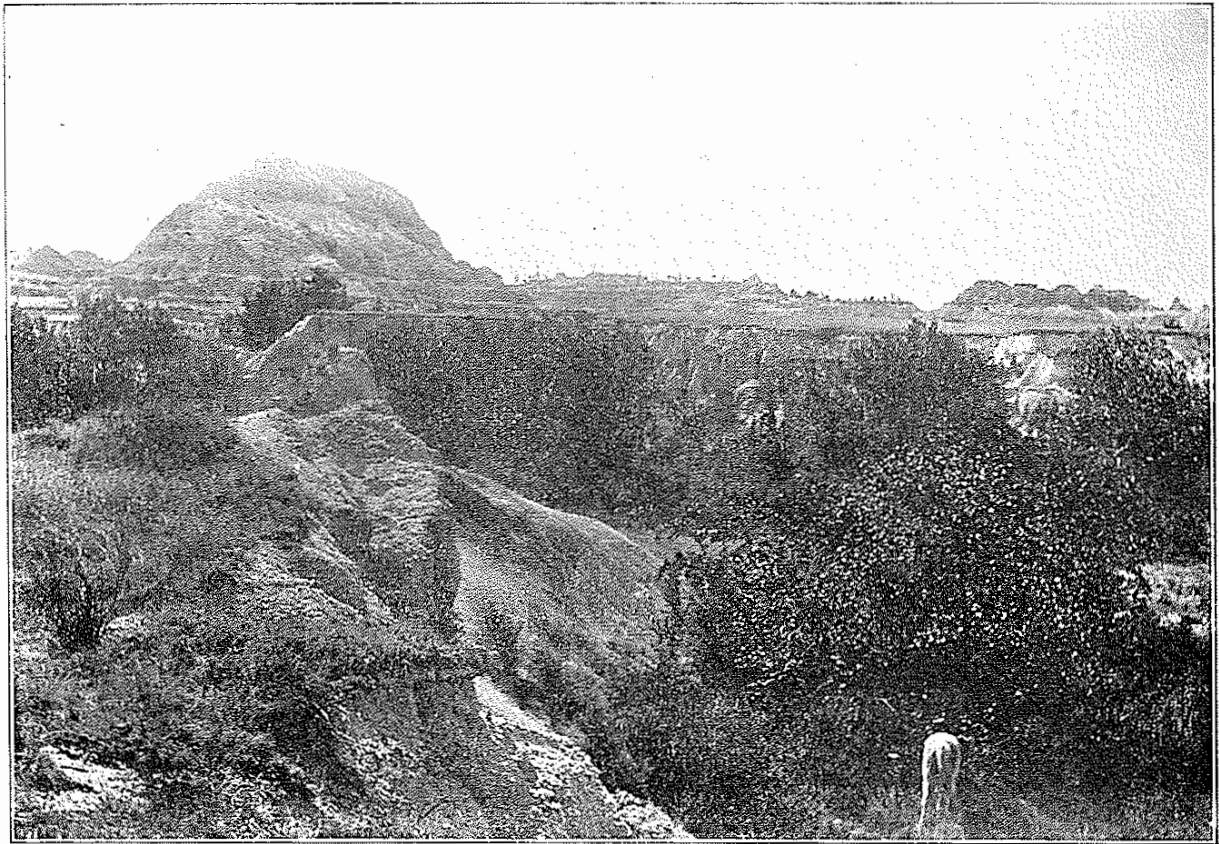


"Iron ore" concretions and a portion of badland surface almost completely covered by a pavement of portions of concretions and of numerous small veins. The finer material has been washed and blown away leaving these angular pebbles. A portion of the Redstone basin in N. E. Washabaugh County.

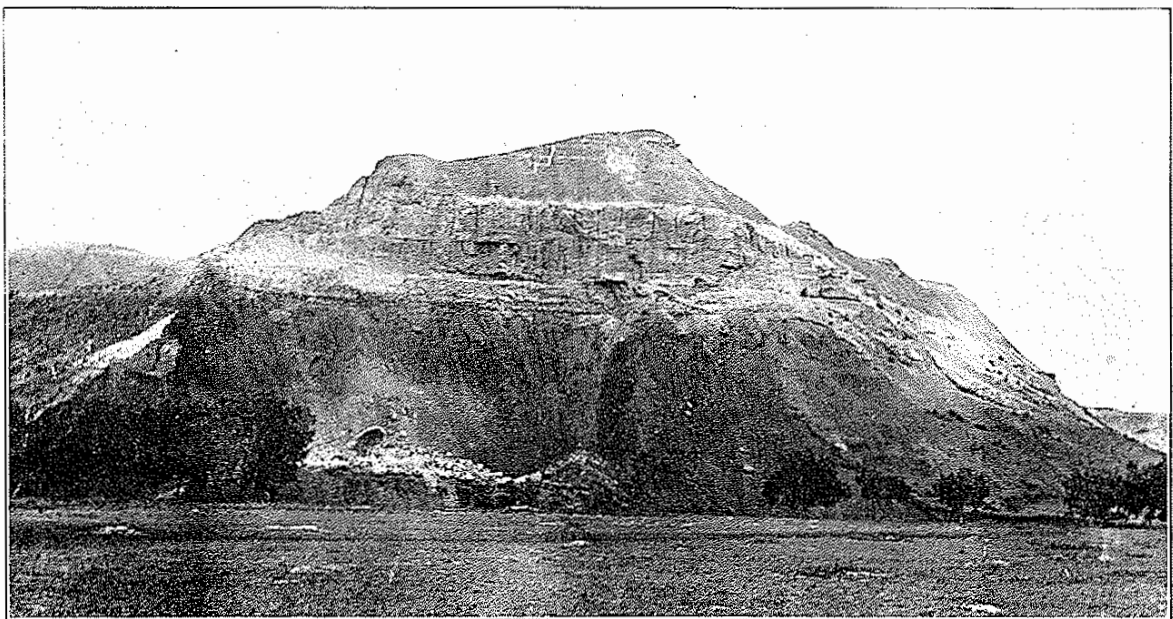
Plate 29



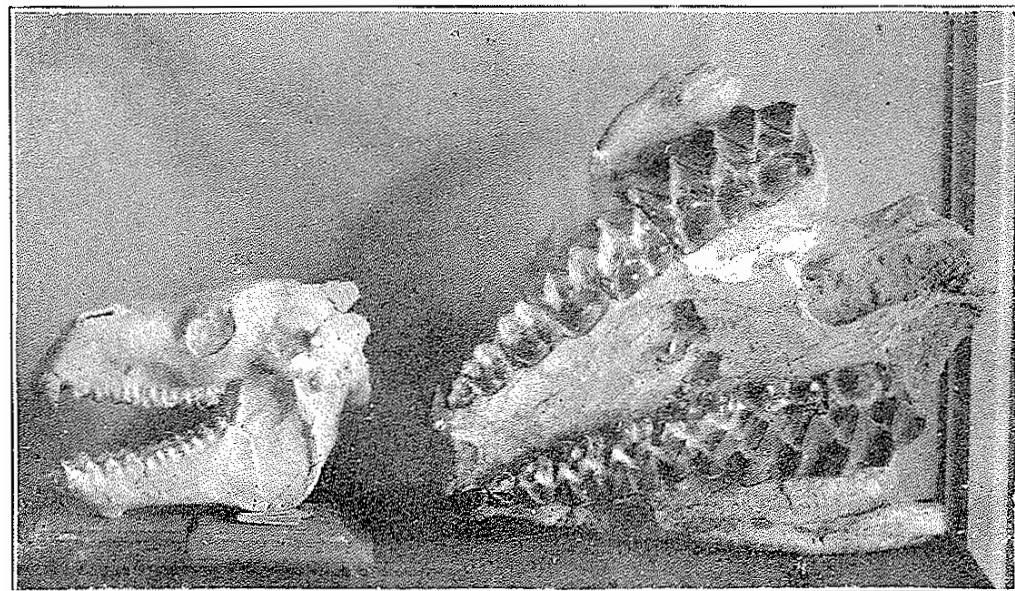
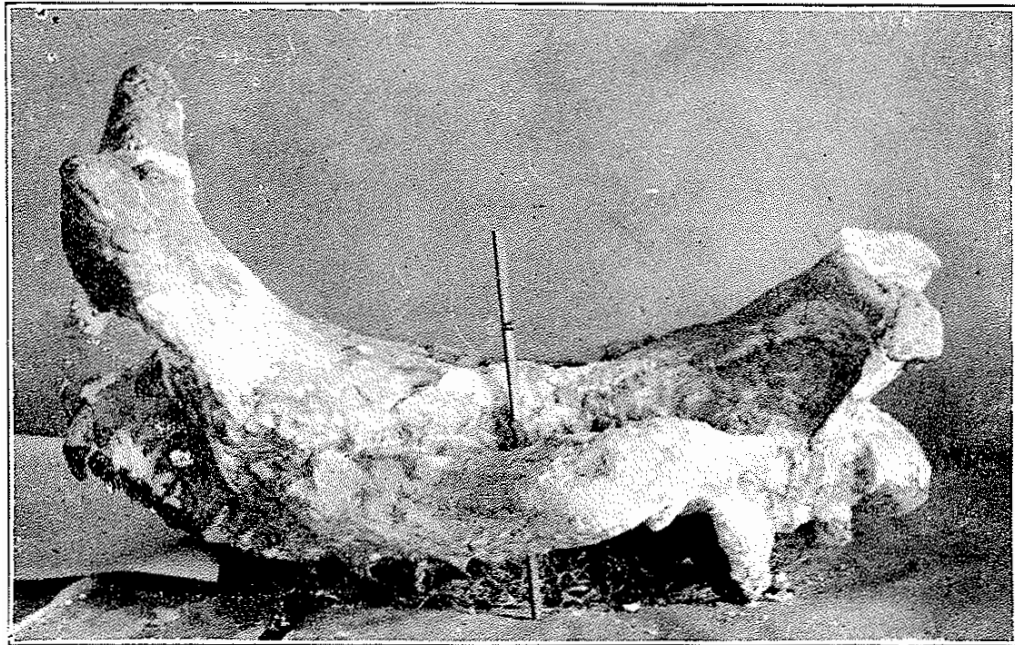
Creek, cracking and crumbling of the material at the base of a steep slope is well shown at this point. Such openings as that largest shown encourages the development of miniature natural bridges.



A view across Cottonwood Creek valley, Washabaugh County. Badlands in the making. Five cycles of erosion shown.



A butte near the edge of the badlands. The dark formation below is the Pierre Shale, the light above, is the Chadron portion of the White River. A small slump of White River has taken place.



Portions of two conspicuous badland fossils.

(a) A portion of the skull of *Titanotherium*.

(b) Skull of *Oreodon major* and jaw of *Titanotherium giganteum*

The *Titanotherium* resembled the elephant in size of body, but was not so tall. Unlike it, instead of a proboscis, it probably only had a somewhat flexible nose like a tapir. Elephant-like, its heavy short legs were tipped with four toes on the front feet and three on the hind. Its habits not improbably were like those of the rhinoceros. Its food was vegetation.

braska, and Gidley of the National Museum, extensively in the Rosebud Reservation. Some eighteen families (dog, cat, mink, beaver, gopher, rabbit, elephant, rhinoceros, horse, oregon, camel and deer families, etc) represented by 34 genera and 70 species are mentioned in Matthew, Faunal lists of Tertiary Mammals (Bull. 361 U. S. G. S.) Matthew states: "The Rosebud fauna contains no new immigrants but is mainly a further development of the John Day fauna." Two species of turtles are found in the Rosebud beds. Fragments of bird bones are reported from Three Point Butte by Reagan.

(d). *Structure.* The Rosebud beds are horizontal and overlie unconformably and sometimes overlap the upper White River beds. Cross bedding is locally prominent and may with certain exposure suggest diastrophism.

(e). *Thickness.* Matthew states that in eastern Shannon County, the Rosebud has a thickness of 500 feet. Reagan reports that at Valentine, Nebraska, just south of Todd County, a thickness of over 400 feet. This formation thins out towards the east and north. At the Artesian well, which is near the north eastern edge of the covered area, the thickness is about 160 feet. Perhaps the average thickness in Todd and Bennett Counties is between four and five hundred feet.

(f). *Manner of Deposition.* The Rosebud is more strictly a stream deposit than is the White River. Old channels, cross-bedding, lenses etc. are conspicuous. Reagan reports some dunesand deposits in his Three Points Butte section. Wind blown materials are also represented by the volcanic ash which is believed to have been carried some hundreds of miles from the volcanic areas of Idaho, Oregon, etc.

(g). *Age.* The beds here called the Rosebud are believed by Osborn and others to represent the lower Miocene in age, and to be equivalent to much of the group called the Arikaree by Darton, who also called what is now believed to be a phase of the basal Arikaree the Gering beds. The Rosebud is further believed to be comparable to the Monroe Creek beds (below) and the Harrison beds (above) of extreme northwestern Nebraska and adjacent Wyoming.

Upper Miocene. What is known as the Nebraska beds occur in northwestern Nebraska and very probably also in adjacent

portions of South Dakota. A fauna of some ten species of mammals is reported by Osborn from the Upper Miocene in South Dakota. Reagan reports some beds near the Rosebud agency as possibly of this age. In our reconnoissance work we were unsuccessful in mapping this division.

Pliocene. There is no certain evidence of the occurrence of beds of this formation (Equus beds) though it is not impossible that detailed study may prove their presence.

Pleistocene and Recent. This region has been undergoing erosion since the Miocene times and consequently such deposits as have been formed are inconsiderable, subordinate and thin. Three types of recent and Pleistocene deposits may be noted: (1) The alluvium along the flood plains of the streams (see soil map) (2) The talus and debris accumulations on the slopes of the buttes and escarpments. Mastodon remains have been found in these deposits near the Rosebud agency. (3) The wind blown sands of the sand-hill region (see soil map).

V. THE GEOLOGICAL HISTORY OF THIS AREA.

1. *Cretaceous Period.* (a). *Dakota Epoch.* The oldest formation known in the region is the Dakota Sandstone which was reached in the Rosebud artesian well. This formation outcrops around the Black Hills and along the Rocky Mountains where water readily enters the porous sandstone and flows underground to furnish the water supply of the deeper artesian wells, as far east as eastern South Dakota. The Dakota sandstone of this general region is known to be terrestrial in origin; that is, it was deposited by streams along their courses. This is indicated, in addition to other evidences, by its flora. The U. S. G. S. issued in 1891 as Monograph 17, a volume by Lesquereux on the flora of the Dakota group. Nearly five hundred species were known at that time from the Dakota formation (Mainly in Kansas) and such normal land genera as the oaks, cottonwood, birch, beech, willow, fig, grasses, etc. were included. The presence of such higher (flowering) plants as the predominant forms of the flora distinguishes the Dakota from lower formations. Flowering plants had their origin but shortly before this epoch.

(b). *Colorado Epoch.* The Rosebud artesian well penetrates two formations of this epoch. They are the Benton Shale and the Niobrara Chalk. These are marine formations. A shallow sea

extended from the Gulf of Mexico far northward, even joining the Arctic ocean at the time the Pierre shale was formed. The Benton shale was formed while the sea was still very shallow and muddy. The chalk was formed after it had become relatively clear, and deeper. In these beds there are occasionally found (especially in Kansas) remains of sea reptiles of several types, some of which were very large (mososaurs, pleisosaurs, etc.) and of especial interest remains of great flying dragons, pterodactyls and pterosaurs, some of which were many times larger than the largest birds. Some of the birds of the Cretaceous were quite peculiar and others were similar to those of today.

(c). *The Montana Epoch.* The Pierre shale, discussed somewhat fully under "The Rock Formations" represents this epoch. The great inland sea had again become muddy and after the deposition of the Pierre shale disappears in the region under consideration. In Stanley County and northward beds known as the Fox Hill beds were deposited.

(d). *The Laramie Epoch,* was a period of erosion in this region as was likewise the *Eocene period.*

2. *The Oligocene Period.* The Oligocene is represented by the White River formation (Chadron and Brule beds) for the discussion of which see "The Rock Formations." This period is of especial interest as being the period of first abundant mammal remains. (The Eocene in some few states has still earlier remains). Though mammals differentiated off from the reptiles as far back as the Triassic (see table of S. D. Rock Series) they were apparently unable to become dominant until flowering plants (grasses, herbs, etc.) were evolved in the Commanchean (lower Cretaceous) and had spread over the earth furnishing an abundant nutritious food supply.

The fossils of the White River beds indicate that during this period South Dakota had a more moderate climate than at present.

3. *The Miocene Period.* (a). *Lower Miocene.* The Rosebud beds belong to this epoch. (See "The Rock Formations") These beds indicate that this region was then the site of deposition by streams. The volcanic ash strata were formed by the accumulation of ash blown by the prevailing westerly winds from the region of volcanic activity of that time, to the west-

ward of the Yellowstone National Park, or possibly from the northern Black Hills.

(b). *Middle Miocene*. Since beds of this epoch are unknown here, the supposition is that the region was undergoing erosion. For a considerable expanse of time, the Black Hills region had slowly been bulging up under the influence of the lava coming up from below. This doming accelerated stream erosion in the region being elevated. The material was partially deposited beyond the elevated part (forming, quite likely part of the White River and Rosebud beds) but as the uplift continued a wider and wider area was effected until at the time of the Middle Miocene, the area under consideration became the site of erosion and not of deposition.

(c). *Upper Miocene*. The Nebraska beds are of very local and slight development in South Dakota. In most sections erosion continued, possibly at an increasing rate throughout the Upper Miocene, the Pliocene, Pleistocene and the Recent time. By this long continued and extensive erosion the present topography has been developed. Starting with a plain at the close of the lower Miocene, the surface has been lowered, not continuously, but by several stages. Prof. Todd¹ has recognized five chief plains. "First, and highest, that of the original Miocene Plain. This we believe to be represented quite closely by the summits of the buttes capping the divides south of White River from Pine Ridge to the Bijou Hills.

"Second, the Pliocene peneplain which corresponds approximately to the general level, sloping from 3500 on the west to 1700 feet near the Missouri. This, we believe to be the work of streams excavating the surface of the country, when the relative altitude of streams was some 400 or 500 feet higher than at present.

"Third, the early Pleistocene represented by the highest terraces along the streams flowing from the Black Hills into the Cheyenne and that of the divide between the Cheyenne and White Rivers, corresponding to the tops of Sheep and Cedar Mountains, the Great Wall, and of the most elevated buttes of the Bad Lands. This corresponds also with the very highest gravel-

¹Bull. 2 S. D. Geol. Survey, 1896 (1898) p. 119.

ly terraces shown along the White River, and the Missouri as far east as northern Knox County, Neb.

"Fourth, the latter Pleistocene corresponding to the principal terrace, or terraces (for it is in some cases subdivided) along the streams heading in the Black Hills, including especially the Cheyenne, and also seen along the White River and Missouri. This is believed, from its relation to the glacial deposits, to correspond to the earliest occupation of the outer moraine. Some of the lower bouldery terraces correspond probably to the times of later moraines.

"Fifth, Recent, including the alluvial bottom lands of the present together with several lower and less bouldery terraces, found along the Missouri, Cheyenne and White Rivers."

During the development of the Pliocene peneplain, the region was relatively stable. At the close of the Pliocene there was another uplift of the Black Hills, which caused rejuvenation and commenced the destruction of the plain.

5. *The Pleistocene Period.* The most striking feature of the Pleistocene was extensive glaciation. Northeastern North America, northeastern Europe, etc. were covered by great sheets of ice similar to that which now covers Antarctica and Greenland. The glacier extended only as far west as the Missouri river in southern South Dakota. Consequently the region under consideration was not directly affected. The ice dammed up for a while the White River, which formerly emptied into the Missouri river east of where it now does, perhaps not far from Mitchell. Even in the 10 or 20 thousand years since the ice left this section, the Missouri river has not cut its channel to as low a level by about a hundred feet, near Chamberlain as it formerly had near Mitchell. Consequently, the White River has been relatively, partially, dammed for this long period, (though much more during the first half than the last half) and hindered in cutting its valley deeper. But neither it nor its tributaries have been hindered in widening its valley.

The third or early Pleistocene level was possibly associated with the capture of the head waters of the White River which formerly was most of the south fork of the Cheyenne. A tributary of the Cheyenne tapped the old White in northeastern Custer County and beheaded that stream. The lower White after

being deprived of a considerable share of its waters, became a relatively smaller stream and unable to lower its former wide valley uniformly. Instead, it cut a narrower valley represented now by a fourth level or principal terrace. The elevation of this lower level was quite possibly controlled by the damming mentioned in the preceding paragraph.

Another capture of interest in this region was that of the head of Minnehaddusa creek by the lower part of the Little White River. That part of the present Little White River which flows east in southern Bennett County was formerly the head of Minnehaddusa creek and consequently about half of Bennett County drained into the Niobrara River. The distance to the Missouri is further that way than by the present route, and the Little White had the advantage over the Minnehaddusa creek and was successful in destroying the divide and finally in capturing its head waters.

The lower terraces are associated with the rapid deepening of the east (glacial) section of the Missouri Valley and with the clearing out of the lower parts of the present White Valley.

During the period when eastern South Dakota, etc. was ice-covered it is highly probable that western South Dakota was cooler and moister in climate than it is now. Woods were probably more extensive and the sand of the present sand hills was more bound down by vegetation so that there were likely no sand dunes.

In the *geologic future* the present flood plains and valleys will widen at the expense of the old ones. The buttes and hills will slowly disappear and the region will gradually approach a peneplain again. The climate will probably become more uniform.

VI. NOTES ON THE MINERAL RESOURCES.

After such a reconnoissance study as we made it is impossible to report except in the most general terms regarding the resources. Future developments will slowly bring to light additional mineral wealth.

(1). THE UNDERGROUND WATER SUPPLY. Water is one of the most abundant and useful of the minerals. (a) *Artesian wells* can be obtained in all parts of these counties though on the higher lands the depth would have to be considerable (in the vicinity of 2000 feet) and the water would not rise to the sur-

Geological Rock Series.

University of South Dakota, Department of Geology---E. C. Perisho and S. S. Visser.

Eras	Periods	Eastern U. S. Epochs	Central States	S. D. Divisions	Physical Characteristic in S. D.		
"Psychozoic" or Age of Man				Recent alluvial, sand, etc.	General	Economic	App. Thickness
Cenozoic	Pleistocene or "Quarternary"	Champlainic	Glacial	Terraces Glacial beds	Some gravel Boulder clay	Gold, tin, clay	150 ft.
	Pliocene	{ Lacking, except on } { Coastal plain }	Equus beds	(Absent?)			
	Miocene		Loup Fork	Massive Rocks of North Black Hills Arickaree Rosebud	Porphyry, etc. Sandy shale	Gold, etc. Volcanic ash	?
	Oligocene		White River	Brule } Protoceras beds Chadron-- Titanatherium } Oreodon beds	Sandstone, etc. Bad land beds Marly shale	Fullers earth Volcanic ash	400 200
	Eocene		Ft. Union	Ft. Union	Light shale, etc	Lignite	600
Mesozoic.	Cretaceous	{ Lacking, except on } { Coastal plain }	Laramie Montana Colorado Dakota	Lance beds Fox hills Pierre shales Niobrara Benton } Carlile Dakota } Greenhorn Graneros	Somber shale Sandy shale Dark gray shale Chalk and shale Shale and S. S. Limestone Sandstone	Lignite and building stone Some artesian wells Artesian wells and gas	400 300 1200 200 400 to 2000 300
	Comanchean	Erosion, Potomac or Tuscaloosa	"Lower Cretaceous"	Fuson Minnewasta Lakota Morrison	Sandstones and shales	Stone, coal and fire clay	300
	Jurassic		Jurassic	Unkpapa Sundance	Dark gray shales and buff sandstone		200
	Triassic	Erosion Newark series	"Redbeds"	Spearfish	Red sandy shales	Gypsum	500
Paleozoic	Permian	Dunkard	"Redbeds" etc.	Minnekahta Opeche	Gray Limestone Red Sandstone	Lime Cement	50 100
	Pennsylvanian	Coal Measures Pottsville Conglomerate	Missourian DesMoines	} Minnelusa	Sandstones, mainly buff, red Some limestone		600
	Mississippian	Mauch Chunk Pocono	Kankaskia St. Louis Osage Kinderhook	Pahasapa Englewood	Massive gray limestone Pink, slabby limestone	Gold Silver Lead Lime	400 50
	Devonian	3. Corniferous or 2. Oriscany 1. Helderberg	Onandaga 5. Chemung-Catskil 4. Hamilton	(Absent)			
	Silurian	Cayugan Niagran Oswegan	Niagran	(Absent)			
	Ordovician	Cincinnati Mohawkian Canadian	Hudson River } Galena } Trenton } St. Peter } Lower Magnesian	} Whitewood	Massive Gray Limestone		50
	Cambrian	Potsdam Middle c Lower c	Potsdam	Deadwood	S.S. conglomerate & quartzites	Gold, etc.	200
Proterozoic	"Algonkian"	Keweenawan		Black Hills granite etc. Sioux Falls gabbro	Gray granite and dolerite	Mica, tin, copper, iron, etc.	?
		Animikean (Upper Huronian)	Baraboo etc., quartzites	Sioux quartzite and Black Hills slates etc.	Quartzites etc Schists and quartzites	Stone and pipe-stone Gold, silver, tungsten, etc.	2000? ?
		Huronian		(Absent?)			
Archeozoic		Granitoid series or Laurentian Schistic series or Kewatin etc.		Ortonville Granite Schist in deep wells near Bristol etc.	Gray and some pink granite Slate like	Stone	?

face. Flows are to be expected along the flood plain of the White river as far as central Washington county, and along Oak Creek, White Thunder Creek and Little White River as far up as the county seat. At the average elevation of Mellette county (2,200 feet) the water would rise within 2 or 3 hundred feet of the surface; Todd county's (average elevation 2600 feet) water head is 2 or 3 hundred feet from the surface; Washabaugh (average elevation 2800 ft.) water would rise up to 300-700 feet from the surface; Bennett county, (average elevation 3300 feet) water would rise to 800-1100 feet from the surface.

The Dakota sandstone, according to Darton, has an elevation of 6 or 8 hundred feet above sea level in southwestern Bennett county (because of the Chadron anticline), about 400 feet in most of the area and slightly over 300 feet in northern Mellette and Washabaugh counties. Knowing the approximate surface elevation and the elevation of the Dakota sandstone at that locality, subtraction gives the necessary depth of such a deep well. Knowing the approximate head of water in that section, the height to which the water will rise is at once approximately known.

(b) *Shallow Wells.* In most parts of these counties it will be unnecessary to drill to the Dakota sandstone for water since shallow wells will furnish an abundance of excellent water. The areas shown in white on geological map (Rosebud beds, etc.) will yield such wells. The area with out-cropping Pierre shale is favorably located for artesian pump wells and even flows while the limited areas covered by the White River formation will in most cases permit of a successful shallow well. The requisite depth for shallow first-class wells varies greatly with the topography of the locality and the beds penetrated. Over most of the area in the valleys and swales good wells can be obtained at from 10 to 30 feet.

(c) *Springs.* There are many excellent springs in this region, both in the Rosebud beds and at the contact between them and the White River and between the latter and the Pierre. Fig. 41 is a photo of an enormous spring in Bennett County. The largest and most permanent springs aside from those in the sand hills are found at or near the top of the White River formation. It is for this reason that most of the old Indian villages or settlements

are found along valleys where they cross these uppermost White River beds.

2. CLAY.

With the great variety of clays found in the counties it is highly probable that beds will be found that will be used to make cement. Some of the lighter colored clays are occasionally used by the Indians with a fair amount of success as a natural cement.

3. BUILDING STONE.

No large deposits of first-class, easily prepared building stone were found. Yet stone of some value abounds at several points. The thin, irregular layers of quartzite sandstone scattered at irregular intervals through the Rosebud and to a lesser degree through the White River may afford quarries of local value. There are beds of white sandy limestone, apparently of an excellent quality which would yield blocks a foot or two square and of similar thickness.

4. FULLER'S EARTH, BARITE, SAPPHIRINE, ETC.

These are all known to occur, but the value of the deposits have not yet been determined. *Fuller's earth* is found in the White River formation at several points. *Barite* was first noted by Dr. Hayden at Rosebud and Pass Creek. Frequent concretions of this material were observed at certain levels in the upper part of the White River formation. No workable beds have yet been found. *Sapphirine*. Some of the calcedony found in the veins of the lower White River beds is colored a delicate blue tint. A sample was submitted by Prof. Todd to a specialist who expressed the opinion that specimens without flaws would be of some value to jewelers. *Volcanic ash*, a sort of glass dust, occurs and may at some future time be valuable. *Gold* has been found in minute quantities in gravels along some of the streams of this region. Placers of a size sufficient to be profitable are not to be expected.



Typical cottonwood groves of the drier semi-humid region. Although this view was taken in 1902 along Rabbit Creek near the Moreau River similar views could be taken along the White River, the Cheyenne or almost any other large stream crossing our plains.

The Biology of South-Central South Dakota

By S. S. VISHER

I. INTRODUCTORY.

1. Biology during the geological past 63
2. Conditions found by the first white men 64
3. Explanatory remarks 64

II. THE ECOLOGICAL FORMATIONS OR BIOLOGICAL ASSOCIATIONS.

1. The grass covered upland, plain or steepe 66
 - (a) Climatic and other conditions 66
 - (b) Some conspicuous plants and animals 67
 - (c) Remarks on the "adaptations" of the life of the steppe 68
2. Grass flats or terraces along the valleys 72
 - (a) Climatic and other conditions 72
 - (b) Some conspicuous plants and animals 73
3. Open groves of deciduous trees along the valleys..... 74
 - (a) Climatic and other conditions..... 74
 - (b) Some conspicuous plants and animals 74
4. Deep woods in the ravines 75
 - (a) Climatic and other conditions 75
 - (b) Some conspicuous plants and animals 75
 - (c) Remarks on the "adaptations" of the life of the woods 76
5. Pine covered and rocky slopes 76
 - (a) Climatic and other conditions 76
 - (b) Some conspicuous plants and animals..... 76
6. Badlands. 77
 - (a) Climatic and other conditions 77
 - (b) Some conspicuous plants and animals..... 78
 - (c) Remarks on the "adaptations" of the life of the badlands 79
7. Dunes or sandhills 79
 - (a) Climatic and other conditions 79
 - (b) Some conspicuous plants and animals 80
 - (c) Remarks on the "adaptations" of the life of the sandhills 81

Field museum party in the badlands. In some of the asphalt pools of California numerous large Tertiary birds have been preserved. Many are very modern. The absence of fossils of the smaller kinds of birds suggests that small birds have since then increased in numbers more than the large ones. Civilization at least has been less severe on the small birds than on the large ones. I know of no fossil insects having been discovered in the Tertiary of South Dakota, but at a few other localities, notably Florissant, Colo. hundreds of species, representing almost all the modern orders and even many modern families and genera have been discovered.

The Tertiary flora of this region was likely not greatly different from the modern flora though tree ferns, sequoias or giant redwood, tulip tree, magnolia, etc. supplemented our flora. However, it is quite probable that some families such as the grasses, legumes (peas, etc.) composites (aster, sage, etc.) were less predominant than at present. It also seems probable that there was a smaller number of species of the higher flowering plants than now.

2. *At the coming of White Man into this region.*

The fauna and flora was different from that of today, mainly in regard to the larger forms. In 1850 there were wild horses (descended from those brought to Mexico and liberated by the Spaniards in the 16th century. For some unknown reason the native American horses became extinct on this continent shortly before the glacial period). There were present large herds of bison, elk, antelope, Bighorn sheep, bear and puma, and more large birds such as the cranes, grouse, ducks, etc. than there are now. There were also more trees. Various small mammals such as some kinds of mice, etc., were lacking, or more rare than now, as is also the case with numerous kinds of birds, "weeds" and household insects.

3. *Explanatory Remarks.*

The biology of even a small area is a topic comprehensive enough to cause any author but the most intrepid to hesitate. The present writer feels only too keenly his inability to treat at all thoroughly such a large subject in regard to an area of 5,000 square miles and as diversified as this one is. However, since the State Geologist has requested its treatment with the remark

that the paper is intended primarily for the residents of the counties treated and secondarily for those of the adjacent counties, the task has been undertaken. During the reconnoissance trip of last summer, a collection of nearly 400 species of ferns and seed plants were made. This collection has been identified at the New York Botanical Garden by the renowned specialist P. A. Rydberg. A collection of several hundred species of insects was made. These have been sent to specialists on the several groups and only partial returns have yet been received.

In the treatment of the biology of a diversified area it is desirable to sub-divide the region into sections having many similarities. In this area there are native perhaps 40 kinds of mammals, 300 kinds of birds, 20 kinds of snakes, lizards and turtles, 5 kinds of amphibians, over a thousand species of insects and considerably over 500 kinds of plants. In addition there are the fishes, mollusks, crawfish, worms and many smaller forms. Of this vast array of life very many are inconspicuous and not observed by non-specialists, although without a doubt every species has its part to play in the biologic economy of the whole. This is made the more evident when it is noted that most of the species have a definite place to occupy. The plants and animals of the ponds are not at all of the same species as those of the hill tops, those of the shaded ravines not at all the same as those of the level prairies.

It is therefore convenient to sub-divide this area into several *biological associations* or *ecological formations*. The largest association is that of the Grass-covered Upland, Steppe, or "Dry Prairie." Other important formations are (b) the grass Flats along the stream valleys. (c) The Groves along the valleys, (d) Pine-covered and Rocky Slopes, (e) Badlands, (f) Dunes or Sand-hills, (g) Marshes, (h) Streams, (i) Ponds.

It is noticeable that these several formations are primarily characterized by their topography, secondarily by their vegetation and lastly by the animals which inhabit them. This is in reverse order of the motility and is to be expected. The topography is practically unchangeable except when considered in a geological sense. The individual plants are stationary, but the species is movable by means of the seeds, runners, etc. In the case of the animals, both the species and the individual are able

to move about, consequently, we would expect the animals to be but partially confined to a given association. The coyote for example may be found in each and every formation mentioned, but we all know that in some, for example, the stream, pond or marsh, its presence only indicates a visit. In the case of animals, the associations in which they breed are considered to be the associations to which they truly belong.

The Ecological Formations*

1. THE GRASS COVERED UPLAND OR STEPPE.

(a) *The Climatic Conditions* of the steppe are severe. It has consequently been classed as a Xerophytic ecological formation.

Precipitation. The rainfall comes sporadically. Sometimes it falls with great violence and is occasionally accompanied by hail. Frequently only slight showers occur. Periods of drought of shorter (a few weeks) or longer (a couple of seasons) duration are expected. Ordinarily, about three-fourths or more of the total rainfall takes place in the five growing months. The dryness of the rest of the year is evident. The relative humidity of the steppe is low. (See table page 30).

Temperature. The range of temperature is very great, almost 150 degrees annually, and frequently 40 degrees daily. The summer months, especially July and August are hot and the winters cold. The seasons are irregular. Freezes occasionally occur as early as October, and as late as May, and frosts as early as September and as late as June. During the winter season, especially in January and March, unseasonably warm weather occasionally starts vegetation only to have it damaged by the succeeding cold snap.

Wind. Steppes are windy. The velocity is seldom high, but a 4-8 mile breeze is almost constantly blowing. In the summer such winds may be exceedingly hot and may blast the vegetation severely. In the winter the winds are often very cold. When driving dry snow, they are indeed cutting.

Light. There is very little protection from the direct rays of the sun for the plants nor for the animals, except those that bur-

*Any inconsistencies in nomenclature between this section and the appended list of plants is due to the fact that this portion was in type before Dr. Rydberg's determinations were received.

row. Cloudiness is unusual. Consequently in regard to light, the steppe closely approaches the desert.

(b). *Some of the conspicuous plants and animals of the steppe.*

The predominant plants are the grasses. Of these there are a great many species. Perhaps chief are buffalo grass (*Bulbilia dactyloides*), grama grass (*Bouteloua oligostachya* plate 34a), wheat grass (*Agropyron tenerum*), needle or spear grass (*Stipa rividula* and *S. Conata*), blue-stem (*Andropogon scoparius*, *A. Halli*, and *A. provinciale*), wire grass (*Aristida longiseta*). The family of second rank, and perhaps surpassing the grasses in regard to activity except in the spring comes the Compositae. This large group is represented by a great many genera and species. There are several species each of *Aster*, *Erigeron*, *Senecio*, *Solidago*, *Helianthus*, and *Artemisia*. Some other conspicuous Composites are *Townsendia grandiflora* (an early bloomer), the purple cone-flower or "nigger head" (*Brauneria angustifolia*), the long headed cone-flowers, (*Ratbida columnaris* and *R. C. pulcherrima* the red variety), purple blazing star (*Laciniaria* [*Liatris*] *squarrosa*), the gum weed (*Grindelia squarrosa*), and the almost leafless Prairie Pink (*Lygodesmia juncea*). The Leguminosae is notable. There are several species of *Astragalus* and *Psoralea* (*P. esculenta* and *P. lanceolata*, the Indian turnip, and *P. tenuiflora*, the wild alfalfa) the lead plant (*Amorpha canescens*), bee-plant or skunk-herb (*Cleome serrulata*), wild sweet-pea (*Lathyrus ornatus*), the loco weed (*Oxytropis Lambertii*) and the prairie clovers (*Kuhnistera purpurea* and *K. candida*). A few other conspicuous plants may be mentioned. Prairie plantain (*Plantago Purshii*), wild flax (*Linum Lewisii* and *L. rigidum*), Cheyenne turnip (*Cymonterus acaulis*), Prairie violet (*Viola nuttalli*), Pasque flower (*Pulsatilla hirsutissima*), two or more species of *Allium* (wild onion) and *Potentilla* (false strawberry), sand-lily or May-flower (*Leucocrinum montanum*), Camas (*Zygodenus elegans*), Spiderwort (*Tradescantia occidentalis*), Blue star-grass (*Sisyrinchium angustifolium*), especially in the LaCreek valley, *Penstemon cristatus* and in the moisture depressions *P. gracilis*. Red false-mallow (*Malvastrum coccineum*) is especially along the roads. Other plants are *Lithospermum angustifolium*, *Gaura coccinea*, *Erysimum asperum*, *Solanum rostratum* and *Cactus viviparus* and the prickly pear *Opuntia polyacantha*).

The steppe grades, in areas of the sandy loam, into the sand-hill formation. The wire-grass association is an intermediate phase between the typical short grass (Grama and buffalo) and the bunch grass type of vegetation which occupies the rougher areas. Steppe areas covered by the Pierre clay frequently have developed on them the wheat grass association.

Among the mammals conspicuous on the plains are the northern coyote (*Canis latrans nebracensis*), the gray or buffalo wolf (*Canis occidentalis*), the kit-fox or swift (*Vulpes velox*), large weasel or ermine (*Putorius longicauda*), striped ground-squirrel or gopher (*Citellus tridecemlineatus pallidus*), Jack rabbit or prairie hare (*Lepus campestris*), pocket gopher (*Geomys bursarius subsp*, and *G. talpoides rufescens*), Occasionally, the prairie dog (*Cynomys ludovicianus*) and the badger (*Taxidea taxus*), and the large skunk (*Mephitis hudsonica*) are found. The grasshopper mouse (*Onychomys leucogaster*), the large meadow mouse (*Microtus pennsylvanicus modestus*), the little vole or meadow mouse (*M. haydeni*) probably all occur. A few antelope still remain in the valley of Pass Creek, I am told.

The plains birds are especially the following: Western Meadow-lark, Desert Horned Lark, Lark Bunting, Chestnut-collared Longspur, Cowbird, Marsh Hawk, Burrowing Owl, Sennett Night Hawk, Upland Plover, and about the blowouts, the Killdeer.

The rattlesnake (*Crotalus confluentus*) is the reptile most commonly found in this association, and it is far from plentiful. Land snails and earth worms are both lacking here. Grasshoppers of several genera and many species, dung beetles, ants, and certain flies are a few of the groups of insects which are fairly conspicuous.

(c) *Remarks on the "Adaptations" of the life of the Steppe.*

The adaptations shown by the *plants* are numerous. The following seem to be the most prominent:

(1) The predominance of perennial herbs of the higher plants.

Though in favorable years annuals are conspicuous, the characteristic vegetation year in and year out is distinctly herbaceous—no true shrubs and of course no trees. This is contrast to woodland, desert, prairie and most marshes.

(2) Compactness of growth of stalk or of flowers or of both.

This compactness of stalk is illustrated by almost all the plants. No abundant upland species reaches a height, in ordinary seasons, of much over a foot and practically none reach two feet. The vast majority have most of their bulk within six inches from the surface. The conspicuous place held in the flora by the Compositae points to compactness of flowering parts. Even the grasses, (Gramma, buffalo, wheat, etc.) have the spikelets compactly arranged instead of loose as is the case of many prairie and woodland grasses.

(3) Root system specialization.

Since they are, in time of drought, frequently only slight showers which do not soak in, there are many plants, notably the short grasses which have a shallow, wide-spreading root system developed. The buffalo and grama grasses have their roots confined to within a foot from the surface. In contrast to these there are such deep-rooted plants as *Psoralea* which has almost all of its roots at a depth greater than four feet, and in some cases penetrates hard sub-soil as deep as six feet. Certain species notably *Artemisia* and *Gutierrezia* have both well developed lateral roots and rather deep tap-roots. The plants showing storage are chiefly the bush morning glory, the blazing star (*Laciniaria*) and the Indian turnip (*Psoralea*). The cacti are the only ones that store considerable amounts of water above ground.

4. Prevalence of narrow, small or resin-covered leaves:

Almost all the plants have either small or narrow leaves. The prairie pink (*Lygodesmia*) and *Gutierrezia* are almost leafless. Abundant species with resin are the cone flowers, gum-weed, *Psoralea*, etc.

(5). Wind dispersal including the tumble weed habit:

The "tumble weed habit" is developed chiefly by plants of the wind-swept plains. Several species belong to the different groups such as the Russian thistle (*Salsola pestifer*) a Chenopod; *Psoralea*, a legume; the tumble-weed (*Amaranthus albus*) a member of the Amaranthaceae, have this habit.

(6). A short growing period not closely confined as to season:

The climate of plains is irregular. In some years the vegetation is several weeks ahead of normal and the next year it may be as far behind. Delays in the coming of the rains occasionally

cause surprising late flowering. We found flowers of the Pasque flower and of the prairie rose in August, following July rains.

(7). Destruction of exposed parts does not result in death of the individual:

In the case of many trees, shrubs and other plants belonging to other ecological associations, the individual is killed by the destruction of the aerial parts. In the case of many steppe plants such destruction is frequent by grazing animals and perhaps in all but the season of greatest growth, by prairie fires. Certain species are killed by too frequent fires (oftener than once in three years for example) or by close pasturing, but the characteristic steppe plants have wonderful resistance in this regard.

(8). Ability to withstand inactivity (forced by drought) for an entire season or even two or three years:

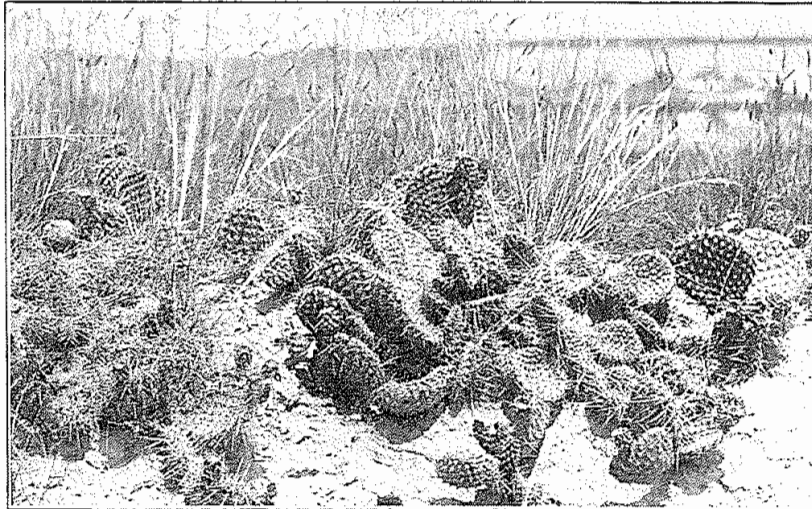
This ability is very essential. After a series of wet years many new immigrants into the steppe flora are noticed. The return of the dry cycle eliminates these species which are only sojourners on the steppe. The characteristic species seem to be uninjured by even prolonged drought. In the summer of 1911 for example, there were localities which for two years had been so dry that no grass at all had started, yet when the unusual rains of September came, everything was green in a few days.

(9). Resistance to unseasonable weather:

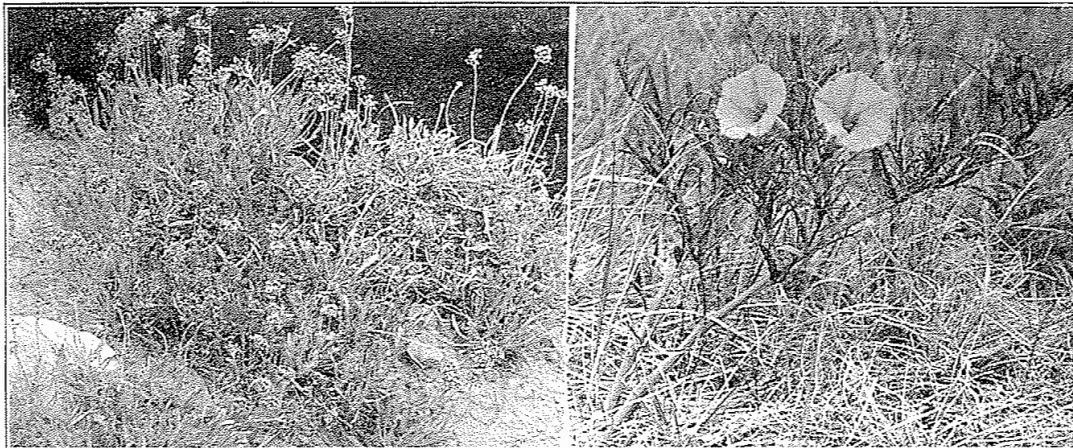
The vegetation does not readily start in the spring. However, if after it has started a freeze comes, there is surprisingly slight destruction of the characteristic plants. Early frosts in the fall also affect the native steppe vegetation scarcely at all.

(10). Marked seasonal succession depending on accumulated temperature, water content of the soil, relative humidity, etc:

The succession of flowers, in an ordinary year is striking. During one month the prairie is tinted by one group of flowers, and during the next month by others, and the succeeding month by still others. In this locality the early bloomers of the plains include *Cymopterus*, *Townsendia*, *Viola*, *Pulsatilla*, *Leucocrinum*. Among those blooming in June are *Pentstemon*, *Allium*, *Zygodenus*, *Oxytropis*, *Linum*. In July, *Braunia*, *Ratbida*, *Psoralea*, *Malvastrum*, *Gaura*, *Euphorbia*, etc. are prominent. During August, the Asters, Solidagoes, Senecios, etc. are in their glory. The Artemesias are in full bloom early in September.

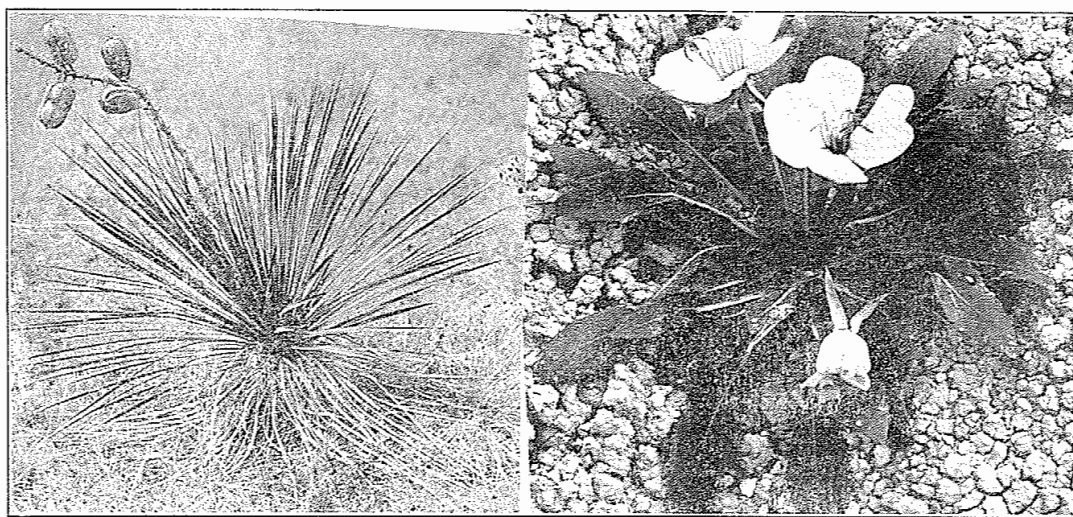


The prickly pear (*Opuntia polyacantha*) especially abundant on the flats or benches along the valleys. Grama grass in background. Snow-on-the-Mountain (*Euphorbia marginata*) abundant in the badlands. A conspicuous plains composite. *Chrysothamus graveolens*.



Eriogonum multiceps, abundant on buttes

Bush Morning Glory, *Opomoea leptophylla*, common on sandy soil.



Bayonet or Bear Grass, *Yucca glauca*, in fruit, abundant in the sand hills and on buttes.

"Gumbo Lily," *Pachylophus caespitosa*, abundant in the badlands.

It has been determined by others that accompanying this progressive activity there is a shifting in the floristic complexion of the region. Early in the season, the plants are mainly related to eastern or mountain plants. While as the season advances the active species are successively related to prairies, plain and finally the desert.

(11). Predominance of plain yellow flowers, with many browns.

Although several of the conspicuous flowers are white, several are orange and a few pale blues, there are few reds, deep blues or violets. Scarcely any are streaked or mottled. In the vast majority of the cases the flowers are small in size as compared with those of other plant formations.

(12). Fertilization accomplished chiefly by the aid of the wind:

The *mammals of the plains* have all adopted one or more of the following characteristics.

1. Fleet runners.

Antelope. (32 miles an hour), jackrabbit (28 miles an hour) Coyote (24 miles an hour),* kit-fox or swift, and gray wolf

2. Burrowers.

Pocket-gophers, striped gophers, badgers, prairie dogs, voles

3. Acute long-range vision.

4. Gray or fawny in coloration.

5. Ability to do without drinking water.

Water for physiological activity and for cooling by perspiration is mainly secured from the food eaten. Mud about the water holes very seldom indicates that these animals have been drinking there.

6. Daily period of activity chiefly in the early morning, also to a lesser degree in the evening, and at night.

Voluntary activity of every one of the above mentioned mammals is very limited during the heat of the summer day. Most of them are in the shade then. Activity liberates heat which must be eliminated by perspiration which in turn requires precious water.

7. Many hibernate.

The fleet long-distance runners are the exception to this rule.

*(Quoted from Seton).

The *birds of plains* possess one or more of the following characteristics:

1. Nests necessarily built on the ground.
2. Many sing on the wing.
Lark Bunting, Longspur, Horned Lark, frequently the Meadowlark, etc.
3. Songs and calls comparatively loud.
4. Tendency to flock not nearly as prominent as in birds of the woods or water. Winter flocking is largely accidental. They gather to feed where food is exposed.
5. Ability to withstand strong wind. Seed eaters feed during the winter in apparent comfort on wind swept hills.
6. Females and nestlings are almost all protectively colored.
This seems required by the exposures of the nesting sites.
7. Highly migratory.

But few individuals remain on unbroken plains during winter and these of different species than in summer, except in the case of the Desert Horned Lark. Even this bird migrates somewhat.

8. Ability to withstand the intense heat of the sun.

This is required especially by the nestlings which are often on dark ground.

9. The birds of the steppe must of necessity require but little drinking water. Heavy dews are rare on the plains.

The *reptiles*, of which the rattle snake and the horned lizard are the chief, possess a surprisingly effective protective-coloration.

Of the *insects* of the steppe the following points may be made.

1. The period of the day when the greatest activity is evidenced is in the forenoon from 7-11 o'clock. Mating is chiefly indulged in between 11 o'clock and one. During the rest of the twenty-four hours the insects are quiescent except when disturbed.
2. Seasonal activity limited to but three or four months of the year. Almost complete inactivity during six months of the year.
3. Many forms burrow or occupy mammalian burrows.
4. Predominance of hoppers.

2. GRASSY FLATS OR TERRACES ALONG THE VALLEYS

(1.) This biologic association is related to the steppe; It also frequently adjoins the wooded bottoms. Its conditions are similar to those of the steppe, but not so severe. There is no more,

and perhaps there is less rainfall, but there is more ground water because of two reasons; (1) The run off from the adjacent elevations. (2) The terraces are lower and consequently near the water table for the district.

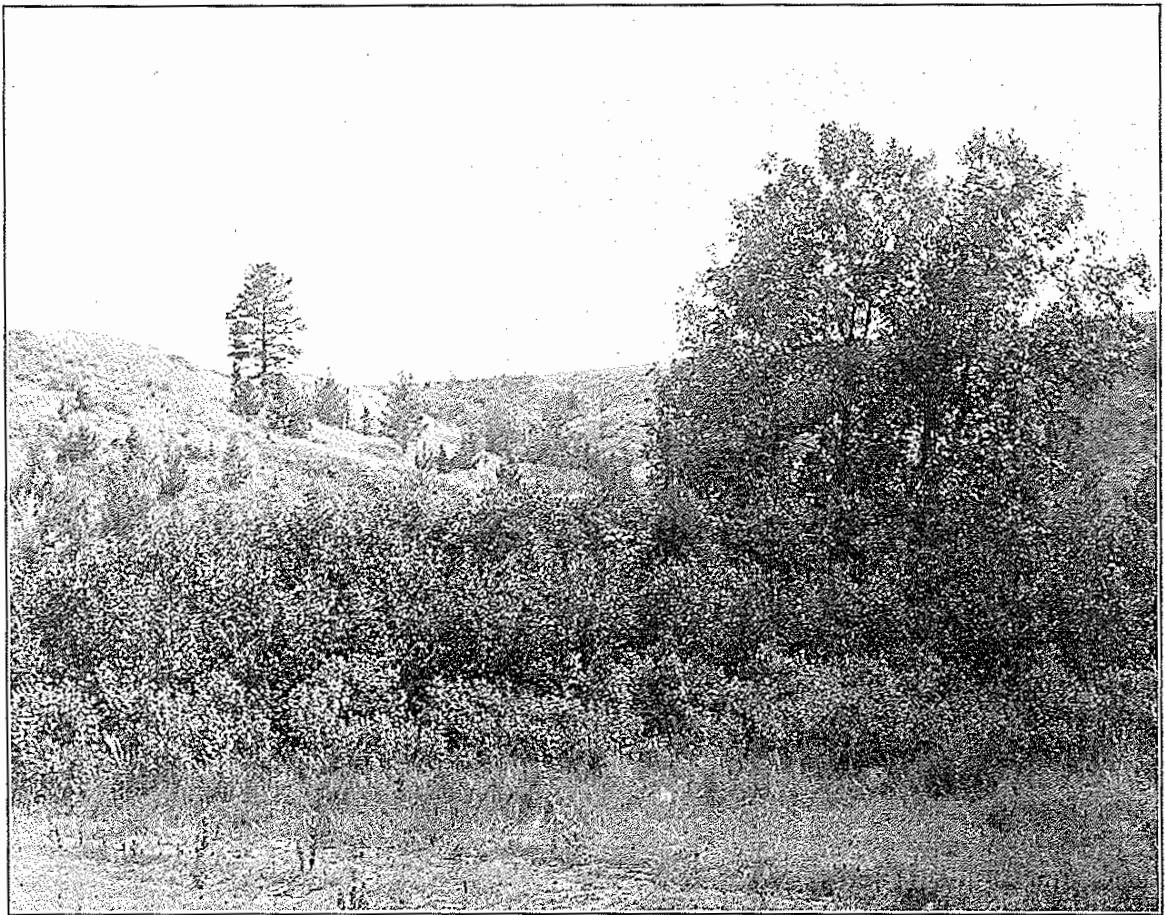
(2). *Some of the conspicuous plants and animals of the grassy flats.* Almost all of the plants of the steppe occasionally grow here. Since the wash of the rain brings down the seeds of almost all the steppe plants it is very reasonable that sporadic representatives should occur. The predominant vegetation, however, is somewhat different. There is a much larger percentage of the wheat grass association (*Agropyron Smithii* and *A. tenerum*) and decidedly more prickly pears (*Opuntia polyacantha*). The showy spurge, snow-on-the-mountain or "showy milkweed" (*Euphorbia marginata*) (plate 34b) is very conspicuous in July and August. There are many large patches of the wolf-berry or "buckbush" (*Symphoricarpos occidentalis*). The wild rose (*Rosa arkansana*) is often associated with these patches. Brome grass (*Bromus porteri* and *B. ciliatus*, etc.) is frequently prominent. Other plants which are usually in evidence are burr tomato (*Solanum rostratum*), the following grasses: Switch-grass (*Panicum virgatum*), blue-joint (*Calamagrostis canadensis*), wild-rye (*Elymus canadensis*), red-top (*Agrostis alba*). In addition there are several species each of *Atriplex*, *Chenopodium*, *Aster*, *Eriogonum*, *Senecio*, *Solidago*, *Helianthus* and *Artemisia*. As far as my observation goes there are decidedly fewer flowers than on the steppe.

The conspicuous mammals making these flats their breeding places are the prairie dog (*Cynomys ludovicanus*) and in these colonies animals that prey on them, especially the weasel (*Putorius longicauda*), black footed ferret and rattlesnake. Large prairie-dog towns are met with throughout the great plains region. They are distinctly less frequent in these counties than in those to the west and north. The western cotton-tail rabbit (*Lepus nuttalli*) is often found on these flats, especially where there is "buck-bush." There also nests the Sharp-tailed Grouse. Other birds that may be mentioned are the Bobolink, Western Meadowlark and other birds more characteristic of the steppe. Every prairie-dog town has its brood or broods of Burrowing

Owls. The smaller rodents as far as we discovered, were those of the steppe and of the open woods.

3. OPEN GROVES ALONG THE STREAMS:

The conditions are decidedly more favorable here for plant growth. The ground water is within the reach of such trees that grow there. These trees partially shade the other vegetation and protect it somewhat from the wind. The relative humidity is raised both because of the evaporation from the leaves of the trees and from the ground which because of its being shaded does not dry as quickly after a shower. The fact that the groves are cooler than the steppe also increases the relative humidity. The percentage of coarse vegetation, even neglecting the trees, is greatly in excess of that of the two previously considered associations. The most characteristic tree is the cottonwood (*Populus sargentii*) which often attains a large size but which is rarely symmetrical (see plate 33). Other common trees are the boxelder (*Negundo aceroides*), ash (*Fraxinus lanceata*), elm (*Ulmus fulva*), hackberry (*Celtis occidentalis*) and in the two eastern counties the burr or scrub oak (*Quercus macrocarpa*.) Among the larger shrubs are the plum (*Prunus americana*), chokecherry (*Prunus melanocarpa*) and buffalo-berry (*Lepargyraca argentea*). The black and the yellow currants (*Ribes aureum*, *R. floridum*), are usual. The skunk bush (*Rhus trilobata*) is in some valleys a predominant shrub, attaining a height of twelve feet. The western poison ivy (*Rhus rydbergii*) is almost always represented. The creeping or twining vines usually met with are the wild grape (*Vitis vulpina*), Bitter-Sweet (*Celastrus scandens*) and clemantine (*Clematis ligusticifolia*). A prominent herb is *Verbena striata*. Among the more conspicuous mammals of such open woods are the cottontail (*Lepus nuttalli*), the little chipmunk (*Eutamias quadrivittatus pallidus*), the porcupine (*Erithizon e. epixanthum*), the large skunk (*Mephitis hudsonica*), big brown bat (*Eptesicus fuscus*) and red bat (*Lasiurus borealis*), Common Shrew (*Sorex personatus*), and mole-shrew (*Blarina brevicauda*) and several mice: Deer mouse (*Peromyscus maniculatus luteus*), Jumping or kangaroo-mouse (*Zapus hudsonius campestris*) and two or more species of *Microtus*, and the raccoon (*Procyon lotor*).



The succession from prairie to ash-elm woodland is here suggested. The grass is chiefly wheat grass. The lower shrubs are roses and buckbush. The next zone is the skunk bush. Near the trees are chokecherry, plum and young ash.



Abundant composites of the grassy plains.

There are many birds nesting in these open groves. Among the most abundant are the Arkansas and common Kingbird, White-rumped Shrike, Mourning Dove, Red-head and Nelson's Downy Woodpecker, Flicker, Bullock Oriole, Magpie, Blue Jay, Western Chipping Sparrow, Long-tailed Chickadee, and Western House Wren. In the thickets there nests the Arctic Towhee, Catbird, Brown Thrasher, Long-tailed Chat, Black-headed Grosbeak, Yellow Warbler and Ovenbird.

It is needless to say there are numerous species of insects: The Cicadas, ants, mosquitoes, various moths and beetles, and flies are a very few of the most noticeable ones. A great variety of spiders were collected on the margins of such woods.

4. DEEP WOODS OF NARROW VALLEYS.

(a). Along some of the north-flowing tributaries of the White River especially along portions of the Little White, Cottonwood, Craven, Eagle-nest and Bear Creeks rather dark, mesophytic woods are found. The conditions are much more favorable to plant growth in the narrow valleys than in the other associations discussed. The narrowness and steepness of these portions of the valleys afford shelter from the wind and the sun. Springs and streams indicate an abundant supply of ground water. The relative humidity is high and the daily range of temperature much less than "in the open." Consequently, plants and associated animals which are more at home in the moisture eastern states can here maintain themselves. Conditions even in the more favorable valleys however are not as favorable as in the more open woods in regions of much more rainfall. Consequently, plants such as the wild strawberry that can there thrive in the open can here establish themselves perhaps only on the north facing bank, the most shaded portion.

(b). *Some conspicuous plants of the deeper woods:* The trees are ash, elm, cottonwood, hackberry and boxelder, supplemented by the western pine (*Pinus scopulorum*) and western cedar (*Juniperus scopulorum*). The ironwood or hop hornbeam (*Astrya virginiana*) grows along the Little White valley west of the Rosebud Agency, where also is the quaking aspen (*Populus tremuloides*) and the burr oak (*Quercus macrocarpa*). Along the brooks grow the large willow (*Salix nigra*). The June or Service berry (*Amelanchier alnifolia*), dogwood (*Cornus stolonifera*)

fera) thrive here as does the Virginia creeper or woodbine (*Parthenocissus quinquefolia*) also the hawthorne (*Crataegus occidentalis*) and *Smilax herbacea*. Among the herbs may be mentioned the meadow-rue (*Thalictrum purpurascens*), fringed loosestrife (*Steronema cilatum*), *Pentstemon grandiflorus*, *Calochortus nuttallii*, false solomon-seal (*Smilacina* [*Vagnera*] *stellata*), *Disporum trachycarpum*, Nettle (*Urtica gracilis*), bedstraw or small cleavers (*Galium trifidum*) and *Heuchera hispida*. In addition there are several which are found in the more open woods as well. Examples are the bittersweet (*Celastrus scandens*) and the poison ivy (*Rhus rydbergii*).

These more mesophytic woods are of such limited extent in these counties that they apparently possess no conspicuous characteristic mammals or birds.

(c). The vegetation of the woods averages infinitely more bulky than does that of the grass lands. The trees of the open groves of this area all have a well developed tap root system. The dispersal of the seeds of the trees is left to the wind to accomplish. There are no nuts and except the locally distributed bur oak, no acorns. Almost all the shrubs bear fruits which are edible to the birds which therefor distribute them.

The birds, instead of being runners or walkers as those of the plains are mainly hoppers or creepers. Most of the nests are placed in the trees or shrubs. Several indeed, nest in holes in the trees. There are numerous other characteristics of woodland birds.

5. THE PINE-COVERED AND ROCKY SLOPES.

On the buttes and along the escarpments of the divides, rocky ledges are frequently exposed. Pines are usually present on the north facing slopes. (See plates 2, 6, 13).

(a). *Conditions*: The buttes are exposed to the winds. It is scarcely ever calm there. Because of the elevation and the wind, excessively warm temperatures are lacking. Occasionally when the clouds hang low the buttes receive precipitation in the form of mist while the low lands receive none.

(b). *Some conspicuous plants and animals*: The red or western yellow pine (*Pinus* [*ponderosa*] *scopulorum*) has associated with it the western red cedar (*Juniperus scopulorum*), Skunk-bush (*Rhus trilobata*), Spanish dagger (*Yucca glauca*),



Along a valley in the "Sandhill Country." The trees are willow, chokecherry, plum, hackberry, etc. The falls is about ten feet high. Such a valley is attractive to picnics and to cattle.



Mentzelia decapetala, a large and showy plant of hillsides.

Prickly Poppy, *Argemone intermedia*, common on bare ground.

(plate 36a) Dogbane (*Apocynum cannabinum*) poison ivy (*Rhus rydbergii*), in the eastern counties an additional shrub is the Smooth sumach (*Rhus cismontana*), wire bunch-grass (*Aristida longiseta*), *Phlox douglasii andicola*, *Pentstemon accuminatus*, blue-bell-of-Scotland (*Campanula aparinoides*), loco weed (*Oxytropis lambertii*), hairy gromwell (*Lithospermum angustifolium*), *Hymenopappus filifolius*, Yarrow (*Achillea millifolium*), *Eriogonum*, two or more species (see plate 35a) Ladies' tobacco (*Antennaria dimorpha* and *A. aprica*), *Potentilla sp.*, and *Sedum stenopetalum*. The Oregon-grape (*Berberis aquilifolium*) is occasionally abundant where the cedar and pine are thickest.

The mammal most frequently seen is the small chipmunk (*Eutamias quadrivittatus pallidus*). The mounds of dirt thrown up by the pocket-gopher (*Geomys bursarius* or *G. talpodes*) are very conspicuous on the sides of some buttes. Cotton-tail rabbits (*Lepus nuttallii*) usually are abundant. Rattlesnakes were frequently seen. The most commonly observed birds were Long-tailed Chickadee, Rock Wren, Prairie Falcon, White-throated Swift, and Mountain Blue-bird.

6. BADLANDS.

The badlands areas are shown by the soil map and also, approximately on the geological map.

(a). *Conditions*: In regard to precipitation these areas fare about the same as does the steppe. Their average temperature is doubtless greater because of the many slopes and the protection from the wind. The white clay reflects the sunlight resulting in a very great intensity of light at some times. During other hours of the day a given spot is in the shade. Deep shade can always be found along the arroyas and behind the steep buttes. The rapidity of the erosion in badlands and the tendency for the clay to crumple and crack up are two factors apparently very important in controlling the vegetation. Another perhaps even more important factor is the inability on the part of the "soil" of the bare surfaces to absorb or hold water. In the midst of the big Bad Lands in northern Washington County there are some sand-hills. Some of the nearby badland buttes are capped with sand. Erosion is evidently as rapid on such buttes as elsewhere, but apparently because of the water absorbed in the sand, a rank vegetation flourishes in the sand. Large portions of the

badland areas are comparatively barren. Still larger portions of these "badland basins" are level and grass covered (see plate 17). Such portions are included under the discussion of "grass covered flats and terraces."

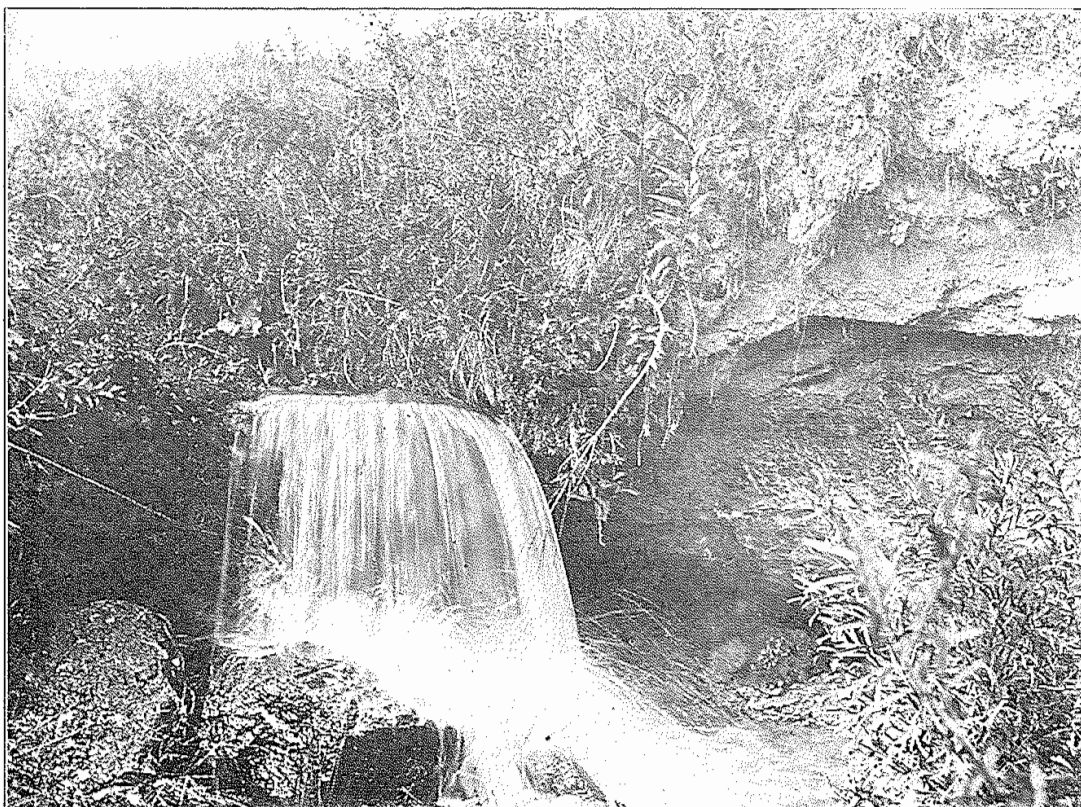
(b). *Characteristic plants and animals of the badlands.* In the typically badland areas (See plate 16) vegetation is scanty. Such that there is, is mainly shrubby and possess long tap roots. Various compositaceous shrubs are especially conspicuous *Chrysothamnus graveolens*, and *C. lanceolatus*, *Gutierrezia sarothrae* and several species of sage (*Artemisia gnaphaloides*, *A. canadensis*, etc.) Other plants are the gumbo lily (*Pachylophus caespitosa* (plate 36b), *Mentzelia decapetala* (plate 40a) *Atriplex nuttallii*, prickly pear (*Opuntia polycantha* (plates 25 and 34a). At the foot of the buttes two annuals the showy spurge (*Euphorbia marginata*, Plate 34e), and thistle tomato (*Solanum rostratum*) are frequently found. Along the channels, the buffalo berry (*Lepargyrea argentea*) frequently forms large thickets and upon the more shaded side of the buttes clumps of western cedar (*Juniperus scopulorum*) may furnish many good fence posts. (See plate 20 and 26).

The badlands because of their inaccessibility are the home of several carnivores. Gray wolves and coyotes are more frequently met here than elsewhere. We frightened individual coyotes from under shaded "cut banks" many times last summer. Bobcats (*Lynx rufus*) are not rare. The puma or mountain lion (*Felis concolor*) was formerly plentiful and we heard a report of one having been seen within a few years. There are still a few antelope (*Antilocapra americana*) left in the badlands. The writer saw a bunch of nine near Reeds Pass in 1908. Bighorn sheep have but recently become extinct, if indeed they are entirely extinct yet. Some have been seen within a couple of years in north-western Washington County. The mammal most frequently seen now days in the badland is the striped chipmunk (*Eutamias quadrivittatus pallidus*). The chief birds are the Rock Wren, Say's Phoebe, Cliff Swallow (See plate 44 for nests), Violetgreen Swallow, Western Lark Sparrow, Turkey Vulture or Buzzard, and Prairie Falcon. Rattle snakes (*Crotalus confluentus*) are not lacking though far from common. The horned "toads" which are true lizards (*Phrynosoma douglassii hermandesi*) are occasion-



This stream comes entirely from one large spring. The fine, clear water wells up from the sand in a surprising volume. In the sand hill country of southern Bennett County.

Plate 42



A Bennett county waterfall. The sources of Lacreek and several other tributaries of the Little White are large springs in the sandhill country. The falls are over cemented layers of the Rosebud formation.

ally met with. One of the most noticeable insects is the Tiger beetle (*Cicindelia sexpunctata*). Ants are numerous.

(c). *The badland life displays several peculiarities:* The plants are mainly longlived perennial shrubs possessing powerful tap and anchor roots and narrow and pubescent leaves. All such shrubs offer great resistance to erosion, undercutting and slumping. They are also conservative, late flowering and present to cattle very little edible stuff. In addition to these perennials there are various annuals which thrive during moist seasons on the moister alluvial flats.

The animals are uniformly grayish in coloration with the exception of the bat, swallows and swifts. The crevices and cavelets furnish homes for the chipmunk, bat, bob cat, Say's Phoebe, Prairie Falcon, Rock Wren, etc. The Cliff Swallow and White-throated Swift find the cliffs suitable for nesting sites. Several of the mammals are notable jumpers (bighorn sheep and mule or black tailed deer).

7. THE SAND HILLS.

The location of the area is shown on the soil map (marked Dune-sand). It is the northern limit of a very extensive sand-hill territory of western Nebraska. It is an attractive region to the collector and camper because of the richness of the flora and fauna, the abundance of clear water and of wild fruits in their season.

(a). *Conditions:* Though there is no more rainfall in the sand-hills than in the surrounding associations there is much more vegetation. This is due to the fact that the sand at once absorbs any rainfall. For a short time after showers the evaporation is very rapid and if this were to continue long this absorbed moisture would soon disappear. However, evaporation from the surface layers of the wet sand soon becomes more rapid than water can be supplied from below by capillary action. Consequently the capillary tubes become broken and evaporation stops long before any considerable amount of the recent precipitation has disappeared. Because of the uneven topography with its many slopes receiving the direct rays of the sun, portions of the sand hills are very hot in the summer. By convection these warm the winds blowing across the district. These hot winds, having

been unsuccessful in absorbing much moisture are very drying to any object which will give up water.

To summarize: *Precipitation*, average for this area. Water soaks in at once, escaping by evaporation from the plants and by springs. Snow accumulates to a greater extent than elsewhere in this district in the shrubbery of the valleys. *Relative humidity*—As low as that of the steppe. *Temperature*—Above the average for this area. *Light*—Intensity considerable, but many small areas shaded. *Wind*—Except in the protected depressions, average velocity and hot.

(b). *A few characteristic plants and animals of the Sandhills.* The bunch grass (*Andropogon scoparius*) is dominant. The sand grass (*Calamovilfa longifolia*) and the spear or needle grass (*Stipa comata*) are common. *Andropogon hallii* is occasionally abundant on the upper slopes and the tops of the ridges. Grasses growing between the bunch grasses are hair grass (*Eriogrostis trichodes*). Indian millet (*Oryzopsis cuspidata*), Black Grama (*Bouteloua hirsuta*), the sand-bur grass (*Cenchrus tribuloides*). There are many additional kinds of grasses. The shrubs of the sandhills are Sand-cherry (*Prunus besseyi*), Choke-cherry (*Prunus melanocarpa*), Spanish bayonets (*Yucca glauca*) bush morning-glory (*Ipomoea leptophylla*), poison ivy (*Rhus Rydbergii*). In the depressions the following shrubs are often plentiful. Dogwood (*Cornus stolonifera*) prairie willow (*Salix humilis*), lead plant (*Amorpha canescens*), buffalo-berry (*Lepargyrea argentea*). The following is a list of the more common herbs.

Eriogonum annuum.

Tradescantia occidentalis (Spiderwort).

Lacinaria squarrosa and *L. punctata* (Purple blazing star).

Psoralea lanceolata.

Carduus plattensis (Western thistle).

Helianthus scaberrimus (Rough sunflower).

Argemone intermedia (Prickly poppy).

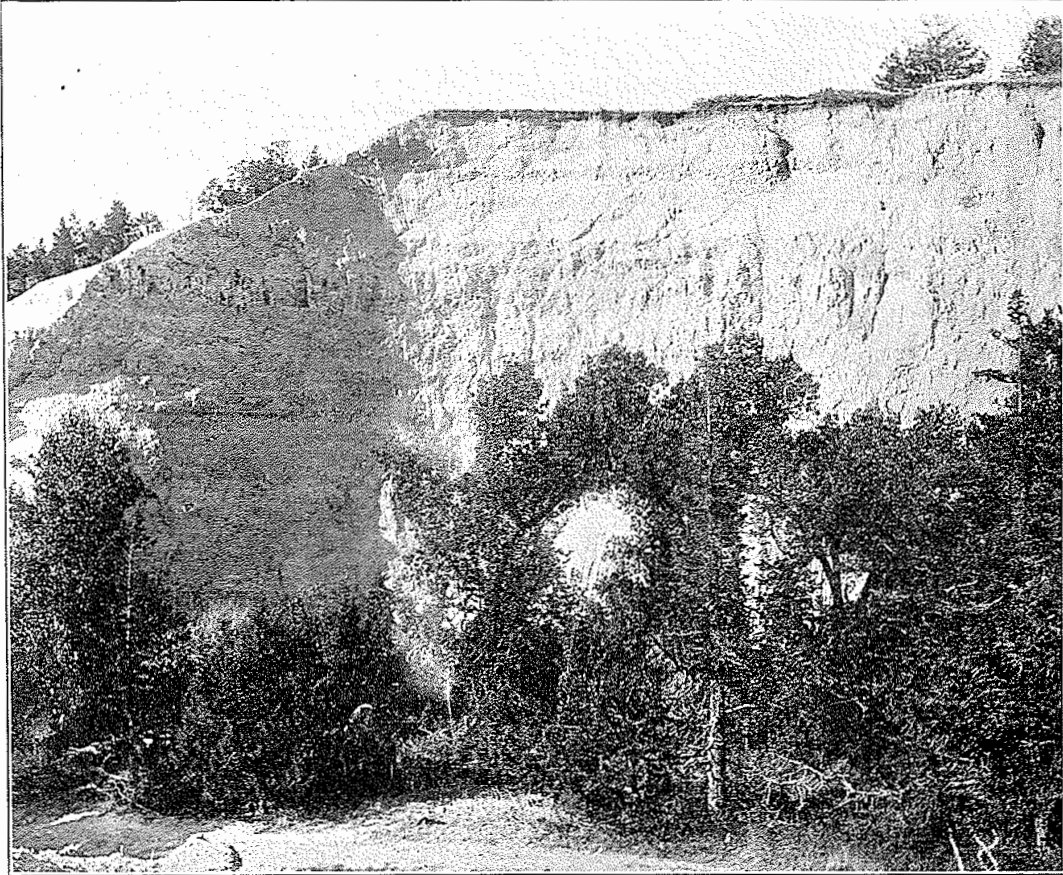
Phaca longifolia (milk vetch).

Lygodesmia juncea (prairie pink).

Euphorbia geyeri (spurge).

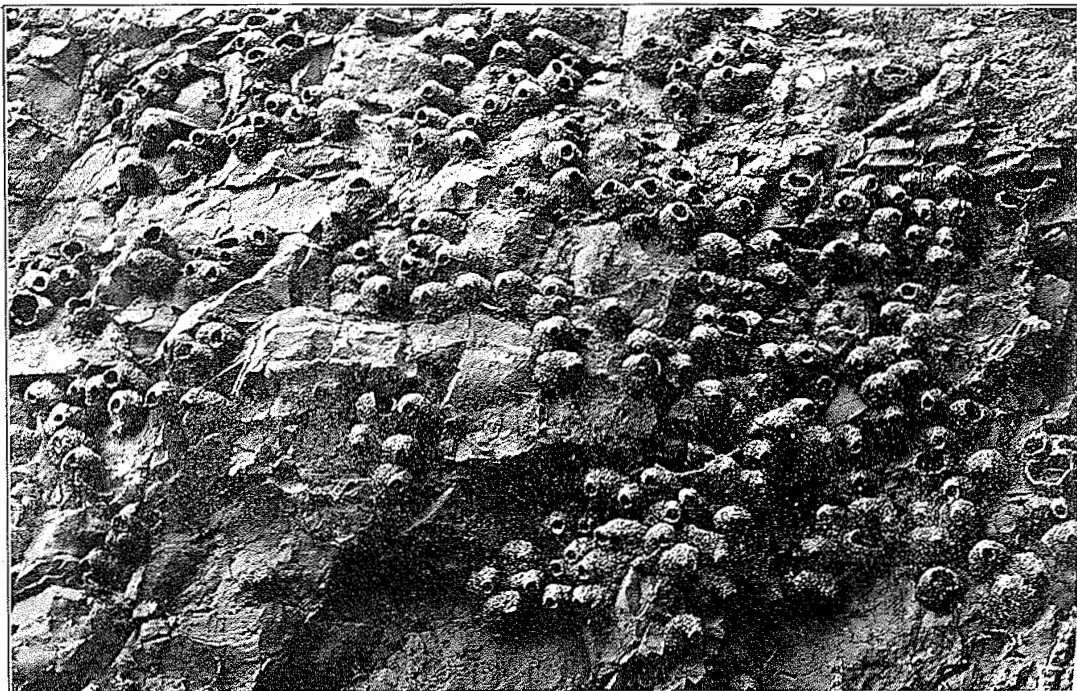
Oenothera rombigetela (yellow evening primrose).

Hymenopappus filifolius.



The canyon wall of a badland valley (Cottonwood Creek, Washabaugh County.)
For some three miles along this valley there is no way out
of the valley.

Plate 44



A small portion of a large group of Cliff Swallows' nests on the steep wall of a bad-
land canyon. The roughly jointed marly shale, of the Brule
formation is perceptible.

Pentstemon acuminatus.

Oxytropis lambertii (loco weed).

Accrates viridiflora (green milk weed).

Lathyrus ornatus (sweet pea).

Chrysopsis villosa (yellow golden aster).

Kuhnistera purpurea, *K. villosa*, *K. alba*.

Cleome serrulata (common bee plant).

Cleome lutea (yellow bee plant on pure sand).

Opuntia humifusa.

And in addition several species each of *Aster*, *Erigeron*, *Senecio* and *Solidago*.

Along the brooks there are often dense thickets (See plate 39) with a highly mesophytic flora. This has been somewhat discussed under "shaded valleys." See also "stream" and "marshes."

Jack rabbits, cottontails and coyotes were the only mammals we noticed during our stay in the sandhills. Certainly there are others. The birds of the region are mainly those of the thicket, pond and marsh. The Lark Bunting, Western Meadowlark and Western Savannah Sparrow are the most numerous of the birds of the dunes themselves.

We found several rattlesnakes though the residents say they are not common. The lizard called the yellow-striped swift (*Sceloporus undulatus*) was very frequently seen.

(c). The plants of the dunes and sandhills possess, with few exceptions, much longer tap roots than do even related species on the harder subsoil of the steppe. One characteristic species (the bush morning glory) has a well developed storage root-enlargement. The vegetation is decidedly coarser than on the steppe, and many more shrubs, especially the roses and allied genera, are abundant. Blowing sand undoubtedly prevents plants unable to resist it from becoming abundant. The glazed bark of roses, ground cherries etc. show such sand is a considerable factor.

MARSHES, STREAMS AND PONDS.

The Marshes. As far as we observed the only prominent marshes are in and near the sandhills. The head waters of several of the tributaries of the Little White River are in large boggy marshes which have a luxuriant flora. Some few of these tributaries have, beyond the hills proper, had their channels shifted by

wind-blown sand. LaCreek has in this way given rise to a large marsh (see map). Marsh plants are meso-hydrophytes or hydrophytes because plenty of ground water is available, except when the marsh goes dry. Because of the evaporation from the surface of the marsh, the temperatures are kept reasonably low. Some of the characteristic plants of Bennett county marshes are: Willow herb (*Epilobium lineare*), marigold (*Bidens glaucescens*), butter-cups (*Ranunculus*, several species), rushes (*Scripus atrovirens*, *S. Americanus*, and *S. lacustris*, and *Juncus balticus*, *J. tenuis* and *J. nodosus*). The cat-tail (*Typha latifolia*) is often abundant as well as several species of *Carex*. An orchid (*Coeloglossum bracteatum*) is occasional, also venus' looking glass (*Specularia perfoliata*.)

The Streams. Along the margins of streams issuing from such marshes are to be found individuals of almost all the marsh species. This is to be expected since their seeds are often carried by the current. In addition, we find the following to be especially conspicuous. Yellow monkey flower (*Mimulus-jamesii*), *Gerardia besseyana*, *Rumex*, several species. Willow (*Salix nigra* and *S. longifolia*), *Spider-wort* (*Tradescantia occidentalis*), bur-reed (*Sparganium eurycarpum*), St. John't wort (*Hypericum virginicum*), *Galium trifidum*, touch-me-not (*Impatiens biflora*), scouring rush or horse-tail (*Equesetum arvense* and *E. laevigatum*).

The small butter-cup (*Ranunculus* [*Halerpestes*] *cympararia*) forms patches along all the streams, and on other wet ground in this section of the state. Streams in various parts of the area contained the water butter-cups (*Batrachium trichophyllum*). The large leaved plantain (*Plantago major*), and the shrubby lead-plant (*Amorpha fruticosa*) are widely common.

The Ponds. There are two distinct kinds of ponds in this area, the salt or alkali ponds, and the fresh water ponds. The former has but little vegetation in or about it. The salt grass (*Distichlis spicata*) is the most striking species. The fresh water ponds often contain several species of *Potamogeten*, and also *Myrophyllum spicatum*, and *Chara foetida*. Their margin is inhabited by marsh plants and the wild rice (*Zizania aquatica*). A fresh water sponge, dragon flies, mosquitoes, copepoda, etc. are abundant aquatic animals. The small temporary waterholes of the plains

have as their most characteristic species *Marsilla vestiga*, and the small butter-cup (*Ranunculus cymalaria*).

The more notable aquatic or semi-aquatic mammals in this region are the musk-rat (*Fiber zibethicus*) which is locally abundant; the mink (*Putorius vison lutrecephalus*) which is generally common; the beaver (*Caster c. canadensis*) which is almost extinct; and the otter (*Lutra canadensis*) which is still occasionally trapped, especially along the Little White River.

There are many migrant water birds most of which are mentioned in the appended "List of Birds of the Pine Ridge Reservation." We found the Wilson Snipe apparently nesting in the bog-marsh. The cat-tail filled LaCreek marsh is the nesting site of the Bittern, Coot, Black Tern, Blue-winged Teal, Redwing and Yellow-headed Black-birds, etc.

(c). *Characteristics of Aquatic Life.*

Plants and Animals found in marshes and other aquatic associations have characteristics which if they were less frequently exhibited would be quite striking.

The plants are chiefly aquatic or semi-aquatic herbs many of which are biennials or short lived perennials. Ordinarily there is an abundance of available water and transpiration can be freely indulged in; occasionally however, the swamps go partially dry. The plants which are most successful in a region where they frequently occur, are those which can resist such dryings. The fertilization is largely by the agency of insects and the seed distribution by water and animals as well as by wind. The tick marigold (*Bidens*) and the wild rice (*Zizania*) are two notable examples of animal distribution. Many if not most marsh plants also propagate by root runners.

The mammals are all semi-aquatic and rear their young either in burrows above the water table or in houses. The muskrat and beaver are examples.

The birds nest in reed hung or floating nests. The females and nestlings are in almost every case grass-colored for protection. Most species are swimmers or waders. The bills are chiefly sharp and adapted to impaling or are adapted to probing or are supplied with strainers.

Almost all the *insects* characteristic of marshes spend a portion of their life as aquatic forms. Examples are mosquitos,

dragonflies, damsel flies, May flies, water beetles, and water boatman, etc.

III. PLANTS OF THE PINE RIDGE RESERVATION*

Collected by S. S. Visher, determined by Dr. P. A. Rydberg of N. Y. Botanical Garden.

POLYPODIACEAE (Fern Family)

Filix fragilis (L) Underw. Brittle Fern.

General in moist, shaded cliffs and banks, (Washabaugh County, Washington County).

MARSILEACEAE

Marsilia vestita Hook. & Grev. "Pond four-leaved Clover."

Common about blow outs and other shallow ponds throughout this section. (Washington County).

EQUISETACEAE (Horsetail Family)

Equisetum laevigatum Br. Horsetail.

Plentiful along streams. (Washington County).

**Equisetum variegatum* Scheich.

Common along stream banks throughout. (Washabaugh County).

**Equisetum robustum* A. Br.

Occasional along the streams especially in the Sand Hills. (Washabaugh County).

**Equisetum hyemale* L. Scouring Rush, Pipe stem.

Occasional along valleys. (Washabaugh County).

PINACEAE (Pine Family)

Pinus scopulorum (Engelm.) Lemmon. Western Yellow or Bull Pine.

Abundant along the high divides in this area (extends east nearly to Tripp County). (Washabaugh County).

**Juniperus scopulorum* Sarg. Red Cedar or Juniper.

Common in the badlands and brakes on the sides of buttes and occasional in flood plains of valleys. (Washington County).

*These plants were collected July 5-23, August 7-26, 1911. The notes on abundance, ecology, etc., were made at the time of the collecting of the species, and in many cases revised before leaving the field. The county or counties in parenthesis at the close of each species is the one in which I collected the specimens. Common names are given in the case of species having such in common use. The asterisk indicates that this species is in addition to the published flora of the state of South Dakota.

Juniperus virginiana L. (?)

Occasional in the flood plain of the White River. (Washabaugh County).

TYPHACEAE (Cat-tail Family)

Typha latifolia L. Cat-tail.

Rare along most of the streams. Abundant in La Creek Marsh. (Washabaugh and Shannon Counties).

SPARGANIACEAE (Bur-reed Family)

Sparganium eurycarpum Englm. Bur-Reed.

Locally abundant on streams. (Washabaugh County).

ALISMACEAE (Water Plantain Family)

**Alisma subcordatum* Raf. Water Plantain.

Rare along almost all the streams. (Washabaugh County).

Sagittaria arifolia (Nutt) J. G. Smith. Broad-leaved Arrowhead.

Frequent in and at margins of streams. Washabaugh County).

**Sagittaria cuneata* Sheldon. Longleaved Arrowhead.

Abundant in La Creek and Little White River. (Shannon County).

GRAMINEAE (Grass Family)

**Andropogon provinciale* Lam. Beard Grass or Blue Stem.

Rare in the sand hills. (Shannon County).

Andropogon Hallii Hackel. Turkey-foot Grass.

Tolerably common on dry sandy soil. (Shannon County).

**Sorghastrum natans* (L.) Nash.

Rare in the Sand Hills near La Creek. (Shannon County).

Panicum virgatum L. Switch Grass "False Redtop."

Abundant on the flood plains and along all valleys: (Washabaugh, Washington Counties).

Panicum Scribnerianum Nash.

Abundant along some of the wooded valleys. (Washabaugh County).

Panicum capillare L. Witch Grass, Tickle Grass.

Plentiful along roads and in old fields. (Shannon County).

Chaetochloa viridis (L) Scribn. Green Fox Tail, Pigeon Grass.

Introduced commonly into fields. (Shannon County).

**Cenchrus carolinianus* Walt. Sandbur.

On the sandy areas. (Bennett County).

- **Aristida longiseta* Steud. Three Awned Bunch Grass.
Often dominant on hillsides. (Washabaugh County).
- Stipa comata* Trin. & Rup. Needle Grass, Spear Grass, Devil's Grass.
Abundant on the dry plains.
- Oryzopsis micrantha* (Trin. & Rup.) Thurb. Rice Grass.
Common among the cedars and on the table of Sheep Mountain. (Washington County).
- Eriocoma cuspidata* Nutt. Indian Millet.
Frequent on dry alluvial flats. (Washington County).
- **Alopecurus aristulatus* (Torr) Mich. Foxtail Grass, Wild Timothy.
Common in meadows along valleys. (Washabaugh and Bennett Counties).
- **Sporobolus brevifolius* (Nutt) Nash. Drop seed.
"*Muhlenbergia Richardsoni*" Rydberg.
Tolerably frequent in ravines. (Washington County).
- Sporobolus cryptandrus* (Torr) Gray. Drop-seed or Rush Grass.
Rare in a field near Sheep Mountain. (Washington County).
- Sporobolus asperifolius* (Nees & Mey) Thurb. Tickle Grass.
Tolerably common in draws and meadows. (Washington County).
- Calamovilfa longifolia* (Hook.) Hack. Sand Grass.
Abundant in sand hills and in sandy soil. Also forming large circular patches here and there on hill sides of the rolling steppe. (Bennett).
- Schedonardus paniculatus* (Nutt.) Treal. Crab Grass.
Rare on the steppe throughout (Washabaugh County).
- Spartina cynosuroides* (L.) Wild. Cord, Marsh or Slough Grass.
Frequent along streams but far less abundant than in the eastern part of the state. (Washabaugh County).
- Bouteloua oligostachya* (Nutt.) Torr. Grama Grass.
Abundant throughout the plains portion. The dominant grass. (Washabaugh County).
- Atheropogon curtispindula* (Michx.) Fourn.
Abundant in bunch grass covered hillsides; frequent but scattered on flats. (Washabaugh and Washington Counties).
- Beckmannia erucaciformis* (L.) Host. False Fox-tail.
Common in wet places along creeks. (Washabaugh County).

- Bulbilis (Buchloe) dactylides* (Nutt.) Raf. Buffalo Grass.
One of the three dominant upland grasses; also forms dense curly patches along open ravines. (Washington County).
- Munroa squarrosa* (Nutt.) Torr. Spiny-jointed Grass.
Abundant in sandy soil. (Shannon County).
- Sphenopholis (Eatonia) obtusata* (Michx.) Scrib. "Wild Timothy."
Frequent in moist ravines and on Sheep Mountain table. (Washabaugh, Washington and Bennett Counties).
- Sphenopholis pallens* (Spreng.) Scrib.
Eatonia pennsylvanica.
From a damp shady spot. (Washabaugh County).
- **Koeleria gracilis* Rydb.
Common on the hills. (Washabaugh County).
- **Distichlis stricta* (Torr.) Rydb. Spike Grass.
Abundant on dry flats especially about depressions. (Washington County.)
- Panicularia americana* (Torr.) Mac. Mill.
Tolerably frequent in the moister meadows. (Washabaugh County).
- Panicularia nervata* (Wild.) Kuntze.
Rare, in wet places. (Washabaugh County).
- Festuca octoflora* Walt. Fescue.
Abundant on the plains. (Washabaugh County).
- **Bromus pingans* L. Brome Grass.
Scattered individuals in tall grass along creeks. (Shannon County).
- Agropyron tenerum* Vasey. Slim Wheat grass.
Common on clay (Washabaugh and Washington Counties).
- **Agropyron Smithii* Rydb. (*A. occidentale*). Western Wheat Grass.
One of the dominant grasses of the region, especially on flood plains. (Washington County).
- **Agropyron albicans* S. & W.
Rare in the draws of badlands. (Washington County.)
- Hordeum jubatum* L. Squirrel-tail, "Foftail."
Occasional in draws. (Washington County).
- **Hordeum pusillum* Nutt. Southern Squirrel-tail.
In dry places in Washabaugh County.

Elymus canadensis L. Wild Rye.

Frequent in swales and on the flood plains. (Washington and Washabaugh Counties).

Elymus virginicus L. Eastern Wild Rye.

Abundant in open groves along the valleys. (Washabaugh and Bennett Counties).

CYPERACEAE (Sedge Family)*

Cyperus acuminatus Torr. & Hack. Sedge.

On wet ground. (Washington County).

**Cyperus diandrus* Torr.

Rare along streams. (Washabaugh County).

Cyperus inflexus Muhl.

Common on wet ground along streams. (Bennett and Washington Counties).

Cyperus Schweinitzii Torr.

Rare on wet soil. (Washabaugh County).

**Cyperus speciosus* Vahl.

Occasionally abundant in ravines of escarpments. (Washabaugh County).

Scirpus americanus Pers. Three-squares.

Rare in small blow-outs on the plains. (Washington County)

Scirpus lacustris L. Bull Rush.

Abundant along streams. (Washabaugh County).

**Scirpus pallidus* (Britt.) Fern.

Abundant in wet ground about springs and along streams. (Washabaugh County).

Eleocharis aciculatus L. Spike Rush.

Very abundant forming dense mats at borders of bodies of water. (Washabaugh and Bennett Counties).

Eleocharis palustris (L.) R. & S. Common Spike Rush.

Abundant on wet ground throughout. (Washington County).

**Eleocharis palustris glaucescens* (Wild) Gray.

In shallow water and on margins. (Washabaugh County).

LEMNACEAE (Duck-Weed Family)

Lemna minor L. Small Duckweed.

Forming a coating on the few stagnant permanent deep ponds. (Washabaugh, Washington County).

*Dr. Rydberg submitted the specimens of *Carex* to a specialist in that genus. Unfortunately his returns were not received in time for insertion in this bulletin.

COMMELINACEAE (Spiderwort Family)

**Tradescantila occidentalis* Britt. Spider-wort.

Common in sandy soil and occasional on loamy steppe. (Bennett County).

JUNCACEAE (Rush Family)

**Juncus Dudleyi* Wieg. Upland Rush.

General in the tall grass of ravines. (Bennett, Washabaugh Counties).

Juncus longistylis Torr.

Common along the Little White River and other clear streams. (Bennett County).

Juncus nodosus L.

Abundant on wet ground. (Bennett County).

Juncus Torreyi Coville. Rush.

The most abundant rush. (Washabaugh and Bennett Counties).

MELANTHACEAE (Bunch-flower Family)

Zygadenus venosus Wats.

The most conspicuous flower on the plains late in May (Tullsen).*

LILIACEAE (Lily Family)

Leucocrinum montanum Nutt. Little White Lily, May-flower.

Tullson says this species is very abundant on the prairies in May.

Yucca glauca Nutt. Spanish Bayonet, Soapweed.

Especially abundant on ridges and in sandy areas. (Shannon County).

CONVALLARIACEAE (Lily-of-the-Valley Family)

Vagnera stellata (L.) Morong. False Solomon's Seal.

Abundant in the more mesophetic, moist and shaded ravines. (Washabaugh County).

SMILACEAE (Smilax Family)

**Nemexia lasioneuron* (Hook.) Rydb. Carrion Flower.

Fairly common in the moister groves along the streams of southeastern Washabaugh County.

*Mr. H. Tullsen of the U. S. Weather Bureau, while a teacher of an Indian school near Manderson wrote a short readable account of a few of the spring plants. This was published in the "American Botanist" for February, 1912.

IRIDACEAE (Iris Family)

- **Sisyrinchium septentrionale* Bickn. Blue-eyed Grass.
Common in the valley of LaCreek. (Bennett County).

SALICACEAE (Willow Family)

- **Populus Sargentii* Dode. Western Cottonwood.
Abundant along all the larger streams except in Bennett County. (Washabaugh County).
- Populus tremuloides* Michx. Quaking Aspen.
Rare in canyons of eastern Bennett County and along the Little White River near Rosebud. (Bennett County).
- **Salix exigna* Nutt. ? False Sandbar Willow.
Common on the middle portion of the Little White River. (Bennett County).
- Salix cordata* Muhl.
Frequent, growing in clumps, along streams especially in ravines. (Washington County).
- **Salix cordata angustata* Anders.
Fairly common over-hanging brooks (Washabaugh County).
- Salix linearifolia* Rydb.
(*Salix fluviatilis* Nutt). Sandbar Willow.
Abundant on the larger streams, the White and Cheyenne and occasional along the smaller. (Washabaugh County).
- **Salix lutea* Nutt.
Fairly common along the brooks. (Washington County).

BETULACEAE (Birch Family)

- Ostrya virginica* (Mill.) Willd. Hop horn bean, Ironwood.
Rare in canyons in eastern Bennett County and eastward. (Bennett County).

FAGACEAE (Beech Family)

- Quercus macrocarpa* Michx. Burr Oak or Mossy Cup.
Abundant along the middle Little White River and in valleys to the eastward. Occasional in eastern Bennett and Washabaugh Counties. (Washabaugh County).

ULMACEAE (Elm Family)

- Ulmus americana* L. White Elm.
Abundant in the narrower flood plains. (Washabaugh County).

Celtis occidentalis L. Hackberry.

Small trees occasionally located along streams, especially in the sand hills. (Washington County).

URTICACEAE (Nettle Family)

Parietaria pennsylvanica Muhl.

Rare in grassy canyons of Washington County.

Urtica gracilis Ait. Nettle.

Rare along creeks. (Washabaugh County).

POLYGONACEAE (Buckwheat Family)

Eriogonum annuum Nutt.

Abundant throughout especially in sand. (Shannon County).

Eriogonum multiceps Nees.

Abundant quite generally especially in rough land. (Washabaugh and Washington Counties).

Rumex altissimus Wood. Peach-leaved Dock.

Rare along streams near Sheep Mountain. (Washington County).

Rumex persicarioides L. Golden Dock.

Common on shores of almost all streams. (Washabaugh, Bennett Counties).

Rumex venosus Pursh. Veined Dock.

Abundant on sand. (Shannon County).

Polygonum Convolvulus L. Black Bind Weed.

Tolerably common in fields. (Washabaugh County).

Polygonum ramosissimum Michx. Bushy Knot-Weed.

Tolerably common along streams. (Washabaugh, Washington Counties).

Polygonum pennsylvanica L. Showy Smartweed.

Filling small water holes on the plains, not frequent. (Bennett County).

Polygonum scandens L. Climbing False Buckwheat.

Rare in fields. (Bennett County).

CHENOPODIACEAE (Goosefoot Family)

Chenopodium album L. Lambs Quarters.

Abundant in certain areas of the plains. (Washabaugh, Washington).

Chenopodium hybridum L.

Fairly abundant especially in fields. (Washington County).

**Chenopodium uncanum* (Wats.) Heller.

Abundant in fields and in loose soil of the plains. (Washington)

Chenopodium oblongifolium (Wats.) Rydb.

Tolerably common especially in fields. (Washington County).

**Chenopodium pratincola* Rydb.

Abundant in banks along streams and about ponds. (Washabaugh County).

Atriplex argentea Nutt. Gray Saltbush.

Common on plains and in badlands. (Washabaugh, Washington Counties).

**Atriplex nuttallii* Wats. Saltbush.

Common on the prairies and abundant in the badlands. (Washabaugh and Washington Counties).

**Sarcobatus vermiculatus* (Hook.) Torr. Greaseweed.

Common in the badlands. (Washabaugh County).

**Salsola pestifer* A. Nels. Russian Thistle.

Abundant.

AMARANTHACEAE (Tumble-weed Family)

Amaranthus retroflexus L. Colorless Redroot.

A common weed. (Washington County).

**Amaranthus Torreyi* (Gray) Britt.

An occasional ruderal. (Bennett County). (This establishes a new northern record which was previously Colorado).

**Acnida Tamariscina* (Nutt.) Gray. Water Hemp.

Rare on the flood plains of eastern Bennett County. As in the preceding species the range is extended from Colorado to South Dakota.

**Froelichia campestris* Small.

Frequent in the sand hills near La Creek. (Bennett County).

MYCTAGINACEAE (Four-O'clock Family)

Allionia linearis Pursh. Umbrellawort.

Abundant in the plains. (Washabaugh County).

Allionia nyctaginea Michx.

Rather common on the plains especially in sandy soil and cultivated fields. (Washington County).

CARYOPHYLLACEAE (Pink Family)

**Paronychia diffusa* A. Nels. Whitlowwort.

Rare in badlands on barren rocks. (Washington County).

RANUNCULACEAE (Buttercup Family)

Anemone cylindrica Gray.

In grassy creek bottoms, common. (Washabaugh County).

Pulsatilla hirsutissima (Pursh) Britt. Pasque Flower.

Recorded by Tullsen as abundant on butte sides in the shadows of pines.

Clematis ligusticifolia Nutt. Clematine, Virgin's Bower.

Abundant in the deciduous woods. (Washabaugh County).

**Batrachium Druetii* Wym. Water Buttercup.

Rare, emersed. in water of Medicine Root Creek. (Washington County).

Ranunculus pennsylvanicus L. Large Buttercup.

Abundant along streams throughout the area. (Washington Bennett Counties).

Halerpestis cymbalaria (Pursh) Greene. Tiny Buttercup.

Abundant on all permanently moist ground. (Bennett, Washabaugh Counties).

**Thalictrum dasycarpum* Fisch. & An. Meadow Rue.

Abundant in and near thickets throughout. (Washabaugh, Shannon and Bennett Counties).

Thalictrum purpurascens L.

Rare in the thickets along Wounded Knee Creek. (Shannon County).

BERBERIDACEAE (Barberry Family)

Berberis aquifolium Pursh. Oregon Grape.

Abundant in woods east side of Pass Creek Divide. (Washabaugh County).

PAPAVERACEAE (Poppy Family)

**Argemone intermedia* Sweet. Prickly Poppy.

Common especially in hillsides. (Washabaugh County).

CRUCIFERAE (Mustard Family)

Lepidium sp.

Rare along roads. (Shannon County).

Eryssimum cheiranthoides L. Western Wallflower.

Abundant in mesophytic thickets. (Bennett County).

Eryssimum inconspicuum (Wats.) Mac. M.

Frequent on the prairies. (Bennett County).

CAPPARIDACEAE (Caper Family)

**Cristatella Jamesii* T. & G. Yellow-flowered Bee-plant.
Abundant in sand-hills. (Bennett County).

Cleome serrulata Pursh. Common Bee-plant.
Very abundant in sandy valleys. In some places practically filling the valley to a depth of four feet. (Shannon County).

Cleome serrulata var. (alba) White-flowered Bee-plant.
Very rare, with the species, but smaller. (Pine Ridge, Shannon County).

Polanisia trachysperma T. & G. Clammy-weed.
Abundant along streams. (Washabaugh County).

GROSSULARIACEAE (Gooseberry Family)

Ribes americanum Mill. Black Currant.

Ribes floridum L'Her.
Abundant about rocks and in wooded valleys. (Washabaugh, Shannon Counties).

**Ribes inebrians* Linde. Currant.
Common on rocky hill sides.

Ribes longiflorum Nutt.

Ribes aureum Dougl. Red Currant.
Abundant in woods along streams. (Washabaugh County).

**Ribes odoratum* Wendl.
In shady groves along streams. (Washington County).

ROSACEAE (Rose Family)

Rubus occidentalis L. Black Raspberry.
Frequent along the streams in the Sand Hills. (Bennett County).

Fragaria americana (Porter) Brit. Wild Strawberry.
Rare in moist ravines.

**Drymocallis agrimonioides* (Pursh) Rydb.
Common on plains throughout. (Bennett County).

Potentilla monspiliensis L.
Common in sands of the ravines. (Bennett County).

**Potentilla strigosa* Pursh.
In depressions, not common. (Washington County).

**Agrimonia striata* Michx.
In groves along ravines. (Bennett County).

**Rosa arkansana* Porter. Prairie Rose.

Abundant on plains especially in sand. (Washington County).

**Rosa Maximiliani* Nees. Wood Rose.

Forming large and high thickets in open woods. (Washabaugh County).

**Rosa suffulta* Greene. Rose.

Abundant in the sandhills. (Bennett County).

POMACEAE (Apple Family)

Amelanchier alnifolia Nutt. Service or Juneberry.

Tolerably common in valleys and also dwarfed specimens in rocks of the buttes. (Bennett County).

**Crataegus sheridana* A. Nels.? Thorn Apple, Hawthorn.

Forming thickets in coulees on sides of high divides, and along the more canyon-like valleys. (Shannon County).

DRUPACEAE (Plum Family)

Prunus americana Marsh. Wild Plum.

Plum thickets are frequent along valleys. (Washabaugh County).

Prunus melanocarpa (A. Nels.) Rydb. Choke Cherry.

Prunus demissa Nutt.

The fruit of the choke cherry is larger in the valleys of the sandhills than anywhere else as far as I have observed. (Washabaugh County).

Prunus Besseyi Bailey. Sand Cherry.

Very abundant on the hillsides of the sand dune districts, also frequent on the rocky buttes. (Bennett County).

LEGUMINOSAE (Pea Family)

Acuan illinoensis (Michx.) Kuntze. "Curly-podded Legume."

Locally abundant forming hillside thickets. (Washabaugh County).

Sophora sericea Nutt.

Quite abundant everywhere on the plains. (Washington County).

Lupinus pusillus Pursh. Lupine.

Abundant in the sand hills. (Washington County).

Lotus americanus (Nutt.) Bisch. Trefoil.

Common along the White and Cheyenne Rivers, etc. (Washabaugh County).

Astragalus canadensis L. Vetch.

In moist places. (Washabaugh, Washington Counties).

Astragalus goniatus Nutt.

Astragalus hypoglottis Richards *not* Torrey.

On dry alluvial soil. (Washabaugh County).

Astragalus gracilis Nutt.

Rare on the hills. (Washington, Shannon Counties).

Astragalus missouriensis Nutt.

Tolerably common on the hills of clay soil. (Washabaugh County).

Astragalus racemosus Pursh.

In very dry places in the badlands. (Washabaugh County).

**Astragalus tenellus* Pursh.

Abundant on rocky bunch-grass hillsides. (Washabaugh County.)

Aragallus lambertii (Pursh) Greene. Loco.

Tolerably common throughout the plains especially on hillsides. (Shannon, Bennett Counties).

Glycyrrhiza lepidota Pursh. Licorice, Bur Legume.

Very abundant on steep banks along streams. (Washabaugh County).

Amorpha canescens Pursh. Lead Plant, Shoe Strings.

Abundant on the plains especially on sandy soil. (Washabaugh County).

Psoralea argophylla Pursh.

Abundant on the plains especially in switch-grass turf. (Washabaugh County).

Psoralea digitata Nutt. "Wild Alfalfa."

Abundant on the plains especially on loam. (Washabaugh County).

Psoralea esculenta Pursh. Indian Turnip.

Uncommon on the flood plains and prairies. (Washington County).

**Psoralea linearifolia* T. & G.

Rare near Porcupine Peak. (Shannon County).

Psoralea tenuifolia Nutt. "Wild Alfalfa."

Very abundant on sandy plains. (Washington, Washabaugh).

Parosela aurea (Nutt) Britt.

Uncommon but widespread on the plains. (Washabaugh County).

**Petalostemon oligophyllus* (Torr.) Rydb. Prairie Clover.

Very plentiful on the plains. (Washabaugh County).

Petalostemon villosus Nutt.

Common in the sand hills. (Bennett and Shannon Counties).

Apios Apios L. MacMill. Vine Legume.

Abundant in thickets along stream valleys. (Bennett County). Hitherto only recorded in South Dakota from the extreme eastern part.

**Mcibomeia dillenii* (Darl.) Kuntze. Showy Legume.

Very abundant along Wounded Knee Creek and in the Sand Hills. Greatly extends the range, (from southeastern Nebraska). (Shannon County).

Lathyrus ornatus Nutt. Wild Sweet Pea.

Reported by Tullsen to be abundant in parts of Shannon County.

GERANIACEAE (Geranium Family)

Geranium carolinianum L. Cranesbill.

Rare in flood plains. (Washington County).

OXALIDACEAE

**Xanthoxalis Bushii* Small. Wood-sorrell, Oxalis.

Common in moist depressions. (Bennett County).

Impatiens biflora Walt. Touch-me-not.

Abundant on stream borders, especially LaCreek and Little White. Hitherto only recorded in South Dakota from the extreme eastern part. (Bennett County).

LINACEAE (Flax Family)

**Cathastolinum compactum* (A. Nels.) Small.

Linum compactum. A. Nels.

Numerous on hillsides. (Washington County).

Cathastolinum rigidum (Pursh) Small. Yellow flowered flax.

Linum rigidum Pursh.

Abundant on plains. (Washabaugh County).

POLYGALACEAE (Milkwort Family)

Polygala alba Nutt. Milkwort.

Rare on sandy soil. (Bennett and Shannon Counties).

EUPHORBACEAE (Spurge Family)

Croton texensis (Klotzsch) Muell.

Abundant on sandy spots wherever they occur. (Washington, Washabaugh Counties).

Euphorbia marginata Pursh. Snow-on-the-mountain.

Abundant especially on flats along streams, in clay.

Tithymalus arkansana (Engelm. and Gray) K. and Garke.

Euphorbia arkansana Englm. and Gray.

On barren buttes in the badlands. (Washington County).

Zygophyllum hexagonum (Nutt.) Small. Yellow-flowered Spurge.

Abundant on sand dunes (Shannon County).

Chamaesyce glyptosperma (Engelm.) Small. Carpetweed.

Euphorbia glyptosperma Engelm.

Common on bare ground, especially about dooryards. (Washington and Shannon Counties).

Chamaesyce serpyllifolia (Pers.) Small.

Euphorbia serpyllifolia Pers.

On sandy soil, rare. (Washington County).

ANACARDIACEAE (Sumac Family)

**Rhus cismontana* Greene. Scarlet Sumac.

Rhus glabra L.

Common on the hillsides to the eastward of the eastern edge of the Pine Ridge Reservation. (Bennett County).

Rhus trilobata Nutt. Skunkbush.

Usual on rocky hillsides where it is commonly less than two feet high; occasionally forming thickets in flood plains, becoming twelve feet high. (Washabaugh County).

**Toxicodendron Rydbergii* Small. Western Poison Ivy.

Rhus Rydbergii Small.

Plentiful along streams, shady steep hillsides and escarpments. (Shannon County).

CELASTRACEAE (Staff Tree Family)

Celastrus scandens L. Climbing Bitter-Sweet.

In mesophytic thickets, infrequent. (Washabaugh, Shannon Counties).

ACERACEAE (Maple Family)

Negundo interior (Britt.) Rydb. Box Elder.

Acer negundo L.

Common on flood plains. (Washabaugh County).

VITACEAE (Vine Family)

Vitis vulpina L. Wild Grape.

Tolerably frequent in wooded flood plains and canyons.
(Washabaugh County).

**Parthenocissus vitaceae* Hitch. Virginia Creeper.

Only locally found in the more mesophytic ravines. (Wash-
abaugh County).

MALVACEAE (Mallow Family)

Malvastrum coccineum (Pursh) Gray. False Mallow.

Very abundant on the plains especially along roads. (Wash-
ington County).

HYPERICACEAE (St. John's-wort Family)

**Hypericum majus* (Gray) Britt. St. John's wort.

Abundant on LaCreek. (Bennett County).

VIOLACEAE (Violet Family).

Viola scabriscula (T. & G.) Schwein. Yellow violet.

Reported by Tullsen.

LOASACEAE

**Nuttallia stricta* (Osberhaut) Greene.

(*Mentzelia decapetala*?)

Common on sand hills and hillsides. (Washington County).

CACTACEAE (Cactus Family)

Cactus missouriensis (Sweet) Kuntze.

Mamillaria missouriensis Sweet.

Tolerably common on the plains throughout. (Washabaugh
County).

Cactus viviparus Nutt.

Mamillaria vivipara (Nutt.) Syn.

Widely distributed on the steppe, but infrequent. (Bennett
County).

Opuntia fragilis (Nutt) Haw.

Frequent especially in clay of benches along valleys.

**Opuntia polyacantha* Haw.

On dry plains especially in badlands.

Opuntia Rafinesquii Engelm. Western Prickly Pear.

Opuntia humifusa Raf.

Abundant on the prairies. (Washabaugh County).

ELAEGNACEAE (Oleaster Family)

Lepargyrea argentea (Nutt.) Greene. Buffalo Berry.

Shepherdia argentea Nutt.

Abundant forming thickets along banks particularly in badlands. (Washabaugh County).

ONAGRACEAE (Evening Primrose Family).

Epilobium adenocaulon Haussk. Common Willow Herb.

Common about all streams, about springs, etc. (Washabaugh and Bennett Counties).

Epilobium lineare Muhl.

Common along clear streams and about springs. (Bennett County).

**Oenothera muricata* L. Yellow Evening Primrose.

Abundant along Wounded Knee Creek. (Shannon County).

**Oenothera rhombipetala* Nutt.

Quite numerous in the sand hills. (Bennett County).

Anogra albicaulis (Pursh) Britt. White Evening Primrose.

Common on bare clay of the badlands. (Washabaugh County).

**Anogra latifolia* Rydb.

Anogra cineria Rydb.

Common along LaCreek. (Bennett County).

**Pachylophus macroglottis* Rydb. Gumbo Lily.

"*Pachylophus caespitosus* (Nutt) Raimann."

Abundant in the badlands on bare clay. (Washington County).

Mercolix serrulata (Nutt.) Walp. Yellow Prairie Mallow.

Abundant on the plains especially in roadsides. (Washabaugh County).

Gaura coccinea Nutt.

Frequent along roads and in fields of the plains. (Washington, Shannon Counties).

Gaura parviflora Dougl. Tall Gaura.

Occasional along roads, etc. (Bennett, Washabaugh Counties).

Circaea lutetiana L. Lousetick.

Along streams in woods. (Bennett County).

UMBELLIFERAE (Parsnip Family)

**Sanicula canadensis* L.

Common in woods along ravines. (Washabaugh County).

Cicuta occidentalis. Greene.

Cicuta maculata L.

Universal on wet soil along streams. (Washabaugh, Shannon, Washington Counties).

**Ammi majus* Walt.

Ptilimnium capellaceum (Michx.) Holleck.

Rare on wet soil along streams. (Washington County).

CORNACEAE (Dogwood Family)

**Suida stolonifera riparia* Rydb. Dogwood, Red Osier.

Cornus stolonifera riparia (Rydb.)

Frequent on banks of streams. (Washabaugh, Bennett Counties).

PRIMULACEAE (Primrose Family)

Steironema ciliatum (L.) Rap. Fringed Loosestrife.

Frequent in moist thicket and along streams of sandhills, etc. (Washabaugh, Bennett Counties).

OLEACEAE (Olive Family)

Fraxinus lanceolata Brock. Green Ash.

Abundant along smaller permanent streams, valleys and in coulees. (Washabaugh County).

APOCYNACEAE (Dogbane Family)

Apocynum cannabinum L. Dogbane.

Fairly common on butte sides; also along some streams. (Washington, Shannon Counties).

ASCLEPIADACEAE (Milkweed Family)

Acerates angustifolia (Nutt.) Dec. Green Milkweed.

Along the White River Valley, frequent. (Washabaugh County).

Acerates viridiflora. (Raf.) Eat.

Common on the plains. (Washington County).

**Acerates viridiflora linearis* Gray.

On sandy and dry prairies, fairly common. (Washabaugh County).

Asclepias incarnata L.

Abundant on LaCreek and other permanent streams. (Washabaugh County).

- Asclepias pumila* (Gray) Vail. Small Milkweed.
Abundant on the plains especially on hillsides. (Washington County).
- Asclepias speciosa* Torr. Large Milkweed.
Common along flood plains especially in overpastured areas. (Washabaugh County).

CUSCUTACEAE (Dodder Family)

- **Cuscuta cuspidata* Engelm. (?) Dodder.
Rare, parasitic on Ambrosia and Legumes. (Bennett County).
- **Cuscuta indecora* Choisy. (?) Pretty Dodder.
Parasitic on various plants of the dry soils. (Washabaugh County).

CONVOLVULACEAE (Morning-glory Family)

- Ipomoea leptophylla* Torr. Bush Morning-glory.
Common in scattered clumps especially on sandy areas, (Washabaugh County).
- Convolvulus americanus* (Sims.) Greene. White Morning-glory, Large Bind-weed.
- Convolvulus sepium* L.
Common in willow thickets on flood plains. (Washabaugh, Shannon Counties).

POLEMONIACEAE (Phlox Family)

- **Gilia longiflora* (Torr.) G. Oon. White Phlox.
Abundant on pure sand. (Bennett County).
- Phlox Douglasii andicola* Britt.
Reported by Tullsen from the elevated ridges.

BORAGINACEAE (Borage Family)

- **Heliotropium spathulatum* Rydb. Heliotrope.
Abundant in deserted fields. (Washington County).
- Allocarya scopulorum* Greene.
On wet saline ground. (Washabaugh County).
- Oreocarya perenans* (A. Nels.) Rydb. Prickly Borage
Frequent on plains especially rough land. (Washington County).
- **Lithospermum mandamese* Sprengi. Puccoon.
Common on the sand hills of Washington County.
- Onosmodium occidentale* MacKenzie. Gromwell.
Abundant on dry hillsides. (Washabaugh County).

VERBENACEAE (Vervain Family)

- **Verbena ambrosifolia* Rydb. Showy Phlox-vervian.
Quite abundant on the plains throughout, especially along roads. (Washabaugh, Washington, Shannon Counties).
- Verbena bracteosa* Michx.
Common in large bunches on hillsides and along road (Washabaugh, Shannon Counties).
- Verbena urticifolia*. White or Nettle-leaved Vervain.
Abundant in tall weeds. (Bennett County).
- Verbena stricta* Vent. Common Vervain.
Common hydro-mesophyte along streams; abundant in openings in woods; a conspicuous plant in wolf berry patches. (Washabaugh County).

LABIATAE (Mint Family)

- Scutellaria lateriflora* L. Skullcap.
Common along permanent streams. (Shannon County).
- Mentha canadensis* L. Mint.
Abundant along all streams. (Washabaugh County).
- Salvia lanceolata* Wild. Sage.
On alluvial soils. (Washabaugh County).
- **Monarda menthaefolia* Graham. Horsemint.
Abundant in open woods of the valleys. (Washabaugh County).
- **Hedeoma longiflora* Rydb. Pennyroyal.
Rather frequent on hillsides. (Washington County).
- **Lycopus communis* Bicknell. Water Hoarhound.
- Lycopus uniflorus* Michx.
Universal on such wet banks of streams as have vegetation. (Washabaugh County).

SOLANACEAE (Potato Family)

- Physalis heterophylla* Nees. Ground-cherry.
A common ruderal. (Washabaugh County).
- Physalis longifolia* Nutt. Ground-cherry.
Not uncommon in moist fields. (Washington County).
- **Solanum interior* Rydb. Western Nightshade.
Common in shaded valleys in the sand hills. (Bennett County).

Solanum rostratum Dunal. Buffalo-burr, Thistle-tomato.

Very generally distributed especially on bare ground along roads on flats. Usually infested by the potato beetle (*Lepidoptera decemlineata*). (Washington County).

Solanum triflorum Nutt.

Infrequent but widespread. (Washington County).

SCROPHULARIACEAE (Figwort Family).

**Pentstemon acuminatus* Dougl.

Abundant on the plains. (Bennett County).

Pentstemon cristatus Nutt.

Pentstemon erianthera Pursh.

Common on the plains, flowering in June (Shannon County).

Pentstemon gracilis Nutt. Beard-tongue.

Common in draws with blue stem. (Washabaugh County).

Pentstemon grandiflorus. Nutt.

"In patches on alluvium near water courses and copses."
(Tullsen).

**Veronica xalapensis* H. S. K. Purslane Speedwell.

In cultivated and wet places, infrequent. (Washabaugh County).

**Gerardia paupercula* (Gray) Britt.

Common along permanent streams especially in the sand hills. (Bennett County).

Mimulus Geyeri Torr. Monkey Flower.

Mimulus Jamesii T. and G.

Abundant in bogs and springy soil of LaCreek and Little White River. (Bennett County).

Monniera rotundifolia Michx. Water Hyssop.

Bacopa rotundifolia (Michx). Wettst.

On edge of ponds, rare. (Washington County).

OROBANCHACEAE.

Orobanche ludoviciana Nutt.

Myzorrhiza ludoviciana (Nutt) Rydb. Brome Rape.

An abundant parasite of the plains, attached to roots of composites, in this area mainly on the gum plant (*Grindelia*) (Washabaugh County).

PLANTAGINACEAE (Plantain Family).

Plantago major L. Eastern Plantain.

Fairly frequent along moist banks of the larger streams. (Shannon County).

Plantago Purshii R. and S. Prairie Plantain.

Abundant everywhere on the plains. (Bennett, Washabaugh Counties).

**Plantago spinulosa*. Decaun.

Infrequent on the prairies. (Washabaugh County).

RUBIACEAE (Madder Family).

**Galium subbiflorum* (Wieg.) Rydb. Small Bed-straw.

Frequent along the margin of LaCreek. (Bennett County).

Galium triflorum Michx. Large Bed-straw, Cleavers.

Abundant in thickets throughout. (Bennett County).

CAPRIFOLIACEAE (Honeysuckle Family).

Symphoricarpos occidentalis Buckbrush.

Very abundant forming patches along valleys, on hillsides and occasionally on the upland steppe. (Washabaugh, Bennett Counties).

CAMPANULACEAE (Bluebell Family).

Campanula aparinoides Pursh. Harebell.

In ravines, common. (Bennett County).

Specularia perfoliata (L.) A. D. C. Venus's Looking Glass.

Frequent in sandhill streams. (Washington County).

LOBELIACEAE (Lobelia Family).

Lobelia siphilitica L. Blue Cardinal Flower.

Along streams, rare. (Washington County).

COMPOSITAE (Composite Family).

**Eupatorium Bruneri* A. Gray. Joe-Pye-Weed.

Eupatorium maculatum L.

Plentiful along permanent streams. (Bennett County).

Kuhnia glutinosa Ell. False Boneset.

Frequent and widespread, especially along roads and in badlands. (Washington, Bennett and Washabaugh Counties).

Lacinaria punctata. (Hook). Kuntze Blazing Star.

Liatris punctata Hook.

Dominant on the plains late in August. (Bennett and Washabaugh Counties).

Lacinaria squarrosa (L.) Hill. Blazing Star.

Numerous in grasslands throughout. (Bennett County).

**Gutierrezia divaricata* Nutt.

Rare in the badlands, on hillsides. (Washabaugh County).

Gutierrezia Sarothrae (Bush). B. and R.

Numerous on the steppe. (Washington, Bennett Counties).

- Grindelia squarrosa* (Pursh) Dunal. Gum Plant.
Very plentiful throughout the plains.
- **Chrysopsis foliosa* Nutt. Golden Aster.
Abundant on the plains. (Washington County).
- **Chrysothamnus graveolens* (Nutt.) Greene. Rabbit Brush,
Rayless Golden Rod.
Highly characteristic of the badlands. (Washington, Washabaugh Counties).
- Sideranthus spinulosa* (Pursh.) Sweet.
Abundant along roads on the plains throughout. (Washabaugh, Washington, Bennett Counties).
- Oligoneuron canescens* Rydb. Thick-leaved Goldenrod.
- Solidago Rigida* L.
Plentiful in patches on the plains. (Washabaugh County).
- Solidago canadensis* L. Robber Goldenrod.
Abundant on flood plains.
- **Solidago mollis*. Barth. Prairie Golden rod.
Abundant on the plains. (Bennett County).
- **Solidago Pitcheri* Nutt.
Rare in woodlands (Washington County).
- **Solidago trinervata* Greene.
Rare on flats along streams. (Washabaugh County).
- **Townsendia grandiflora* Nutt. Badland Blue-aster.
Characteristic and abundant on loose clay of badland slopes.
(Washington County).
- **Aster longulus* Sheldon.
Rare in the ravines. (Bennett County).
- **Aster polycephalus* Rydb. Plains Aster.
- Aster hebecladus* DC.
Very abundant and conspicuous in late August on the plains.
(Washabaugh County).
- Machaeranthera sessiliflora* (Nutt.) Greene. Viscid Aster.
Frequent in badlands and sand dunes.
- **Erigeron Bellidiastrum* Nutt.
Rare in the sand hills of Washington County.
- **Erigeron divergens* T. and G. (?)
Tolerably common along roads. (Washabaugh County).
- **Erigeron ramosus* (Watt.) B. S. P. Daisy Fleabane.
Abundant on plains. (Washabaugh County).

- Leptilon canadense* (L.) Britt. Prairie Fireweed, Horse Weed.
Characteristic on deserted fields and along old roads. (Washington, Bennett Counties).
- Iva axillaris* Pursh. Marsh Elder.
Abundant along sandy valleys, rare on uplands. (Washington County).
- **Ambrosia media* Rydb. Sand Ragweed.
Abundant on sand. (Shannon County).
- Ambrosia psilostachya* DC. Western Ragweed.
In worn-out pastures along the rivers. (Washington County).
- Heliopsis scabra* Dunal. False Sunflower.
Common in grass of open woods. (Washabaugh, Washington, Bennett Counties).
- Braunera angustifolia* (DC.) Heller. Niggerhead.
On the steppe, very frequent. (Washabaugh County).
- **Rudbeckia flava* Moore. Prairie Blackeyed Susan.
Very abundant everywhere on the uplands. (Bennett County)
- Ratibida columnaris* (Sims). ? D. Don. Cone Flower.
One of the most characteristic species of the steppe. (Washabaugh County).
- **Ratibida columnaris pulcherrima* (DC.) D. Don. Red Cone Flower.
Occasional on the plains. (Washabaugh County).
- **Helianthus lenticularis* Dougl. Large Sunflower.
- Helianthus annuus* L.
Common on the steppe. (Washabaugh County).
- Helianthus petiolaris* Nutt. Low Sunflower.
Plentiful on the steppe especially in old fields. (Washington County).
- **Bidens glaucescens* Greene. Beggar's Tick.
Common in bogs of the Sand Hills. (Bennett County).
- **Bidens tricosperma tenuiloba* Gray. False Marsh Marigold.
A pest along the Little White and LaCreek. (Bennett County).
- Hymenopappus filifolius* Nutt.
Abundant on the plains. (Washabaugh County).
- Picradenipsis oppositifolia* (Nutt.) Rydb.
- Bahia oppositifolia* Nutt.
Abundant on the plains. (Washington County).
- **Boebera papposa* (Vent.) Rydb. Fetid Marigold.
Rare on flood plains. (Washington County).

Artemisia dracunculoides Pursh. Common Wormwood.

Especially plentiful on sand, wide spread. (Washabaugh County).

Artemisia filifolia Torr.

Common on wooded areas about the badland buttes. (Washabaugh County).

Artemisia gnaphalodes Nutt. Eastern Sage.

Common in the meadows. (Washington County).

Artemisia longifolia Nutt.

Abundant in the badlands, flowers in September. (Washabaugh County).

**Senecio Riddellii* T. & G.

Abundant along old roads.

Carduus altissimum L. Tall Thistle.

Common on flood plains. (Washabaugh County).

**Carduus flodmanii* Rydb.

Carduus filiendus (Engelm) Rydb.

Rare on the plains near Medicine Root. (Washington County)

**Carduus Nelsonii* Pammell.

On the sides of Washington County sandhills; rare.

Carduus undulatus Nutt. Common Thistle.

Generally distributed on the plains, especially in worn-out pastures.

Tragopogon parvifolius L. Salsify. Oyster Plant.

Occasional in old fields and along roads. (Washington County).

Lygodesmia juncea (Pursh) Don. Prairie Pink, Leafless Plant.

Abundant on prairies and fields. (Washington County).

Lactuca canadensis L.

Frequent on borders of marshy brooks. (Washabaugh County).

Lactuca pulchella DC. Wild Lettuce.

Plentiful on low, wet meadows. (Washabaugh County).

**Lactuca virosa* L.

Lactuca integrata (Gren. and Godr.) A. Nels.

Rare on the flood plains of Bear Creek. (Washabaugh County).

**Taraxacum erythrospermum* Andy. Red-seeded Dandelion.

Rare along Wounded Knee Creek. (Shannon County).

IV. A LIST OF THE BIRDS OF THE PINE RIDGE
RESERVATION

The following list is based on two chief sources.

(1) A. Tullsen spent most of the time from October, 1901 to June, 1908 on the reservation. A readable account, "My Avian Visitors: Notes from South Dakota" was published in the May, 1911 Condor, pages 89-104. Mr. Tullsen has kindly sent me supplementary notes with permission to publish them.

(2). As a member of the South Dakota State Survey it has been my privilege to work in this area during parts of two summers. During the first two weeks of September, 1908, the White River Valley in Washabaugh County was visited (Note 1). July and August, 1911, (Note 2) were occupied in traversing this and adjacent areas. The route of our wagon is shown on the map by a broken line. The dotted line indicates the longer of my side trips on horseback or on foot. A "game getter" was constantly carried and about fifty species of birds were collected for the state museum.

The Pine Ridge Indian Reservation until the autumn of 1911 comprised the counties of Washabaugh, Bennett, Shannon and Washington situated between the White and Cheyenne Rivers and Nebraska, and midway between the Missouri River and the Wyoming boundary, in the southwest central part of South Dakota. The area comprising over 3300 square miles, has a population of less than 7,000 and no railroads.

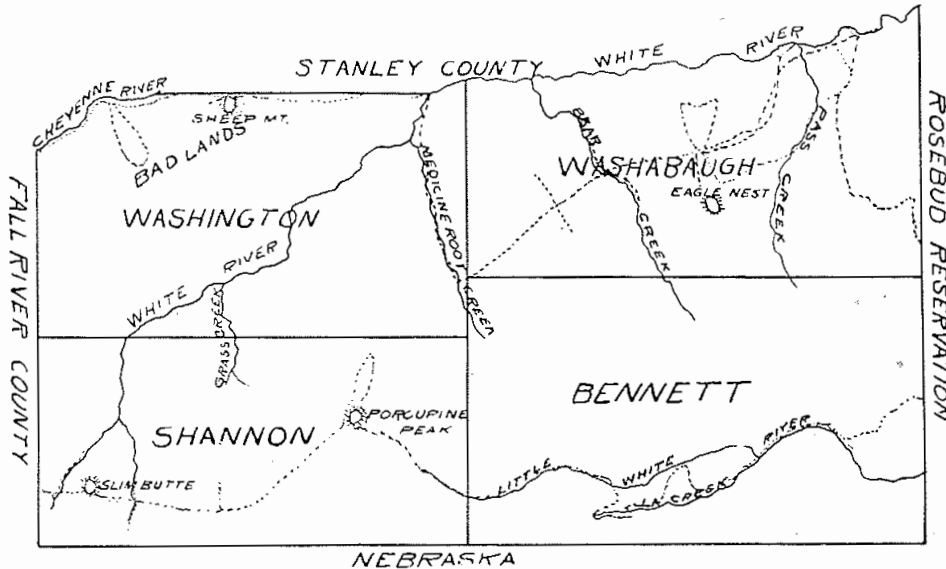
This is a region of considerable diversity. In elevation the range is from about 2100 feet above sea level in the lower White River Valley, to over 3500 feet on the high plains of the southern part. The major part of this area is an eroded stretch which slopes toward the White River from a high plateau in the southern section. Badlands are well developed along the lower courses of the tributaries of the White River and in Washington County between the White and Cheyenne Rivers. Sand-hills are present in southern Bennett and in north central Washington counties. The White and Cheyenne Rivers have broad flood plains more or less, "forested" with cottonwood trees. The creek val-

Note 1—For a list of birds noted in Southwestern Stanley County see "The Auk" April, 1909 pp. 144-153.

Note 2—For a list of birds observed in Fall River County see "The Wilson Bulletin" March, 1912 pp. 1-6.

leys are generally partially filled with groves of ash, elm, willow and cottonwood with some cedar and pine. The escarpment of the plateau and numerous out-liers of this called "buttes" are sprinkled with pine.

The accompanying map shows the drainage, etc. of this area,



A Sketch Map of the Old Pine Ridge Reservation

The five chief biological associations or ecological formations of this area are:

(1). The plains or steppe characterized by short grasses such as grama, buffalo and needle, and many flowers including *Psoralea*, *cactus* and the bush morning-glory. The most noticeable birds are Western Meadow-lark, Desert Horned Lark, Lark Bunting, Chestnut Collared Longspur, Cowbird, Marsh Hawk, Burrowing Owl, Sennett Nighthawk, Upland Plover, and Killdeer.

(2). Badlands are characterized by steep slopes and bare surfaces. The grassy "flats" are mainly covered with the wheat grass-cactus type. Scattered compositaceous shrubs, and gumbo poppy, etc., are general. The chief birds are the Rock Wren, Say's Phoebe, Cliff Swallow, Western Lark Sparrow, Turkey Vulture and Prairie Falcon.

(3). On the buttes and along the escarpment are clumps of western yellow pine (*Pinus ponderosa scopulorum*) with an under-growth of skunk-bush, *Yucca* and *Eriogonum*. The birds

usually seen in such situations in July and August are Long-tailed Chickadee, Rock Wren, Prairie Falcon, White-throated Swift, and Bluebird.

(4). The abundant birds of the open cottonwood woods are Arkansas and common Kingbird, White-rumped Shrike, Mourning Dove, Redhead and Downy Woodpecker, Flicker Bullock Oriole, Magpie, Blue Jay, Sparrow Hawk, Screech Owl, Western Wood Pewee, Western Chipping Sparrow, Long-tailed Chickadee, and Western House Wren.

In the plum, buffalo berry, chokecherry and other thickets are: Arctic Towhee, Catbird, Brown Thrasher, Long-tailed Chat, Black-headed Grosbeak, Yellow Warbler and Ovenbird.

(5). In southern Bennett County wind-blown sand has interfered with the drainage and several ponds and one large marsh (LaCreek Marsh) have been formed. There are numerous water birds in this region, including many ducks and snipe during migration, and Black Tern, Yellow-headed Blackbirds, Bittern, Coot, etc.

THE LIST.

Franklin's Gull (*Larus franklini*). "Gulls were occasionally seen at LaCreek but too far away to be secured or identified."—Tullsen.

Black Tern (*Hydrochelidon nigra surinamensis*). Nested in 1911 at LaCreek and on a pond in northwestern Washabaugh County. Quite common in spring at LaCreek."—Tullsen.

White Pelican (*Pelicanus erythrorhynchos*). Reported to be a rare migrant.

Hooded Merganser (*Lophodytes cucullatus*). Reported to be an abundant migrant.

Mallard (*Anas platyrhynchos*). An abundant migrant. A few nest at LaCreek and along the Little White. Some remain in the fall until the springs are frozen over. Reported to have formerly been abundant during the nesting season.

Green-Winged Teal (*Nettion carolinense*). An abundant migrant arriving by August 15.

Blue-Winged Teal (*Querquedula discors*). An abundant migrant. Breeds at LaCreek and in other favorable places. Teals, Mallard, Shoveller and Pintail are perhaps the most abundant ducks.

Shoveller (*Spatula clypeata*). An abundant migrant and rare summer resident.

Pintail (*Dafila acuta*). An abundant migrant arriving with the first promise of spring, usually in late February. A few broods are reared in this reservation.

Canvasback (*Marila valisineria*). A large flock of these ducks were seen on the White River in September of 1908.

Buffle-Head (*Charitonetta albeola*). Reported as a common migrant.

Ruddy Duck (*Erismatura jamaicensis*). Reported by hunters to be frequently seen during migrations.

Snow Goose (*Chen hyperboreus hyperboreus*). "Taken during migrations."—Tullsen.

Bittern (*Botaurus lentiginosus*). Nests abundantly in marshes along LaCreek in Bennett County.

Great Blue Heron (*Ardea herodias herodias*). Several seen in August along the Little White River and LaCreek.

Black-Crowned Night Heron (*Nycticorax nycticorax naevius*). A common breeder near LaCreek marsh.

Whooping Crane (*Grus americana*). Reported as formerly abundant on LaCreek.

Sandhill Crane (*Grus mexicana*). "Breeds at LaCreek."—Tullsen. We saw one east of this area August 18.

Sora Rail (*Porzana carolina*). "Common in LaCreek marsh."

Coot (*Fulica americana*). Many nest on LaCreek marsh.

Wilson's Phalarope (*Steganopus tricolor*). Several seen on a small lake in Bennett County August 12.

Avocet (*Recurvirostra americana*). One seen with the phalaropes.

Wilson's Snipe (*Gallinago delicata*). One seen in a spring marsh in the sandhills of southern Bennett County August 11. "Tolerably common at LaCreek."—Tullsen.

Stilt Sandpiper (*Micropalama himantopus*). A tolerably common migrant in the fall of 1911.

Pectoral Sandpiper (*Pisobia maculata*). Seen several times during our sojourn.

Baird's Sandpiper (*Pisobia bairdi*). An abundant migrant. Small flocks of sandpipers were seen about each of the "blow-outs" which were filled by the rains of July.

Least Sandpiper (*Pisobia minutilla*). A common migrant.

Sanderling (*Caladris leucophaea*). Small flocks were seen July 12 and August 11.

Marbled Godwit (*Limosa fedoa*). One seen in Bennett County August 12th.

Yellowlegs (*Totanus falripes*). A fairly abundant migrant, first seen July 12.

Solitary Sandpiper (*Helodramas solitarius solitarius*). Frequently seen from July 10 to the first of August.

Upland Plover (*Bartramia longicauda*). Nests fairly plentiful on the more grassy plains.

Spotted Sandpiper (*Actitis macularius*). Tolerably common all summer long.

Long-Billed Curlew (*Numenius americanus*). Only a few remain. These breed in the wilder parts of the reservation.

Killdeer (*Oxyechus vociferus*). A very abundant summer resident. By far the most-frequently-seen water bird. Shallow water holes are common on these plains. Almost every hole has its brood.

Bobwhite (*Colinus virginianus virginianus*). A tolerably common resident locally in the White River Valley throughout its course, and in some of its tributaries, especially the Little White.

Prairie Chicken (*Tympanuchus americanus americanus*). "LaCreek vicinity only."—Tullsen. Reported that within the last few years as occasionally shot in Washabaugh County.

Prairie Sharp-Tailed Grouse (*Pedioecetes phasianellus campestris*). A fairly numerous resident, especially near the valleys. This species is very rapidly being exterminated by the July and August hunting and has become rare in most of southwestern South Dakota.

Mourning Dove (*Zenaidura macroura marginella*). A very abundant summer resident. It is decidedly the most conspicuous bird in the larger valleys in which there are scattered large cottonwood trees.

Turkey Vulture (*Cathartes aura septentrionalis*.) A common summer resident, especially about the badland.

Marsh Hawk (*Circus hudsonius*). Abundant in the plains of the southern half of the reservation. Rarely noted in the northern half.

Sharp-Shinned Hawk (*Accipiter velox*) Seen once late in August.

Krider's Hawk (*Buteo borealis krideri*), Seen several times in July and August.

Western Red-Tail (*Buteo borealis calurus*). A tolerably common summer resident.

Swainson's Hawk (*Buteo swainsoni*). An abundant summer resident.

Ferruginous Rough-Leg (*Archibuteo ferrugineus*). An individual was seen in each of the two southern counties.

Golden Eagle (*Aquila chrysaetos*). "Rare resident."

Bald Eagle (*Haliaeetus leucocephalus leucocephalus*), Reported as a very rare visitor.

Prairie Falcon (*Falco mexicanus*). An abundant resident in badlands and about peaks such as Porcupine Peak, Eagle's Nest, etc.

Richardson's Pigeon Hawk (*Falco columbarius richardsoni*). Seen several times in July and August.

Sparrow Hawk (*Falco sparverius sparverius*). Very abundant summer resident where trees occur.

Osprey (*Pandion haliaetus carolinensis*). One seen in September, 1908 along the White River in Washabaugh County.

Short-Eared Owl (*Asio flammeus*). "Abundant breeder along LaCreek; nest found."—Tullsen.

Screech Owl (*Otus asio asio*). A common breeder, seen in widely separated parts of the area. We collected a red screech owl near the 103 meridian. Most seen were grays and possibly *a maxwelliae*.

Western Horned Owl (*Bubo virginianus pallescens*). Juvenal specimens were seen along the White River in August.

Snowy Owl (*Nyctea nyctea*) Reported as a winter resident, sometimes abundant.

Burrowing Owl (*Speotyto cunicularia hypogaea*). Abundant summer resident in the few prairie dog towns of the reservation.

Yellow-Billed Cuckoo (*Coccyzus americanus americanus*). "Rare summer resident along the wooded valleys."—Tullsen.

Belted Kingfisher (*Ceryle alcyon*). A common summer resident along the larger streams.

Hairy Woodpecker (*Dryobates villosus subspecies*). A common breeder in the valleys which are wooded with the largest trees.

Downy Woodpecker (*Dryobates pubescens medius*). Abundant in summer.

Red-Headed Woodpecker (*Melanerpes erthrocephalus*). Very common summer resident of the open groves. The most common woodpecker of this section of the state.

Northern Flicker (*Colaptes auratus luteus*). Tolerably common breeder.

Red-Shafted Flicker (*Colaptes cafer collaris*). Very common summer resident. Hybrids between these flickers are more frequently seen here than the pure forms.

Poorwill (*Phalaenoptilus nuttalli nuttalli*). Several were heard August 14 along the Little River just west of Rosebud. The valley here is quite canyon-like. The poorwills were on the high terraces.

Western Nighthawk (*Chordeiles virginianus henryi*). Nests commonly especially on the "forested" buttes.

Sennett's Nighthawk (*Chordeiles virginianus sennetti*). Most of the nighthawks of the plain regions are of this variety.

White-Throated Swift (*Acronautes melanoleucus*). Nests abundantly about the steeper buttes of the northern badland portions of the area. Found nesting as far east as the 101° meridian.

Kingbird (*Tyrannus tyrannus*). Broods are frequently met in the valleys which have deciduous groves.

Arkansas Kingbird (*Tyrannus verticalis*). An abundant summer resident on the plains, nesting in the clumps or single ash, boxelder, or cottonwood in "draws" or in the groves along the streams.

Say's Phoebe (*Sayornis sayus*). An abundant summer resident, especially about cliffs, and consequently in the badlands.

Western Wood Pewee (*Myiochanes richardsoni richardsoni*). Quite common in summer nesting in the wooded "bottoms."

Traill's Flycatcher (*Empidonax trailli trailli*). A common breeder in the thickets along LaCreek in the Sand Hills.

Desert Horned Lark (*Otocoris apestris leucolaema*). An abundant resident. One of the most numerous of the birds of the plain.

Magpie (*Pica pica hudsonia*). Numerous wherever there are trees. Resident.

Blue Jay (*Cyanocitta cristata cristata*). Quite numerous along the White River in the northeastern part of the area. Reported by Tullsen from the western part.

Crow (*Corvus brachyrhynchos brachyrhynchos*). Not common. Tullsen reports them as rare in the winter.

Clarke's Nutcracker (*Nucifraga columbiana*). One recorded by Tullsen from No-Flesh Creek in western Washabaugh county.

Pinon Jay (*Cyanocephalus cyanocephalus*). I saw several on Sheep Mountain in Washington County, July 14-16. Tullsen reports them as locally abundant at all seasons of the year. He further reports a nest.

Bobolink (*Dolichonyx oryzivorus*). "Very abundant in summer in the low meadows along LaCreek. One flock seen on Medicine Root Creek." Tullsen. Seen August 13.

Cowbird (*Molothrus ater ater*). Numerous in summer.

Yellow-Headed Blackbird (*Xanthocephalus xanthocephalus*). Seen frequently during the summer. Nests abundantly in the few favorable locations of which the LaCreek marsh is the most notable.

Thick-Billed Red-Wing (*Agelaius phoeniceus fortis*). A common summer resident. "Nested in wolfberry (*Symphoricarpus*) thickets along Grass Creek."—Tullsen.

Meadowlark (*Sturnella magna magna*). "Occasional in the White River Valley." (Sweet) "Far more abundant than the western species in the flat valley of LaCreek."—Tullsen.

Western Meadowlark (*Sturnella neglecta*). Abundant from early in March till November upon the prairies. Easily one of the half dozen most numerous birds of the area.

Orchard Oriole (*Icterus spurius*). Nests rarely in the wooded tributaries of the White River.

Bullock's Oriole (*Icterus bullocki*). Breeds commonly.

Brewer's Blackbird (*Euphagus cyanocephalus*). A common breeder nesting in groves. "Especially abundant in spring."—Tullsen.

Bronzed Grackle (*Quiscalus quiscula aeneus*). Nests fairly common in the wooded valleys of the two northern counties.

English Sparrow (*Passer domesticus*). Fairly numerous. They usually nest in the hay covered horse sheds of the Indians.

Crossbill (*Loxia curvirostra minor*). A rare breeder along the White River.

White-Winged Crossbill (*Loxia leucoptera*). "Straggler, in winter."—Tullsen.

Redpoll (*Acanthis linaria linaria*). "One flock in winter on Medicine Root Creek."—Tullsen.

Goldfinch (*Astragalinus tristis tristis*). Common during the summer months.

Snow Bunting (*Plectrophenax nivalis nivalis*). "Tolerably common in winter."—Tullsen.

Lapland Longspur (*Calcarius lapponicus lapponicus*). Common in winter."—Tullsen.

Chestnut-Collared Longspur (*Calcarius ornatus*). An abundant summer resident on the high plains of the southern half of the area.

McCown's Longspur (*Rhynchopanes mccownii*). Fairly numerous on the plains after August 10.

Western Vesper Sparrow (*Pooecetes gramineus confinis*). Breeds abundantly in the sandhill region. Seen very frequently elsewhere.

Western Savannah Sparrow (*Passerculus sandwichensis alaudinus*). Several were seen about LaCreek marsh during the second week of August.

Western Grasshopper Sparrow (*Ammodramus savannarum bimaculatus*). Locally an abundant summer resident in the grassy swales in northern counties.

Western Lark Sparrow (*Chondestes grammacus strigatus*). An abundant breeder. Nests were found under soap weeds (*Chrysothamus*) on the sides of canyons in the badlands.

Harris's Sparrow (*Zonotrichia querula*). "Common in migrations from late in April to May 24."—Tullsen.

White Crowned Sparrow (*Zonotrichia leucophrys leucophrys*). "A regular migrant."—Tullsen.

Western Tree Sparrow (*Spizella monticola ochrocea*), "Abundant in winter."—Tullsen.

Western Chipping Sparrow (*Spizella passerina arizonae*), Breeds abundantly in this district along the edges of the groves.

Clay-colored Sparrow (*Spizella pallida*). Fairly common in summer.

Western Field Sparrow (*Spizella pusilla arenacea*). Nests quite plentifully in the wooded valleys.

Slate-Colored Junco (*Junco hyemalis hyemalis*). "Fairly common in migrations and rare in winter."—Tullsen.

Song Sparrow (*Melospiza melodia melodia*). Quite abundant during the summer, especially in the Sandhill region.

Arctic Towhee (*Pipilo maculatus arcticus*). Nests very abundantly in those valleys which contain thickets. Tullsen reports, "I have reason to think a few sometimes winter in especially sheltered valleys."

Black Headed Grosbeak (*Zamelodia melanocephala*). An abundant breeder along the wooded valleys.

Western Blue Grosbeak (*Guiraca caerulea lazula*). Nests rarely along the wooded valleys. We collected young of the year, even sixty miles east of these counties; east of the 100° meridian.

Dickcissel (*Spiza americana*). Tullsen reported dickcissels as fairly plentiful in 1905 and 1906 though he saw none in 1904. I saw them in the summer of 1908 in the White River valley. During the summer of 1911 none were observed in this entire section of the state.

Lark Bunting (*Calamospiza melanocorys*). The "white-winged blackbird" nests quite abundantly on the plains, and sandhills, especially of the two southern counties.

Western Tanager (*Piranga ludoviciana*). "One male, near Grass Creek June 31, 1905."—Tullsen.

Purple Martin (*Progne subis*). "One pair Medicine Root Creek June 11, 1904."—Tullsen. We saw a pair in northeastern Washabaugh County early in July.

Cliff Swallow (*Petrochelidon lunifrons lunifrons*). An abundant breeder in the badlands areas and seen every day

until August 10, after which date we noted them but a few times.

Barn Swallow (*Hirundo erythrogastra*). A common summer resident wherever there are buildings.

Northern Violet-Green Swallow (*Tachycineta thalassina lepida*). Nests tolerably common in the badlands.

Bank Swallow (*Riparia riparia*). Colonies seen several times in 1911.

Rough-Winged Swallow (*Steligidopteryx serripennis*). A few pairs nested along the White River in northeastern Washington County.

Bohemian Waxwing (*Bombycilla garrula*). "In winter wanders in good sized flocks about the cedar country and feeds on berries."—Tullsen.

Cedar Waxwing (*Bombycilla cedrorum*). A few nested on Eagle-nest Creek and Bear Creek in summer of 1911.

White-Rumped Shrike (*Lanius ludovicianus excubitorides*). Breeds very abundantly in the large cottonwoods of the valleys. One of the most conspicuous of the valley birds.

Red-Eyed Vireo (*Vireosylva olivacea*). "Common May 24, 1905 at Grass Creek."—Tullsen. A few were seen early July on Bear Creek and on the White River in Shannon County in August.

Western Warbling Vireo (*Vireosylva gilva swainsoni*). A rare summer resident of wooded valleys.

Bell's Vireo (*Vireo belli belli*). Seen at the headwaters of LaCreek, Bennett County, August 11.

Black and White Warbler (*Mniotilta varia*). "Common in migration May 8, 1904."—Tullsen. I saw three females or young in the Little White River valley a few miles east of this reservation August 14.

Yellow Warbler (*Dendroica aestiva aestiva*). Nests fairly abundant in the woods along the streams.

Audubon's Warbler (*Dendroica auduboni auduboni*). "Tolerably common in migrations."—Tullsen.

Black Poll Warbler (*Dendroica striata*). "Common migrant."—Tullsen.

Blackburnian Warbler (*Dendroica fusca*). "Taken May 17, 1903. Seen at other times during migration that spring."—Tullsen.

Oven Bird (*Sciurus aurocapillus*). Nests quite abundantly along the wooded valleys, especially Bear and Medicine Root Creeks.

Western Yellow-Throat (*Geothlypis trichas occidentalis*). Common in summer along the smaller permanent streams and about LaCreek marsh.

Long-Tailed Chat (*Icteria virens longicauda*). Found in almost every large thicket in abrupt valleys.

Redstart (*Setophaga ruticilla*). Reported by Tullsen as a common migrant, arriving about May 14. We found it nesting in the wooded valleys and quite plentiful after the first week in August.

Pipit (*Anthus rubescens*). "Several seen late in September, 1907, and one taken on September 29."—Tullsen.

Sprague's Pipit (*Anthus spraguiei*). This species was seen and its characteristic *che che* frequently heard on the plains during the first half of August.

Catbird (*Dumetella carolinensis*). A fairly common summer resident in the wooded valleys.

Brown Thrasher (*Taxostoma rufum*). Nests abundantly. Choke cherries seem to be the favorite food during July and the first half of August.

Rock Wren (*Salpinctes obsoletus obsoletus*). One of the badlands most notable residents. Also common about the pine-decked butte tops.

Western House Wren (*Troglodytes aedon parkmani*). Quite plentiful in those wooded valleys which have large trees. Box-elders, which are often partly rotten with hollows, are the usual nesting site.

Prairie Marsh Wren (*Telmatodytes palustris iliacus*). "Seen Sept. 17 and 18, 1902."—Tullsen.

Red-Breasted Nuthatch (*Sitta canadensis*). Nests rarely, in the pines of the buttes.

Longtailed Chickadee (*Penthestes atricapillus septentrionalis*). An abundant resident wherever there are trees.

Willow Thrush (*Hylocichla fuscescens salicicola*). "Common in migration. Taken at LaCreek May 18, 1907."—Tullsen.

Robin (*Planesticus migratorius migratorius*). "Fairly abundant."—Tullsen. We saw a few along the wooded valleys in Washabaugh County early in July.

Bluebird (*Sialia sialis sialis*). Nests in the wooded portions fairly plentiful.

Mountain Bluebird (*Sialia currucoides*). "Not seen, except in migrations."—Tullsen. We found it quite plentiful. A fledgling collected.

A SUPPLEMENT TO THE LIST OF BIRDS

A portion of the bird collection made in this area was submitted to the U. S. Biological Survey. Returns were received at the time the indexing of the bulletin was in progress. In addition to the substantiation of over a dozen varietal names which, based on observation alone had been perhaps somewhat uncertain, the returns now warrant the addition of two forms which because of the great extensions of the hitherto known ranges it had been thought wise to omit until the determinations could be verified.

Rocky Mountain Screech Owl, (*Otusasio marcelliae*). Oberholser's identification of a specimen bears out the suspicion expressed on page 114.

Dakota Song Sparrow. (*Melospiza melodia juddi*). An individual, seemingly like all the rest, many of which were bobtailed from moulting and had apparently bred there, was shot in the sand hills near LaCreek. This is a notable extension of range of a subspecies which was formerly known to nest only in northern North Dakota and adjacent Canada.

Semipalmated Plover. (*Aegialeus semipalmatus*). A specimen was shot from a small flock near Norris. Omitted thru error from the list proper.

V. A PARTIAL LIST OF THE INSECTS COLLECTED IN
SOUTHWESTERN SOUTH DAKOTA, JULY AND
AUGUST 1911.*

ORTHOPTERA (Grasshoppers)

Determined by Professor L. P. Morse, Ph. D. Wellesley College.

Scientific Name	Common Name	Where Collected
<i>Ageneotettix</i> sp.		Indian Creek, flood plain.
<i>Alpha</i> sp.		Indian Creek, flood plain.
<i>Anlocara</i> sp.		Indian Creek.
<i>Brachystola Magna</i>	Giant Grasshopper.	LaCreek, Edgemont.
<i>Dactylotum pictum</i>	Brilliant Locust.	Edgemont.
<i>Dissosteria carolina</i>	Carolina Locust.	LaCreek, Potato Creek, Edgemont.
<i>Hadrotettix trifasciatus</i> ...		Indian Creek.
<i>Hippiscus</i> sp.	Coral-winged Locust.	Indian Creek.
<i>Melanophus bivittatus</i>	Two Striped Locust.	Bear Creek.
<i>Melanophus</i> sp.	Red legged (short horned) Grasshopper.	Indian Creek.
<i>Nachyrhachis</i> sp.		Indian Creek, numerous on flood plain.
<i>Oecanthus</i> sp.		LaCreek.
<i>Opeia</i> sp.		Indian Creek, flood plain.
<i>Phlibostroma</i> sp.	Barren-ground Locust.	Indian Creek.
<i>Spharagemon aequale</i>	Lance tailed. (long horned) Grasshopper.	Indian Creek.
<i>Xiphidium</i> sp.		LaCreek.

COLEOPTERA (Beetles)

Determined by Wm. M. Mann, Bussey Institution, Harvard University;
assisted by J. H. Paine of Stanford University.

<i>Acmacodera pulchella</i>	Spotted Buprestid.	Edgemont.
<i>Chalcophora angusticollis</i> ..	Large Buprestid.	Cheyenne Valley, Washing- ton County.
<i>Chariessa pilosa</i>		Pine Ridge Agency.
<i>Chrysochus auratus</i>	Green Chrysomelid.	Bear Creek.
<i>Diabrotica atripennis</i>	(Cucumber Beetle Genus)	LaCreek Valley.
<i>Eleodes obsoleta</i>	Pinacata bug or Ground- Beetle.	Porcupine Butte.
<i>Eleodes opaca</i>	Pinacata bug or Ground- beetle.	LaCreek Valley.
<i>Eleodes tricostata</i>	Pinacata bug or Ground- beetle.	Porcupine Butte.
<i>Epicauta ferruginea</i>	Blister Beetle.	Pine Ridge Agency.
<i>Epicauta maculata</i>	Blister Beetle.	Edgemont.
<i>Epitragus canaliculatus?</i> ..		Indian Creek, Fall River Co.
<i>Epitragus</i> sp.		LaCreek Valley.
<i>Harnaalis eraticus</i>	Carabid.	Edgemont.
<i>Lachnosterna lanccolata</i> ...	June Beetle.	Bear Creek and Indian Creek.
<i>Nemognatha</i> sp.	Trunked Beetle.	Edgemont.
<i>Odontota rubra</i>	Red Quadrate Beetle.	Edgemont.
<i>Silpha ramosa</i>	Carion Beetle.	LaCreek Valley.
<i>Tetraopes tetraophthalmus</i> var	Milk-weed Beetle.	LaCreek and Cheyenne Val- ley Washington County.
<i>Tropisternus sublaviv</i>	Smaller Water-beetle.	LaCreek Valley.

HYMENOPTERA (Wasps)

Determinations by Mann & Paine.

<i>Eucoila</i> sp.		LaCreek.
<i>Cremastus</i> sp.		LaCreek.
<i>Pelecinus polyturator</i>	Parasitic Hymenopteron.	LaCreek.
<i>Vespa</i> sp.	Yellow-jacket.	Porcupine Butte.

DIPTERA (Flies)

<i>Gastrophilus equi</i>	Bot-fly.	Kyle.
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*This list includes only a portion of the insects collected. Those species which would require much time for identification unfortunately could not be named by the several specialists in time for insertion into this bulletin.

VI. NOTES ON ANIMALS AND PLANTS OF ECONOMIC IMPORTANCE.

1. ANIMALS OF PREY.

(a). The *gray wolf* is moderately plentiful, and because of the proximity of rough lands will probably continue to give some trouble to horse and cattle raisers for some years to come.

(b) *Coyotes* are plentiful. At present they cause little damage. With the introduction of sheep raising they may become a menace. However, fences that are coyote proof are not difficult to make.

(c) Weasels and skunks are especially feared by poultry raisers. Since their activities are limited to the hours of darkness, precautions can easily be taken against their entrance.

(d) Hawks and owls are, with a couple of exceptions, very great allies of the farmer, because they live on gophers and rabbits. Consequently, they ought by all means to be permitted to live. The only owl which is destructive to poultry is the very large Horned Owl which is occasionally seen in this area. The Sharp-shinned Hawk, a rather small, swift-flying hawk, is the only one found at all regularly here, which merits destruction. Persons who discriminately shoot every hawk or owl that they can get at are extravagant to say the least.

(e) All the snakes are useful. The only one that has any serious faults is the rattler. Even they do much good, and exceedingly rarely do any damage. However, they are rapidly approaching extinction.

2. GREGARIOUS OR VERY ABUNDANT ANIMALS.

(a) The *prairie dog* is not abundant in these four counties. We saw but a half dozen small towns. The poisoning of these pests is comparatively such a simple task that no one need have a town near his land unless he is too lazy to get rid of it. Large towns have been entirely destroyed by one application of poisoned food done properly and at the right time.

The poisons found most satisfactory, and recommended by the Biological Survey of the Department of Agriculture are (1) Sulphate of strychnine. Care should be taken to secure *strychnine sulphate* since the strychnine usually sold by druggists is insoluble in water. One and one-half ounces of strychnine sul-

phate to a bushel of grain is sufficient. The strychnine should be dissolved in 2 1-2 gallons of water by heating in a covered receptacle. After thoroughly dissolved, add the grain and allow to stand over night. The grain will absorb the liquid. In distributing the grain, one-half teaspoon full should be put just outside of each hole, and had better be distributed during the evening hours.

(2). One ounce of strychnine sulphate dissolved in one gallon of water mixed with green alfalfa or green, growing grain cut in lengths of 2 to 4 inches and distributed in the evening so that it may be eaten before it is dried by the sun, is usually entirely successful.

(3). Crude bisulphide of carbon suitable for killing burrowing animals costs about 8 cents per pound in 50 pound carboys or drums. It is a volatile liquid and hence should be kept tightly corked. It is highly explosive. A tablespoonful of crude bisulphide should be poured in a piece of dried horse manure, corncob or other absorptive material and this should be thrown as far as possible down a burrow into which a prairie dog has just disappeared. The burrow should be immediately closed. Bisulphide can be used to best advantage after a heavy rain.

It should be clearly understood that the method recommended consists of two steps—(1) to destroy the great bulk of the inhabitants of the colony by poisoning with strychnine in winter or early spring when food is scarce; (2) to kill the remaining animals with bisulphide of carbon. In this way it is believed that colonies of any size may be wiped out at a total cost of not to exceed 16 or 17 cents per acre, probably less.

(b). *Gophers*. The carbon bisulphide method of killing prairie-dogs can be applied to gophers. Trapping and digging-out as well as shooting is very much more simple with gophers than with the prairie dogs, and is usually sufficient. We found the gophers to be far less abundant in these counties than further east, in Iowa for example.

(c). *Rabbits* are chiefly destructive to young fruit trees and gardens. We heartily recommend that anyone setting out an orchard or garden to first have it fenced with a rabbit-proof fence.

(d) *Wild Mice* are caught in baited traps even more easily than the house mouse. Of course, the best way to keep down the mice in the fields and meadows is to allow hawks, owls and snakes to be unmolested.

(e). *Blackbirds, crows, magpies, and jays* are all highly useful during the most of the year. Occasionally they are troublesome for short periods. At such times it is recommended that they be frightened away rather than killed.

(f) *Grasshoppers* are abundant but ordinarily not destructive. It is occasionally worth while to soak binding twine in tar.

(g) *Striped potato beetles* can usually be controlled by proper application of Paris Green. Since the few individuals which winter are the ones which multiply sufficiently to cause the trouble, it is good economy to go over the patch shortly after the potatoes are up and to kill these adults before they have laid eggs. If clumps of yellow eggs are observed on the lower side of the leaves they ought to be destroyed. During a hot day this can be most delicately done by picking off that portion of the leaf and allowing it to dry up. The bur-tomato, or buffalo-burr thistle (*Solanum rostratum*) is frequent in this era, especially on deserted ground. This plant is fed upon by the potato beetle, which by its means can exist long distances from potato fields. Since these plants are easily killed, the wide awake farmer, and the one who endeavors to save himself future work will cut down all available plants of this species. This plant, by the way, is the original food plant of the potato beetle (*Leptinotarsa decimlineata*). Until the cultivated potatoes were introduced into its range, this beetle was found only occasionally, as we found it, on the scattered *Solanum rostratum*.

3. PARTICULARLY USEFUL ANIMALS.

(a). *Insectivors*: All birds feed their nestlings upon insects, worms or other soft animal food. Most birds subsist almost totally upon insect life during the summer months. Almost all birds in summer time, especially the so-called song birds are useful and many are so highly useful as to be almost invaluable. Every farmer can well afford to put himself out to encourage the birds. In many treeless localities a clump of trees or a plum thicket would attract them. It is an excellent plan to place water

ing this, Epsom salts may be given (mature cattle dose—1 pound; calves, 2 oz.; horses, 8 oz.; sheep, 4 oz.). Animals chronically locoed in addition need a remedy to overcome nervousness. For horses arsenic in the form of Fowler's solution (4-6 drams) given in the grain or drinking water is effective after a considerable time, usually more than a month. Cattle respond best to hypodermic injections of exceedingly small daily doses (3 or 4 twentieths of a grain) of strychnine. Locoed cattle are easily killed by doses which would be considered small in ordinary veterinary practice. It is usually necessary to treat cattle for thirty days or more.*

On the principle that an ounce of prevention is worth a pound of cure, careful stock men will keep their stock out of pastures badly infected with loco until the grass has started well in the spring, and at other times when the grass is short. It is not a difficult plan to kill the loco plants—chopping them off just below the ground is sufficient.

(b). *Poison ivy*. This low, three-leaved shrub is found in the woods and upon north-facing hill sides and about the buttes. The leaves resemble those of the boxelder. The poisoning is caused by a nonvolatile oil and is not spread by the blood. It causes swellings, itchings, and finally, in bad cases, running sores. The oil is readily dissolved and can be washed off by 50-75 per cent alcohol. If all the sugar of lead (Lead acetate) which will be readily dissolved be added to weak alcohol a cure can be secured as a result of several applications a day for a few days. Applications of castile soap are beneficial.

(c). Snow-on-the-mountain. (*Euphorbia marginata*). Honey made from the flowers of this plant is hot and disagreeable to the taste and causes vomiting and purging. The milky juice of this plant may cause skin eruptions similar to those produced by poison ivy. This blistering is, in fact so decided that a few stock raisers in Texas use the juice to brand cattle, it being held by them to be superior to red-hot iron for that purpose, because the scar heals more satisfactorily.**

*These notes on the treatment of locoed stock are taken from Farmers Bulletin 380 U. S. Department of Agriculture.

**According to Farmers Bulletin 86.

6. PLANTS USED IN MEDICINE.

Quite a variety of plants which are used in medicine and for which, under proper conditions, have a market value, occur in these counties. For directions concerning collecting, as well as description, price, etc. see Farmer's Bulletin 188 U. S. Dept. of Agriculture which can be secured free of charge through your Congressman or Senator. A list of the plants treated in this bulletin which are found somewhat commonly in these counties as follows.

Tansy (*Tanacetum vulgare*).

Gum plant (*Grindelia squarrosa*)

Boneset (*Eupatorium perfoliatum*)

Yarrow (*Achillea millefolium*).

Fleabane (*Eriogeron* [*Leptilon*] *canadensis*).

Wormseed (*Chenopodium ambrosioides*, etc.).

Mustard (*Brassica nigra* and *Sinapis alba*).

At least three other species not mentioned in Farmer's Bulletin 188, of considerable medical importance are common in this area.

Smooth Sumach (*Rhus glabra*) (dried fruit).

Oregon grape (*Berberis aquifolium*) (Rhizoms and roots).

Slippery elm (*Ulmus fulva*). (inner bark).

7. PLANTS AS SOURCE OF FOOD.

The chief wild fruits are (1) the *plum* found in thickets along all wooded velleys (2) *chokecherry* found with the plum and especially abundant and large in the sand hills (3) *sandcherry*, abundant in the sandhills and occasionally on buttes, etc. (4) *buffalo-berry* found in thickets along streams, especially in the badlands (5) wild *goose-berry* and *currants* along the flood plains and in the woods, (6) wild *grapes*, plentiful in sand hills and common in woods, (7) a few *raspberries* occur in the sand hills. (8) The June or *service berry* occurs scattering in brush throughout the counties.

Herbs used somewhat for food include the Indian Turnip (*Psoracla*), ground cherry (*Physalis*), and night shade (*Solanum*).

8. PLANTS AS SOURCES OF WOOD.

Pine timber of local value occurs on the rougher lands, buttes, etc. Valuable cedar thickets are found here and there in the

badlands, both on the sides of the larger buttes and locally in the valleys. Oak is quite abundant but of small size in the two eastern counties. A good share of Bennett County is without trees. In each of the other counties, groves of ash, boxelder, cottonwood, etc. sufficiently large to furnish fuel and much fence material and even small amounts of lumber occur.

9. WEEDS.

In the regions weeds are not abundant. This is due mainly to the dryness. Most weeds require more water than is available. An additional reason is that as yet but few weeds have been introduced and established. Fields almost perfectly free from weeds are not infrequently met with.

SUMMARY OF BULLETIN AND CONCLUSIONS

Mellette, Bennett, Todd and Washabaugh Counties located in south western South Dakota are being opened for settlement. The first two were opened in 1911; Todd County in 1912 and Washabaugh will probably be opened in 1913. About one-fourth of this would be classed as rough land, about one-fourth as smooth and the rest as rolling. The soils vary but most of the region has an excellent loam soil. In regard to rainfall these counties probably fare better than nearby ones, except to the east. However the rainfall is periodically deficient. The Indians have selected much of the choicest land, but here and there an excellent piece has been left vacant. Even the less desirable areas are good mixed farming or grazing land. Indian lands can be rented at a reasonable rate. In a few years much of their land can be purchased. At present these counties are not very accessible to railroads, but extensions of the Northwestern railroad are expected soon.

The agricultural success of the eastern part of the old Rosebud Reservation (Gregory and Tripp counties) has been phenomenal. These counties increased 600 per cent in population in the last decade. We expect a prosperous future for these four counties.

The State Survey

(Extract from the last biennial report of the State Geologist)

What the Geological and Natural History Survey of the State has accomplished and what it proposes to do is of vital interest to the people of South Dakota.

South Dakota is rich in her natural products; far more wealthy than some of us think. Too rich she is not to make a larger use of her minerals. To the people of this state belong these treasures. It is the duty of the survey, not only to discover such deposits, but also to investigate them so that they will add to the material prosperity of all the people of this commonwealth. The earlier they are made accessible the more valuable they will be.

Another important work of the survey is in answering the hundreds of letters received asking advice on such matters as soils, climatic conditions, well, or the value of deposits, samples of which are sent for examination. There is no doubt but that citizens of South Dakota could annually expend in fees to outsiders a larger sum than the total appropriation for the survey, for such advice if there were no survey to advise them free of charge.

Two years ago a report of its work was widely published by the press of the State. Since that time the Survey has been engaged as extensively as funds would permit.

I. FIELD WORK.

1. DURING 1910.

The investigations were, in the main, confined to Harding County. As in 1909 the coal received the most attention. The coals seams were carefully examined as to; (1) location, (2) thickness, (3) quality, (4) general accessibility.

There are few subjects more important to the people of our State than the one of cheap fuel. The Survey is anxious that all that there is be known of the lignite coal of South Dakota should be available for all the people of our state.

Another important object was to make a collection of the summer plants of the region, as well as to take notes on the various animals. The collecting of animals was greatly handicapped by the lack of funds.

The party consisted of: Barthold Iverson of Clay County, Stephen Sargent Visher of Sanborn County, William Pipal of Montana, F. D. Fromme of Brookings. The State Geologist was with the party for a portion of the time.

Mr. Iverson found that good seams of lignite coal underlie much of the area, and outcrop along the larger streams and about the buttes, especially the Slim Buttes and Cave Hills. Seams of from seven to ten feet thick are not infrequent, and some even thicker occur. However, due to the general absence of a rock roof, tunneling cannot be cheaply done. The lignite's propensity to slake to a powder further decreases its present commercial value. Methods will doubtless be devised to overcome the first objection, just as briquetting is the second, so that some day this coal will be very valuable, since it burns readily after once started, and gives much heat. Practically everyone of this area burns the lignite, since it is more convenient and cheaper than wood. In most places it can be had for the digging and hauling, or at most, for two dollars a ton, loaded in your wagon.

Mr. Visher found the biology of Harding county to be more interesting than expected. Over 150 kinds of birds were met with, several of which had not previously been found in the State. More than 400 sorts of plants were collected, showing that this county, because of the forested buttes, is as well favored in regard to variety of plants, as many of the more eastern counties.

3. FIELD WORK IN 1911.

During the month of June Mr. Visher re-visited, on his motor cycle, Harding county and considerably supplemented the herbarium collection. Several geological problems were cleared up.

Also during June, H. E. Lee of Pierre completed excellently the mounting of a small number of birds and a coyote for the museum. The Survey also procured, through Mr. Lee, for the museum a considerable collection of archeological relics of the Aricharee Indians, which formerly dwelt near the present site of Pierre. This collection, dug from the mounds and with every

specimen labeled and accompanied by scientific notes is a noteworthy addition to the museum.

July and August were occupied in making a reconnaissance examination of the Pine Ridge Reservation and adjacent areas. We were fortunate in securing several excellent fossils from the Badlands, a fine series of photographs, a large collection of plants and many birds, insects, etc., for the museum. The members of this party were S. S. Visher of the State University, R. W. Chaney and A. B. Helms. The state geologist was in the field a portion of the season.

The examination of artesian well conditions was continued for the Survey by B. A. Iverson, who also as a representative of the state geologist, accompanied Governor Vessey and party on an automobile trip into the northwestern part of the state to guide them to the best outcrops and mines of lignite coal.

II. PUBLICATIONS OF THE SURVEY.

The most important publication of the Survey is its bulletins. Bulletins I, II and III are out of print. Bulletin IV may still be obtained upon request. The chief articles of this bulletin are:

1. Preliminary Report on the Geology of Northwest Central South Dakota—Professor J. E. Todd, former State Geologist.
2. Preliminary Report on the Geology of Gregory and Tripp Counties—State Geologist.
3. Lists of the birds, mammals and plants of the old Rosebud Reservation—A. B. Reagan and Sheridan Jones.
4. Drainage in South Dakota—Professor A. B. McDaniel, University of South Dakota.

The chief publication since the last biennial report is Bulletin V. It contains the following articles:

1. A Report on the Geography of Mellette, Washabaugh, Bennett and Todd counties, recently portions of the Pine Ridge and Rosebud reservations.
2. A Preliminary Report on the geology of this area by the State Geologist and S. S. Visher.
3. A Preliminary Report on the biology of this area by Stephen Sargent Visher.

Newspaper publications: Brief, simple, though scientific accounts of the various regions examined are sent to the papers

from time to time. Within the past year accounts of the recently opened counties of Mellette and Bennett, and an account of Harding county were widely published.

III. WORK TO BE UNDERTAKEN.

There are a number of investigations that the Survey should soon make for the people of our state. Among these may be mentioned: 1.—The collecting and proper mounting of the types of fauna and flora. The longer this work is delayed the more difficult it will be to procure the needed specimens. A sum expended now in the biological work of the Survey will accomplish much more than even a larger appropriation will in a few years hence.

It is the ambition of the Survey, not only to locate and discuss and put to the service of the people the economic products of the State, but also to form a good working museum, where there will be found, in usable condition, the type fauna and flora of South Dakota. We are certain that everyone, especially teachers and students, will be interested in seeing a large and complete collection of the mammals, birds and insects, trees, wild flowers and grasses, all properly mounted and described.

It is well known that the surveys of our neighboring states have published educational bulletins concerning the animal and plant life of their respective areas. No one questions the value of such publications, nor doubts the propriety of extensive appropriations made for such purposes. South Dakota as yet has no such reports. The people of our state not only need, but are frequently requesting this information, and they should have it.

2.—The fuel products of the State. The investigation of the coal should be completed. A study of our gas supply should be thoroughly pursued until its extent and usefulness are known.

3.—The clay, cement and building material of the State should be carefully studied. These are valuable resources.

4.—The artesian water supply. Too much emphasis cannot be placed upon the importance of our artesian wells. No fact is better known than that the flow of water is decreasing in many of these wells. If the decrease in pressure is due to the loss of water, this must be caused by one of the following reasons: (1) Drainage into rivers which have cut down into the water-bearing stratum. (2) Loss of water at the artesian wells. It seems probably that the very sudden decline in the flow of our wells is due

to loss at the wells. This loss may be either through the pipe at the surface or around the pipe below the surface into porous beds. The whole problem of our artesian wells should be carefully studied by our Survey in order that proper precautions may be taken to conserve this great resource. If careful investigation shows that the amount of water escaping through the tube at the surface is quantitatively important, laws regulating the size of wells and the flow of water must be passed and enforced. At present not more than 2 per cent of the water supplied by the artesian wells is used. However, if investigation proves that much more water leaks into porous beds below ground than escapes at the surface, then great efforts will have to be taken to save our artesian well supply, since leaks usually become larger and larger. That there be no hole around the pipe through which water can escape will have to be required by law. At the time of the first piping of new wells, proper precautions can easily be taken. Methods for the stopping of leaks in the older wells will have to be devised. That we have been careless in the past concerning our artesian wells, the greatest mineral product of the eastern part of the State, is evident to all. The time for action has certainly come if this great resource is to be shared with our children.

FUNDS NEEDED.

The Survey expects to publish three bulletins during the coming year: Bulletin VI. on the Geography, Geology, Biology and Coal Resources of Northwestern South Dakota, especially Harding and Perkins counties; Bulletin VII., a preliminary report on the birds of South Dakota; Bulletin VIII., a revised "List of the Plants of South Dakota." Several papers which could be incorporated in a fourth bulletin, on the Badlands, are in hand. Three bulletins can scarcely be published and distributed gratis for less than twelve hundred dollars.

The legislature appropriated \$3,000 for the past biennial period. In consideration of the work which ought to be done and the reports now awaiting publication, we feel that the appropriation for the coming period should be at least \$2,000 a year. If all the problems outlined above are to be advantageously undertaken a larger fund will be required.

The policy of the Survey is to do things which will be of the greatest possible use to the largest number of our people. A State Survey exists, not for the few, but for the many. Its work is not only utilitarian, but educational. Its aim is not only to further industries, but to advance knowledge. That it may be of the greatest value to our State, the Survey solicits the hearty cooperation of all the citizens of South Dakota.

Address all communications to

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INDEX

Numbers refer to pages. Italic numbers refer to pages of lists of species. Italic words are Scientific names.

A	Page		Page
<i>Acanthis</i>	117	Rosebud sand	34
<i>Accipiter</i>	114	Pierre clay	36
<i>Accrates</i>	81, 101	<i>Anas</i>	111
Aceraceae	98	<i>Andropogon</i>	38, 36, 67, 73, 87
<i>Acerotherum</i>	48	<i>Anemone</i>	93
<i>Achillea</i>	77, 129	Animals, list of conspicuous ...	
<i>Acnida</i>	92	.....	68, 73, 74, 77, 78, 81, 83
<i>Actitis</i>	113	<i>Anlocara</i>	122
<i>Acuan</i>	95	<i>Anogra</i>	100
Adaptations of life,		<i>Anthus</i>	120
Of steppe	68-72	Antilope	
Of woods	76	speed of	64, 68, 71, 78
Badlands	79	<i>Antilocapra</i>	78
Sand hills	81	Ants	68, 75
Marshes	83	<i>Antenteria</i>	77
<i>Aemacodera</i>	122	<i>Apios</i>	97
<i>Aeronautes</i>	115	Apples, Thorn	95
<i>Ageneotettix</i>	122	<i>Apocynum</i>	77, 101
<i>Agrimonionia</i>	94	Aquatic life, characteristics of... 83	
<i>Agropyron</i>	33, 36, 67, 73, 87	<i>Aquila</i>	114
<i>Agrostis</i>	73	<i>Aragalus</i>	96
Alfalfa wild	67, 96	<i>Archibutes</i>	114
Alismaceae	85	<i>Ardea</i>	112
<i>Alisma</i>	85	<i>Argemone</i> ...80, view of opp. 76, 93	
<i>Allocarya</i>	102	Arikaree beds	32, 53
<i>Allionia</i>	92	<i>Artistida</i>	67, 86
<i>Allium</i>	67, 70	Artesian wells	58
<i>Alopecurus</i>	86	<i>Artemesia</i> ...67, 69, 70, 73, 78, 108	
<i>Alpha</i>	122	Artiodactyla in Chadron beds... 47	
Amaranthaceae	92	<i>Asclepias</i>	101, 102
<i>Amaranthus</i>	69, 92	Ash	74, 75, 101, 130
<i>Ambrosia</i>	107	<i>Asio</i>	114
<i>Amelanchier</i>	75, 95	Association ecological, steppe..66-84	
<i>Ammi</i>	101	Wire-grass	68
<i>Ammidramus</i>	117	Bunch-grass	68
Ammonites, in Pierre shale	44	Short-grass	68
Amorpha	67, 80, 82, 96	Wheat-grass	68, 73
Amphibians	65	Aspen	75
Anacardiaceae	98	Aster, View of opp.74,67,70,73,81,106	
Analyses, mechanical, of soils,		<i>Astragalus</i>	67, 196
Rosebud loam	32	<i>Astrya</i>	75
		<i>Astragalinus</i>	117

	Page		Page
<i>Atherapagon</i>	86	Rasp.	129
<i>Atriplex</i>	73, 78, 92	Service	129
B			
<i>Bacopa</i>	104	Betulaceae	90
<i>Baculites</i> in Pierre shale	44	<i>Bidens</i>	82, 83, 107
Badger	68, 71	Biological Survey, U. S.	121, 123
<i>Badlands</i> ,		Biology,	
Photos of, incipient, opp.	20	A report by S. S. Visser. .	161, 130
Of Cottonwood and Bear Creeks		Of the past	63, 64
opp.	22	Biologic associations	65, 84
Banding, opp.	45	Birch trees in Dakota epoch .	54, 90
Flats, opp.	45	Bojón Hills	56
Erosion, opp.	47	Birds of the Cretaceous period	55, 63
Dyke and vein in opp.	48	Of Tertiary	63
Shales of, opp.	49	Number of	65
Re-worked materials in, opp.	51	Of the plains	68
Surface features, opp.	52	Characteristics of Plain birds	72
Skulls if common fossils of, opp	55	List of	109, 121
Terraces in, opp.	53	Bison or Buffalo	64
Location of	18	Bittern	83, 112
Definition, causes, etc.	19, 20	Bitter-sweet	74, 76, 98
Vegetation of	20, 72	Blackbirds	83, 111, 116
Ecology of	77-97	Black Hills, origin of	56
Birds of	110	<i>Blarina</i>	74
<i>Bahia</i>	107	Blazingstar	67, 69, 81, 105
Barbour, E. H., quoted.	50, 51, 52	Blowouts, Photo of,	opp. 17
Barite	60	Blue-bell	77, 105
<i>Bartramia</i>	113	Bluebird	77, 111, 121
Bat	74, 79	Bob-cat	78, 79
<i>Batrachium</i>	82, 93	Bobolink	73, 116
Bayonet, Spanish	80	Bobwhite	113
View of opp.	70	Boebera	107
Bear	64	<i>Bombycilla</i>	119
Beard-tongue	104	Boneset	105, 129
Beaver	83	Boraginaceae	102
<i>Beckmannia</i>	86	<i>Botaurus</i>	112
Bedstraw	76, 105	<i>Bouteloua</i> , on Rosebud loam.	33
Beech trees in Dakota epoch. .	54, 90	On uplands	67
Bees in Cretaceous	63	Sand hills	80, 86
Bee-plant	67, 81, 94	Boxelder	74, 75, 98, 130
Beetles, list of	122	<i>Brachystoia</i>	122
Bennett County, elevations of. .	18	<i>Brassica</i>	129
Springs in	59	<i>Braunia</i>	67, 70, 107
<i>Berberis</i>	77, 93, 129	Brome-grass	73, 87
Berry,		<i>Bromus</i>	73, 87
Buffalo	129	Brule Beds	47-49
Goose	129	Views of	opp. 45, 47, 49
		Geologic position of	45

	Page		Page
Brush, Rabbit	106	<i>Canis</i>	68
Bubo	114	Canyon, of Little White	18
<i>Buchloe</i>	87	Of Cottonwood; view in	opp. 78
Buck-bush	73, 105	Capparidaceae	94
Buffalo-berry	74, 78, 80, 112	Cap rock	16
Burr	109, 125	<i>Carduus</i>	80, 108
Building stone	60	<i>Carex</i>	82, 88
<i>Bulbilis</i>	87	Carnivora	78, 126
Bunch-flower	89	Caryophyllaceae	92
Bunting, Lark	68, 72, 81, 110, 118	<i>Castor</i>	83
Snow	117	Catbird	75, 111, 120
Buprestids	122	<i>Cathartes</i>	113
Bureau of Soils, U. S., work of	13, 31	Cat-tail	82, 83, 85
Bur-reed	82, 85	Cedar	75, 76, 78, 84, 129
Bur-tomato	73, 78, 104, 125	Celastris	74, 76, 98
Bush,		<i>Celtis</i>	74, 91
Buck	73, 105	<i>Cenchrus</i>	80, 85
Rabbit	106	Cenozoic formations	45-54
Salt	29	<i>Ceryle</i>	115
Skunk	74, 98	Chadron beds	46, 47
Butte,		<i>Chactochola</i>	85
Views of	opp. 15, 53	Chamberlain, S. D.	57
Eagle Nest	15	Chaney, R. W., of 1911 party	13
Three Point, section of	43, 49, 51	<i>Chatcophora</i>	122
Origin of	15, 16, 17	<i>Chamaecybe</i>	98
Birds of	110	Chalk, Niabrara	54, 55
Sheep Mt.	13, 15, 56	Chara, geologic importance of	16, 82
Bigfoot	15	<i>Chariessa</i>	122
Cedar	15, 56	Chat	75, 111, 120
Porcupine Peak	49	Chenopodiaceae	91
Rattlesnake	49	<i>Chenopodium</i>	73, 91, 92, 129
Devil's Hill	50	Cherry County, Neb., location of	14
<i>Butco</i>	114	Cherry,	
Butter-cup	82, 83, 93	Choke	74, 80, 95, 129
Buzzard	78, 113, 110	Ground	103, 129
		Sand	80, 95, 129
C		Chickadee	75, 77, 110, 120
Cactus	67, 69, 99, 110	Chicken, Prairie	113
<i>Calamovilfa</i>	38, 80, 86	Chipmunk	74, 77, 78, 79
<i>Calamagrostis</i>	73	<i>Chondestes</i>	117
<i>Calamospiza</i>	118	<i>Chordeiles</i>	113
<i>Calcarius</i>	117	<i>Chrysochus</i>	122
Calcedony	60	Chrysmelids	122
Calcite -sand crystals	50	<i>Chrysothamus</i>	78, 106
<i>Calochortus</i>	76	View of	opp. 66
Camas	67	<i>Chrysopsis</i>	80
<i>Campanula</i>	77	Cicadas	75

	Page		Page
<i>Cicendela</i>	79	Along streams	74, 75
<i>Cicuta</i>	101	Views of	opp. 61, 130
<i>Circaea</i>	100	Cowbird	68, 110, 116
<i>Circus</i>	114	Coyote	66, 68, 71, 78, 81, 123, 126
<i>Citellus</i>	68	Crane,	64, 112
Clay	60	Crane's bill	97
Pierre	35-38	<i>Crataegus</i>	76, 95
Cleavers	76, 105	Creeks,	
<i>Clematis</i>	74, 93	Black Pipe	17, 18
Clemantine	74, 93	Bear	17, 18, 46
<i>Cleome</i>	67, 81, 94	Views in	opp. 11, 22, 47, 75
Climatic conditions in this		Cottonwood, views in	
region	20-30	.....	22, 45, 49, 50, 53, 75
In geologic past	54, 55, 56, 58	Caven	46, 75
Of the plains	66	Pass Creeek	17, 18, 60
Grassy plats	72	Eagle's Nest	46, 75
Groves	74	Medicine-root	46
Woods	75	Minnechaddusa	17, 58
Badlands	76	Oak	17, 59
Sandhills	79	White Thunder	59
Marshes	81	Creeper, Virginia	76, 99
Clovers, prairie	67, 97	<i>Cremastus</i> ,	122
Four leaved	84	Cretaceous formations.....	43, 45
Coal	111, 112, 83	Period	54
<i>Coccyzus</i>	115	<i>Cristalella</i>	94
Coffey, G. N., in charge U. S.		Crocodiles in Chadron beds	47
Soil Survey of area	31	Crops, suitable for Rosebud	
<i>Colaptes</i>	115	Loam	33
<i>Colinus</i>	113	Rosebud sand	35
<i>Cocloglossum</i>	82	Pierre Clay	36
Colorado epoch	54	Crossbill	117
Commelinaceae	89	<i>Crotalus</i>	68, 78
Compositae,		<i>Croton</i>	97
Views of	opp. 66, 74	Crow	116, 125
In Tertiary	64	Crystals, sand-lime, at Devil's	
On plains	67, 69, 105	Hill	50
Concretions, in Rosebud loam....	31	Cuckoo	115
In Pierre Shale	44	Curlew	113
Cone-flower	69	Current, wild	74, 94
Convolvulus	152	<i>Cuscuta</i>	102
Convolvulus lulaceae	102	<i>Cyanocephalus</i>	116
Copepoda	82	<i>Cyanocitta</i>	116
Corkscrews, Devil's	51, 52	<i>Cymopterus</i>	67, 70
<i>Cornus</i>	75, 80, 101	<i>Cynomys</i>	68, 73
<i>Corvus</i>	116	Cyperaceae	88
Cottonwood trees,		Cyprus	88
In Dakota epoch	54		

D	Page
Dactyloctenium	122
Daemonelix	51
Dakota Sandstone	54, 59
Epoch	54, 63
Dagger, Spanish	76, 80
View of	opp. 70
Dapila	112
Darton, N. H., quoted	53
Deer	78
Dendroica	119
Diabrotica	122
Dickeissel	118
Diptera	122
Dissosteria	122
Disporum	76
Distichlis	82
Divides	16
Dock	91
Dodder	102
Dog, Prairie	68, 71, 73, 123
Dogwood	75, 80, 101
Dogbauc	77, 101
Dolichonyx	116
Dove	75, 111, 113
Drainage, the	16
Drupaceae	95
Drymocallis	94
Dryobates	115
Ducks,	64, 111, 112
Duck-weed	88
Dune sand	38-39
Dyke in badlands, view of opp. . .	47

E	
Earth, Fuller's	60
Eatonia	87
Ecological formations or associa-	
tions	65-84
List of	65
List of	110
Elder, Marsh	107
Elaeagnaceae	100
Eleocharis	88
Elcodcs	122
Elevations, table of	18, 19
Elk	64

	Page
Elm	18, 74, 75, 90, 129
Elymus	74, 88
Empidonax	116
Eocene period	55
Epicanta	122
Epilobium	81, 100
Eptesicus	74
Epitrogus	122
Equesetum, geologic importance	
of	16, 84, 82
Equus beds	54
Equesetaceae	84
Erigeron	74, 81, 106, 129
Eriocoma	86
Eriogonum	77, 80, 110
view of opp.	70
Erismatura	112
Erogrostis	80
Erosion, views of, in badlands	
opp.	47
Erysimum	61, 93
Eucoila	122
Euphorbia	70, 74, 78, 80, 98
view of opp.	66
Euphorbia poisoning	128
Eupatirum	105, 129
Eutamias	74, 77, 78

F

Falco	114
Falcon	77, 78, 79, 110, 111, 114
Fagaceae	90
Felis	78
Ferns	84
tree of	64
Ferret	73
Festuca	87
Fiber	83
Figs, in the Dakota epoch	54
Figwort family	104
Filix	84
Flax, wild	67
Flats, grassy	72
Fleabane	106
Flies, in Cretaceous	63, 84
dragon	84
damsel	84

	Page		Page
May	84	Goldenrod	106
Flicker	75, 115	Goldfinch	117
Flora of Cretaceous, Tertiary ...	64	Goosefoot family	91
Flows, artesian	59	Gooseberry	94
Flower, Carrion	89	Gopher	68, 71, 77, 124
Bunch	89	Grackle	117
May	89	Gramineae	85
Wall	83	Grape, wild	74, 99
Flycatchers	116	oregon	77, 93, 129
Food, Wild Plant,	129	Grass	
Fort Meade, S. D. precipitation at	25	Beard	85
Fossils, photos of skulls of opp...	55	Blue joint	38, 67, 73
in Brule formation	48	Blue stem	85
in Pierre Shale	44	Brome	73, 87
in Chadron	47	Buffalo	67, 69, 87
Four-o'clock	92	Bunch	80
Fox Hills formation	45, 55	Cord	86
Fox-tail	85	Devils	86
<i>Fragaria</i>	94	Drop-seed	86
<i>Fraxinus</i>	74	Family	85
<i>Froelichia</i>	92	Foxtail	86
Frost, dates of killing	29	Gama	33, 67, 69, 80, 86
Fuller's Earth	60	Hair	80
		In the Dakota epoch	54
		in Tertiary	64
		Marsh	86
		Millet	80
		Needle	67, 80, 86
		Origin of	55
		Of the plains	67
		Pigeon	85
		Redtop	73
		Rice	86
		Sand	38, 80, 86
		Salt	82
		Sand-bur	80
		Slough	86
		Spear	86
		Spike	87
		Spring-jointed	87
		Star	67
		Squirreltail	87
		Switch	73, 85
		Three Awn	86
		Tickle	85
		Turkey Foot	85
		Wheat	33, 36, 67, 69, 81

G

<i>Galium</i>	76, 82, 105
<i>Gallinago</i>	112
<i>Gastrophilus</i>	122
<i>Gaura</i>	67, 70, 100
Geese	126
Geography of the area.....	14-30
<i>Geomys</i>	68
Geological Formations,	
map of	43
chart of, general opp.	54
sections of	42, 43
<i>Geothlypis</i>	120
<i>Greanium</i>	97
<i>Gerardia</i>	82, 104
Gering beds,	53
Gidly, J. W. fossil collecting by..	53
Glaciation	57
Glaciated regions, subsoils of....	40
<i>Glycyrrhiza</i>	96
Godwit	113
Gold	60
Golden-aster	81, 106

	Page
Wild Rye	73
Witch	85
Wire	67, 77, 127
Grasshoppers, list of	122, 125
Grease-wood	92
Gregory County, geology of	13
soils of	33, 34, 36
<i>Grindelia</i>	67
view of, opp.	74, 106, 129
Grainwell	77, 102
Grosbeak	75, 111, 118
Ground-squirrel	68
Grouse, Prairie	64, 73, 113, 126
Grossulariaceae	94
Groves,	
Cottonwood, view of opp.	61
birds of	75, 11
<i>Grus</i>	112
<i>Guiraca</i>	118
Gulls	111
Gumbo, soil, nature of	36
Gum plant	67, 69, 129
<i>Gutierrezia</i>	69, 78, 105

H

Hackberry	74, 75, 91
<i>Hadroleptis</i>	122
<i>Haliaeetus</i>	114
<i>Harpalus</i>	122
Harrison Beds	51, 53
Hatcher, J. B., quoted	46
Hawks	114, 123, 126
Marsh	68, 110, 114
Sparrow	75, 111, 114
Hawthorn	76, 95
Hay Springs, Neb. precipitation	
at	23
<i>Hedeoma</i>	103
<i>Helianthus</i>	73, 80, 107
<i>Heliopsis</i>	107
<i>Heliotropium</i>	102
Heliotrope	102
Helms, A. B. of 1911 party	13
<i>Helodramas</i>	113
Hemp	92
Herb, willow	82, 100
Heron	112

	Page
<i>Heuchera</i>	76
Hills, relation to buttes	16
Bijou	56
<i>Hippiscus</i>	122
<i>Hirundo</i>	119
History, Geological	54-58
Hoarhound	103
<i>Holerpestes</i>	82, 93
<i>Hordeum</i>	87
Horn-beam	75
Horse-mint	103
Horsetail	82, 84
Horse, three toed	47
ancient	64
Humidity, relative tables for	30
<i>Hyerochelidon</i>	111
<i>Hylocichla</i>	120
<i>Hymenopappus</i>	77, 80, 107
Hymenoptera	122
<i>Hypericum</i>	82, 99
Hyssop	104

I

<i>Icterus</i>	116
<i>Icteria</i>	120
Illustrations, list of	7
<i>Impatiens</i>	82, 97
Indian	
View of ranch opp.	11
view of buildings opp.	13
villages	59
Reservations, limits of	13
Exploration in	13
map of	110
<i>Inoceramus</i> in Pierre Shale	44
Insects, list of species collected	122
in Cretaceous period	63
in Tertiary	64
on the plains	68
flats	72
groves	75
badlands	79
aquatic	83
Insectivora	125
Interior, S. D., Precipitation at	24
Introduction to report	13

	Page		Page
<i>Ipomoea</i>	69, 80	<i>Lepidium</i>	93
view of opp.	70	Leptauchenia layer,	48, 50
Iridaceae	90	<i>Leptinotarsa</i>	125
<i>Iris</i>	90	Leptilon	107, 129
Ironwood	75	<i>Lepus</i>	68, 77
<i>Iva</i>	107	Leslie, S. D., precipitation at ...	24
Ivy, poison	74, 76, 77, 80, 98	Lesquereux, Leo, quoted	54
Treatment for	127	Letter of transmittal	5
		Lettuce, wild	105
		<i>Leucocrinum</i>	67, 70, 89
J		<i>Liatris</i>	67, 69, 80, 105
Jay	75, 111, 116, 125	Licorice, wild	96
Joe-pye-weed	105	Life, variety of found here	65
Juncaceae	89	Light conditions on plains	66
<i>Junco</i>	118	groves	74, 75
<i>Juncus</i>	82, 89	badlands	77
June-berry	75, 95	sandhills	79
Juniper	75, 76, 78, 84	Lilacaceae	89
<i>Juniperus</i>	75, 76, 78, 84	Lily, gumbo	78, 100
		Lily, prairie	89
		Lily, sand	67
K		view of, opp.	70
Kadoka, location of	15	<i>Limosa</i>	113
Killdeer	68, 110, 113	<i>Linum</i>	67, 70, 97
Kimball, S. D., precipitation at..	27	<i>Lithospermum</i>	67, 77, 102
Kingbirds	75, 111	Lizard, Horned	72, 78
Kit-fox	68, 71	Loasaceae	99
<i>Koeleria</i>	87	<i>Lobelia</i>	105
<i>Kuhnia</i>	105	Location, of the area treated, ...	14
<i>Kuhnistera</i>	67, 81	Loco-poisoning, treatment for ...	127
		Loco weed	67, 77, 81, 96
L		Locusts	122
Labiatae	103	Longspur	67, 72, 110, 117
<i>Lachnosterna</i>	122	Loosestrife	76, 101
<i>Lacinaria</i>	67, 69, 80, 105	<i>Lophodytes</i>	111
LaCreek, S. D.,	34, 82	<i>Lotus</i>	95
<i>Lactuca</i>	108	Lousetick	100
<i>Lanius</i>	119	<i>Lucina</i> , in Pierre Shale	44
Laramie formation	45	Lupine	95
period	55	<i>Lupinus</i>	95
Lark	67, 72, 110, 115	<i>Lutra</i>	83
<i>Larus</i>	111	<i>Lycodesmia</i>	67, 69, 80, 108
<i>Lasiurus</i>	74	<i>Lycopus</i>	103
<i>Lathyrus</i>	67, 81	Lyman County, location of.....	13
Layers, harder, influence of....	16	soils of	36
views of opp.	51	<i>Lynx</i>	78
Lead-plant	67, 82, 96		
Leguminosae	67, 95		
<i>Lemna</i>	88		
<i>Lepargyraca</i>	74, 78, 80, 100		

M	Page	Page	
<i>Machacranthera</i>	106	Mice	64
Magpie	75, 111, 116, 125	deer	74
Mallard	111	jumping or kangaroo	74
Mallow,	67, 99, 100	harvest	74, 125
<i>Malvastrum</i>	67, 70, 99	<i>Microtus</i>	68, 74
<i>Mamillaria</i>	99	<i>Micropalma</i>	112
Mammals, rise of	55, 63, 64	Milk-weed	81, 101, 102
number of	65	wort	97
list of plain	68	<i>Mimulus</i>	82, 104
adaptations of	71, 83	Mineral Resources	58-60
Mann, Wm. M.	122	Mink	83
Maps,		Minnehaddusa creek, beheaded.	58
General opp.	10	Mint family	103
Geological opp.	43	Miocene formations	49-54
Local opp.	14	lower	49-53, 55
Of Pine Ridge Reservation	110	middle	56
Soil	31	upper	53, 54
<i>Marila</i>	112	Mitchell, S. D.	57
Marigold	82, 83, 107	<i>Mniotilla</i>	119
Marine formations	54, 55	Mole-shrew	74
Martin	118	<i>Molothrus</i>	116
Marshes, ecology of	81	<i>Monarda</i>	103
<i>Marselia</i>	83, 84	Monkey-flower	62, 104
Marsilaceae	84	<i>Monniera</i>	104
Mastodon	54	<i>Monroa</i>	87
Matthews, W. D., quoted	49, 53	Monroe Creek beds	53
localities studied by	52	Morning-glory, bush 69, 80, 102, 110	
May-flower	67, 89	view of opp.	70
Meadow	76	Morse, L. R.	122
Meadow-lark 68, 72, 73, 81, 110, 116		Mososaurs	55
<i>Mcibomeia</i>	97	<i>Muhlenbergia</i>	86
<i>Melanerpes</i>	115	Muskrat	83
Melanthaceae	89	Mustard	93, 129
Mellette County, elevations in...	19	<i>Myiochanes</i>	115
<i>Melonophus</i>	122	<i>Myrophyllum</i>	82
<i>Mclospiza</i>	118, 121	<i>Myzorrhiza</i>	104
<i>Mentha</i>	103	N	
<i>Mentzctia</i>	78, 99	<i>Nachyrhactus</i>	122
view of opp.	76	<i>Nautilus</i> , in Pierre Shale, note..	44
<i>Mephites</i>	68, 74	Nebraska beds	53, 56
<i>Mereolix</i>	100	<i>Negundo</i>	74, 98
<i>Merganser</i>	111	<i>Nemexia</i>	89
<i>Mesohippus</i>	47, 48	<i>Nemognantha</i>	122
Mesophytic woods	75, 81	Nestlings	72
Metamynodon layer	48	<i>Nettion</i>	111
		Nettle,	76, 91

	Page		Page
Nightshade	103	of Geologic section	11, 12
Nighthawk	68, 110	of biologic section	61, 62
Niggerhead	107	Ovenbird	75, 111, 120
Niobrara Chalk	54	Owl	68, 74, 110, 114, 121, 123
Norris, S. D., view near	17	Oxalidaceae	97
<i>Numenius</i>	113	<i>Oryzochus</i>	113
Nutracker	116	Oxytroplis	67, 70, 77, 81
Nuthatch	120		
<i>Nuttallia</i>	99	P	
<i>Nyctea</i>	114	<i>Pachylophus</i> , view of, opp. ..	70, 100
<i>Nycticorax</i>	112	<i>Pandion</i>	114
O		Panicularia	87
Oak in valley of Little White... ..	18, 74, 75, 90, 130	<i>Panicum</i>	85
In Dakota formation	54	<i>Parietaria</i>	91
<i>Occanthus</i>	122	<i>Parosela</i>	96
<i>Odontota</i>	122	<i>Paronychia</i>	92
Oelrichs, S. D., precipitation at. 25		Parsnip family	101
<i>Oenothera</i>	80, 100	<i>Parthenocissus</i>	76, 99
O'Harra, C. C., quoted. 46, 48, 51, 57		<i>Passerculus</i>	117
Oleaster family	100	Pass, Reed's	78
<i>Oligineuron</i>	100	Pasque-flower	67-70
Oligocene Period	55	Pea family	95
Olive family	101	<i>Pediocetes</i>	113
Onagraceae	100	<i>Pelecinus</i>	122
Onion, wild	67	Pelican	111
<i>Onosmodium</i>	102	Penneplains	15, 56
<i>Onychomys</i>	68	Pennyroyal	103
<i>Opeia</i>	122	<i>Penthestes</i>	120
<i>Opuntia</i>	67, 81, 99	<i>Pentstemon</i> .67, 70, 76, 77, 81, 104	
views of opp.	66	Perisho, Ellwood C., work of 5, 7, 13	
Orchid	82	report of	131-136
<i>Oreocarya</i>	102	<i>Petalostemon</i>	96
Oreodon, view of skull opp.	55	Peterson, O. A., fossil collecting	
Oreodon Beds	47, 48	by	52
Oriole	75, 111, 116	<i>Petrochelidon</i>	118
Orobanchaceae	104	Pewee	111, 115
<i>Oryzopsis</i>	80	<i>Phaco</i>	80
Osborn, W. F., quoted ... 49, 53, 54		Phalarope	112
Osier	101	<i>Phalacroptilus</i>	114
<i>Osprey</i>	114	<i>Philibostroma</i>	122
<i>Ostrya</i>	90	<i>Phlox</i>	77, 102
<i>Otocoris</i>	116	Phoebe	110, 115, 78, 79
<i>Otus</i>	114	<i>Phrynosoma</i>	78
Otter	83	<i>Physalis</i>	103, 129
Outline; of Geographic section of		<i>Pica</i>	116
report	11	Pierre Clay	35-38
		Location of	36

	Page		Page
Utilization	36-38	glaciation	57
Pierre Shale, a view of opp.	53, 55	Pliocene, beds	54
wells in	59	peneplain	56
Pierre, S. D., precipitation at.	24	Plover,	68, 110, 113, 121
Pinaceae	84	Plum	74, 86, 95, 129
Pine Ridge Reservation	13	Poison for prairie dog	123
birds of	109	Poison-ivy	74, 76, 77, 80
plants of	84	<i>Polanisia</i>	94
map of	110	Polemoniaceae	102
Pine Ridge Agency, Precipitation		<i>Polygala</i>	97
at	23	<i>Polygonum</i>	91
Pine trees	18, 75, 76, 84, 110	Polygonaceae	91
Pink Family	92	Polypodiaceae	89
Pink, Prairie	67, 81, 108	Pomaceae	95
<i>Pinus</i>	75, 76, 84	Ponds, ecology of	82, 83
Pipestem	84	<i>Poecetes</i>	117
<i>Pipilo</i>	118	Poorwill	115
Pipit	120	Popoveraceae	92
<i>Piranga</i>	118	<i>Populus</i>	74, 75, 90
<i>Pisobia</i>	112, 113	<i>Poppy</i>	81, 93
Placenticerus in Pierre Shale,	44	view of opp.	76
Plains the,	14	Porcupine	74
life of	66-72	<i>Porzosa</i>	112
see steppe		Potato family	103
Plantain	67, 82, 104	Potato-beetle	125
Plantain water	85	<i>Potentilla</i>	67, 77, 94
<i>Plantago</i>	67, 82, 104, 105	<i>Potamogeton</i>	82
<i>Planesticus</i>	120	Precipitation, comparative	20, 21
Plants,		tables of	20-28
View of conspicuous species		and crops	20, 21
opp.	66, 70, 79, 76	at Rosebud	22, 27
List of species collected	84	at Valentine	22
on plains	67	Pine Ridge	23
on terraces	73	Hay Springs	23
in groves	74, 75	Pierre	24
on buttes	77	Leslie	24
in badlands	78	Interior	24
in sandhill	80	Meade	25
in marshes	82, 85	Oelrichs	25
number of species.	65	Rapid City	26
adaptations of	68-71, 76, 78	Kimball	27
<i>Plectrophenax</i>	117	average number of days with 20	
Pleisosaurs	55	average fall various points.	28
Pleistocene, beds	54	chart of average monthly	28
peneplain	56	Prickly-Pear	67, 99
period	57	view of opp.	66
		Primrose	81, 100

	Page		Page
Primrose family	101	Redwing	116
<i>Procyon</i>	74	Regents of Education, list of	3
<i>Progne</i>	118	Report on Biology	61
Protoceras Beds	47	on geography	11-30
<i>Prunus</i>	74, 80, 95	geology	31-60
<i>Psoralea</i> ..67, 69, 70, 80, 96, 110, 127		biennial of state geologist	
Pterodactyls	55	Reptiles,	
Pterosaurs	55	sea	55
<i>Ptilimnion</i>	101	ancient land	63
Puccoon	102	number of	65, 68, 72
<i>Pulsatilla</i>	67, 93	Reservations,	
<i>Pinna</i>	64, 78	Indian, location, changes in ..	13
<i>Putorius</i>	68, 73, 83	Pine Ridge, plants of	84
		birds of	109
Q		sandhills in	38
Quail,	113, 126	Reworked materials, views of opp.	50
Quartzite, mode of formation... 41		Rhinoceras family	47
on buttes	49, 50	<i>Rhus</i>	74, 76, 77, 80, 98
<i>Quercus</i>	74, 90	<i>Rhynchophanes</i>	117
<i>Querquedula</i>	111	<i>Ribes</i>	74, 94
		Rice, wild	82, 83
R		<i>Riparia</i>	119
Rabbit, Jack ....68, 71, 81, 124, 126		Rivers,	
Cottontail		Flooding of	17
.....73, 74, 77, 81, 124, 126		Keya Paha	17
Raccoon	74	Little White	17, 18
Ragweed	107	White	17
Rail	112	Robin	120
Railroads, of the region,	14	Rock, the country	41-42
Ranching, a good range country,		Description of the commoner	
Plates 3, 12, 13, 20.		kinds of	41
<i>Ranunculus</i>	82, 83, 92	Rodents	126
Rape, broome	104	<i>Rosa</i>	94, 95
Rapid City, S. D., precipitation at 26		Roses, wild	38, 70, 94, 95
Raspberry	94	Rosebud formation, geologic posi-	
<i>Ratbida</i>	67, 70, 107	tion	45
Rattle-snake		distribution of	49
.....68, 72, 73, 77, 78, 81, 123		description of	49-52
Reagen, A. B. geological work of 13		Fossil, content of	50
quoted	43, 51, 53, 54	structure and thickness	53
<i>Recurverosta</i>	112	manner of deposition	53
Red-head	75	age	53
Redpoll	117	source of	56
Red-root	92	building stone in	60
<i>Redstart</i>	120	Rosebud artesian well, log of 42, 54	
Redstone basin		Rosebud Reservation, Limits of 13	
Views in	45, 52	Geological work in	13, 14

	Page		Page
Rosebud Agency, precipitation at	22, 27	<i>Sceloporus</i>	81
fossils near	54, 60, 75	<i>Schedonardus</i>	86
Rosebud Silt Loam soil	31-34	<i>Scirpus</i>	82, 88
Origin	32	Scrophulariaceae	104
Location	32	<i>Scutellaria</i>	103
topography	33	Sections of rock formations	42, 43
native vegetation	33	Sedge	88
utilization	33-34	<i>Sedum</i>	77
Rosebud Sandy loam soil	34, 35	Seed-eaters	126
Rubraceae	105	<i>Senecio</i>	70, 73, 81, 108
<i>Rubus</i>	94	Service-berry	75
<i>Rudbeckia</i>	107	Seton, E. E. quoted	71
Rue	93	<i>Setophaga</i>	120
<i>Rumex</i>	82, 91	Shale,	
Rushes	82, 88	Pierre Shale	43-45
Rushes, scouring	82, 84	a view of, opp.	53
Rydberg, R. A.	65, 84	Fossil content	44
Rye, wild	88	Structure	44
		thickness	44, 45
		manner of deposition	45, 55
		age	45
		wells in	59
S		Description of	41
<i>Sagittaria</i>	85	Formation of	42
Sage, wild	67, 69, 70, 73, 78, 103, 108	Benton	56
Sandhills,		Shannon county, location of	14
Description of	20, 38	plants of	84
ecology of	79	birds of	109
marshes of	81	Shanty, Photo of claim, opp.	13
views in, opp	76, 80	Sheep, Bighorn	64, 78, 79
<i>Salix</i>	75, 80, 82, 90	<i>Shepherdia</i>	100
<i>Salpinctes</i>	120	Shoveller	112
Sand-bur	85	Shrew	74
<i>Salvia</i>	103	Shrike,	111, 75, 119, 75
<i>Salsola</i>	69, 92	<i>Sialia</i>	121
Sanddunes	38	<i>Sideranthus</i>	106
in rock formation	53	<i>Silpha</i>	122
Sanderling	113	<i>Sisyrinchium</i>	90
Sand-lily	67	<i>Sitta</i>	120
Sandpipers	112, 113	Size, of the area treated	14
Sandstone,		Skull-cap	103
formation of	16, 42	Skulls of fossils, views of opp.	55
description of	41	Skunk	74, 123
<i>Sanicula</i>	101	Skunk-herb	67
Sappharine	60	Skunk bush	76, 98
<i>Sarcobatus</i>	92	Slopes, Rocky	76, 77
<i>Sayornis</i>	115	Smilacaceae	89
<i>Scaphites</i> in Pierre Shale, note.	44		

Page	Page		
Smilacina	76	State Survey	131
<i>Smilax</i>	76, 89	work of	131, 134
Snakes, value of	123	field work in 1910,	131
Snipe, Wilson	85, 112	field work in 1911	132
Snowfall, Table of depth of	26	publications of	133
Snow-on-the-mountain	128	Staff-tree family	98
Soils	31-39	Star-grass	67
types of	31	Stanley County, soils of	36
Rosebud Silt Loam	31-34	geological work in	13
Rosebud Sandy Loam	34-35	<i>Steganopus</i>	112
Pierre clay	35-38	<i>Steironema</i>	101
Dunesand	38-39	Steligidoptery	119
River bottom	39	Steppe or upland	66-72
Map of opp.	31	conditions of	66, 67
<i>Solanum</i>		animals of	68
.....	67, 73, 78, 103, 104, 125, 129	conspicuous plants of	67
<i>Solidago</i>	70, 73, 81, 106	adaptations to	68-72, 110
Solomon-seal	76, 89	<i>Steronema</i>	76
<i>Sophora</i>	95	<i>Stipa</i>	67, 80
<i>Sorex</i>	74	Stone, building	60
<i>Sorgastrum</i>	85	Strawberry, false	67
<i>Spalula</i>	112	wild	75, 94
<i>Sparganium</i>	82, 85	Stream piracy or capture	57, 58
Sparganiaceae	85	Streams, ecology of	82
Sparrow, list of	117, 118, 126	St. John's wort	82, 99
Chipping	75, 111	<i>Sturnella</i>	116
Lark	78, 110	Subsoils	39-41
<i>Specularia</i>	82, 105	origin of the local	41
<i>Spartina</i>	86	Succession, ecological, view of	
Speedwell	104	opp.	74
<i>Spenopholis</i>	87	<i>Suida</i>	101
<i>Spotyto</i>	114	Sumach	77, 98, 129
<i>Spharagemon</i>	122	Summary	130
Spider-wort	67, 80, 82, 89	Sunflower	107, 81
<i>Spizella</i>	118	Susau, Black-eyed	107
<i>Spiza</i>	118	Swallows	78, 79, 110, 118
Spiders	75, 81	view of colony of Cliff S. nests	
Sponge, fresh water	82	opp.	78
<i>Sporobolus</i>	86	<i>Symphoricarpos</i>	73, 105
Springs	59		
view of opp.	80	T	
Spurge	81, 98	<i>Tachycineta</i>	119
Squirrel	68	Talus, definition,	16
State Geologist, present, see Ell-		photo of a block opp.	15
wood C. Perisho former see J.		<i>Tanager</i>	118
E. Todd.		Tansy	129
		<i>Taraxacum</i>	108

Page	Page		
<i>Tanacetum</i>	128	<i>Troglodytes</i>	120
<i>Taxidea</i>	68	<i>Tropisternus</i>	122
Teal	83, 111	Tullsen, A.,	89, 109
<i>Telmatodytes</i>	120	Turnip, Indian	67, 96
Temperature, tables for	29	Turtles in Chadron beds	47
of the steepe	66	<i>Tympanuchus</i>	113
of the groves	74, 75	Typha	82, 85
badlands	77	Typhaceae	85
sandhills	79	<i>Tyrannus</i>	115
Terraces	56, 53, 18, 19, 20		
life of	72	U	
Tern	83, 111	<i>Ulmus</i>	74, 90
Tertiary, subdivisions of	45	Umbelliferae	101
Views of formations opp.		Umbrella-wort	92
..... 45, 47, 48, 49, 52, 53, 78		Underground water supply	58, 59
flora of	64	<i>Urtica</i>	76, 91
<i>Tetraopes</i>	122	Urticaceae	91
<i>Thalitricum</i>	76, 93		
Thickets, birds of	111	V	
Thistle, Russian	69, 91	Valentine Neb., precipitation at 22	
Western	81, 108	Rosebud formation near	53
Thrasher	75, 111, 120	<i>Vagnera</i>	76, 89
Thrush	120	Vein, in badlands, view of	48
Tick, Beggar's	107	Venus looking glass	82
Titanotherum beds	46, 47	<i>Veronica</i>	104
Titanotheres	47	<i>Verbena</i>	74, 103
view of opp.	55	Vervain	103
<i>Tithymalus</i>	98	<i>Vespa</i>	122
Toad, Horned	72, 78	Vetch, milk	81, 96
Tobacco, Ladies	77	Dakota	95
Todd, J. E., quoted.	13, 49, 56, 60	<i>Viola</i>	67, 70, 99
Todd County, elevations of.	19	Violet	67, 99
Tomato wild or bur	73, 78	Vireo	119
Topographic features, general	14	<i>Vireosylva</i>	119
Touch-me-not	82, 97	Visher, S. S., Chief of 1911 party 13	
<i>Totanus</i>	113	articles by	1-30, 31-60, 61-130
Towhee	75, 111, 118	<i>Vitis</i>	74, 99
<i>Townsendia</i>	70, 106	Vitaceae	99
<i>Toxostoma</i>	120	Volcanic ash	49, 50, 53, 55, 60
<i>Toxicodendron</i>	98	Vole	68, 71
<i>Tradescantia</i>	67, 80, 82, 89	<i>Fulpes</i>	68
<i>Tragopogon</i>	108	Vulture	28, 110, 113
Trees in valleys	18		
in the Dakota epoch	54	W	
Trefoil	95	Wall, badland	19, 56
Tripp County, Geology of	13	Warbler	75, 111, 119
soils of	33, 34, 36	Washabaugh, elevations of	18

	Page		Page
Washington County, location of..	14	Willow	75, 80
plants of	84	Willow trees in Dakota epoch	54, 82
birds of	109	family	90
Wasps	122	Wind, tables for direction and	
Waterfalls in sandhills, cause of	49	velocity	30
view of	80	on the plains	66
Waterholes	17	on buttes	76
life of	83	on sandhills	79
Waxwing	119	Wolf	68, 71, 78, 123
Weasel	68, 123	Wolf-berry	73
Weed,		Woodbine	76
Bind	91	Woods, deep	75
Carpet	98	plants of	76
Clammy	94	Woodpeckers	75, 111, 115
Fire wood	107	Wood-sorrel	97
Gum view of opp.	74, 106, 129	Wormwood	108
Horse	101	Wren, House	75, 111, 120
Knot	91	Wren Rock.....	
Milk	101	.....	77, 78, 79, 110, 111, 120
Rag	107		
Smart	91	X	
Soap	89	<i>Xanthozalis</i>	97
Tumble	69, 92	Xerophytic formations .	66-74, 76-79
Well, Artesian	58, 59	<i>Xiphidium</i>	122
depth to	59		
shallow	59	Y	
Log of the Rosebud	42, 53, 58	Yarrow	77
Whitlow-wort	92	Yellowthroat	120
White River,		Yellowlegs	113
view of valley, frontispiece;		<i>Yucca</i>	38, 76, 80
views of stream opp.	18	view of opp.	70, 89, 110
wells in	59		
importance of	17, 18	Z	
Terraces along	18, 57	<i>Zamelodia</i>	118
formations and its subdivisions	45	<i>Zapus</i>	74
distribution	46	<i>Zenaidura</i>	113
physical description	46	<i>Zizania</i>	82, 83
source of material	56	<i>Zonotrichia</i>	117, 118
wells in	59	<i>Zygodenus</i>	70, 89
building stone in	60	<i>Zygophyllidium</i>	89

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