# CHAPTER XI.

## AGRICULTURAL AND MATERIAL RESOURCES OF THE AREA OF LAKE AGASSIZ.

Agriculture must evidently be always the chief industry and source of wealth throughout the prairie portion of the area of Lake Agassiz, attended, in villages and towns, by needed branches of trade and manufactures. The great fertility of this district and its capabilities for agriculture depend largely on the character of the underlying alluvial, lacustrine, and drift formations, which in their diverse development upon different tracts give considerable variety to the soils. Beyond and above the inherent qualities of the land, its value to the farmer and herdsman is further dependent in a very large degree on the climatic conditions which are brought by the changing seasons of the year. Both these factors of agricultural prosperity had expression, before the land was cultivated or pastured, in the native flora of the country and in its former herds of elk, antelopes, and buffaloes. After the consideration of these sources, conditions, and natural evidences of the adaptation of this district for diversified and successful agriculture, the development of this industry is shown by a partly statistical review of its rapid progress in the production of wheat and other crops and in stock raising and dairying.

The more strictly geologic resources of this region are next noticed, comprising its building stone, lime, and bricks, all of which, and especially the last, have much economic importance. Mention is also given to its salt springs, lignite, and natural gas, none of which, however, occurs in such amount that it can be profitably utilized.

Lastly, the water power and other natural aids for the development of manufactures within the area of this glacial lake are considered. Some of its streams, as the Red Lake and Clearwater rivers, the upper part of the Red River before it enters this lacustrine area, and especially the Winnipeg

River, are unsurpassed in the value of their water power, which can be made uniform throughout the year by using the lakes tributary to these streams for reservoirs. Probably much of the wooded portion of the country that was covered by Lake Agassiz will be cleared and used as farming land; while the waterfalls and rapids which abound on rivers within the Archean part of the wooded district will become the sites of manufacturing villages and cities.

### VARIETY AND DISTRIBUTION OF THE SOILS.

Over nearly the entire prairie district of Lake Agassiz and upon the higher and more undulating or rolling country that stretches thence westward, a sandy clay, often with some intermixture of gravel and occasional bowlders, forms the soil, which has been colored black to a depth of 1 or 2 feet below the surface by decaying vegetation. The alluvial and lacustrine beds, or the glacial drift, the same as the soil, excepting that they are not enriched and blackened by organic decay, continue below, being usually yellowish gray to a depth of 10 or 15 feet, but darker and bluish beyond, as seen in wells. The glacial drift contains many fragments of Cretaceous shale, magnesian limestone, granites, and crystalline schists; and its fine detritus and the silty deposits carried into Lake Agassiz by its tributaries are mixtures of these pulverized rocks, presenting in the most advantageous proportions the elements needed by growing plants.

The till or glacial drift of this region is remarkably contrasted with that of New England and the other Northern States westward to the Mississippi River by its containing a smaller proportion of bowlders, cobbles, or comparatively small rock fragments and gravel. On an average the surface of the till in this southwestern part of the area of Lake Agassiz has probably not more than one-twentieth as many bowlders as the average in the States farther east. They are so few that they present no obstacle to the cultivation of the soil, except on the occasional morainic belts, where bowlders are plentiful, often strewing the ground upon limited tracts, which usually are knolly and hilly. These tracts can not be profitably subjected to tillage, but have generally a fertile soil and afford excellent pasturage. The smooth, gently undulating or nearly flat areas of till, which are far more extensive than the morainic belts, can be plowed often across a distance of several miles, bounded only by stream courses, without encountering a bowlder or tree or bush to require the plow to deviate from its straight and continuous furrow. The few bowlders which are found on these lands, seldom exceeding 3 to 5 feet in diameter and varying in numbers from perhaps one to five or ten per acre, are scarcely so many as the farmer desires for the construction of cellar walls, foundations of buildings, and for other uses.

Large portions of the deltas of Lake Agassiz, and the whole of the broad, flat expanses of lacustrine and alluvial silt which adjoin the Red River, have no bowlders nor gravel. Here the ideal conditions are found for the cultivation of single fields of grain occupying hundreds or thousands of acres. Though the subsoil of many arable tracts of the Red River Valley is saturated with moisture throughout the year at the depth of only a few feet below the surface, even these moist areas have sufficient slopes to drain away the water of snow-melting and the rains of spring in season for early sowing. While the soil of both the till and the lacustrine and alluvial deposits is prevailingly clayey, it yet is nearly everywhere sufficiently sandy and porous to permit a part of these waters and a large proportion of the summer rains to be absorbed by it. Whenever a temporary drought comes, the water thus received and stored at a moderate depth in the subsoil is raised by capillary attraction to the surface. The roots of vegetation are thus nourished, and the growth of the crops is continued without check or a bountiful harvest is often matured without the aid of rainfall during a month or more.

Some tracts of the Red River Valley are marsh, owing to the flatness of the land and the depression of these tracts a few feet below their natural avenues of drainage. The marshes vary in extent from patches of a few hundred acres up to 50 square miles.

An enumeration of the most noteworthy of these boggy, partially inundated areas in Minnesota includes the marsh, 6 miles in diameter, occupying the greater part of Winchester, Norman County, in crossing which the south branch of the Wild Rice River becomes diffused and lost, until it is gathered again on the western border of the marsh by the union of the waters of many rills, brooklets, and springs; the marshy grounds in Anthony and Halstad townships, also in Norman County, lying on each side of the Marsh River; the great swamp in southwestern Polk County, in which the Sand Hill River is lost for about 8 miles, being again formed by many brooks that flow from the western edge of the swamp along a distance of 5 miles from south to north; the Snake River marsh in Sandsville, on the north line of Polk County; the marsh in Bloomer, Parker, and Big Woods, Marshall County, in which the Middle River is lost for 5 miles next above its junction with the Snake River; and the large swamp in the northern edge of this county, extending also into Kittson County, formed by the outspread waters of the Tamarack River, which is thus lost across a distance of 8 miles.

Excavation of channels for these rivers through their marshes and for a distance of several miles below them to the depth of 5 to 10 feet below the present waterways, with the cutting of side ditches in the marshes, will drain these wet lands, which will then have a very deep and fertile soil, sufficiently dry for tillage, being doubtless the best and most enduring in productiveness among all the rich lands of this valley plain. A survey for a plan of drainage of the eastern side of the Red River Valley, lying in Minnesota, was made in 1886; and the estimate by Mr. C. G. Elliott, the engineer in charge, for the expenditure needed to provide the main ditches and to deepen the existing watercourses is $746,228. The number of acres to be benefited by the drainage is 808,600, showing an average cost of 92 cents per acre. Minor ditches, which will be dug on each side of the roads, following the section lines, are not included in this estimate.

The part of this flat valley in North Dakota is dotted here and there with many small marshes, but with very few that have so large an area as several square miles. The most considerable in size are the marsh, 2 to 3 miles across, in Berlin and Hammond, Cass County, in which the Rush River is lost; marshes adjoining Salt Lake, through which the Forest River flows in Ardoch, Walsh County; and a low meadow, mostly mown for its marsh hay, but in small part a permanent bog, extending 12 miles from south to north, with a width of a half mile to 2 miles, in the east part of Midland, Pembina County.

In both Minnesota and North Dakota these bogs are destitute of trees and shrubs, and are occupied mostly by rushes, sedges, and marsh grasses, which usually attain a very rank growth. No malarial diseases, however, are produced by the marshes in their present condition, and the principal injury to be charged against them is that they hinder or prevent the construction of roads which would be a public convenience. So long as they remain undrained, these lands are almost or quite worthless, but when well drained and brought under cultivation they will be a great addition to the wealth and resources of this fertile valley.

East of the Red River Valley, the wooded part of the area of Lake Agassiz in northern Minnesota contains frequent swamps, ranging from a few acres to many square miles in area, usually occupied by a sparse growth of tall and slender tamarack and black spruce trees, but in their central portions often destitute of trees and covered by peat mosses, in which there may be a pool or lakelet, either of clear water or filled with rushes. Extensive swamps of this kind, locally called muskegs, adjoin Red Lake, Mud and Thief lakes, the Lake of the Woods, and Roseau Lake. Indeed, they are reported as covering a large part of the country northeastward from Red Lake to the international boundary, forming a region which is well-nigh impassable excepting in winter, when the surface of the muskegs is frozen.

The vast forest region of Lake Agassiz comprised within Canadian territory has many scattered muskegs, but also much land with dry and rich soil, worthy to be cleared and cultivated, throughout all its extent from Rainy Lake and River and the Lake of the Woods northwestward by the great lakes of Manitoba to the Saskatchewan. During many years to come no attempt will probably be made to utilize the swamps or muskegs of the wooded country; but in Manitoba, as already noted in Minnesota, many of the marshes and swamps of the prairie region are being drained for agriculture. The main ditches are dug as a part of the public improvements by the Provincial Government, which is reimbursed by the sales of the marsh lands, worthless before they are drained, but afterward very valuable.

Several of the prairie marshes of Manitoba, lying west of the Red River and on both sides of the Assiniboine, range in extent from 20 to 75 square miles, namely, the marsh in which Tobacco Creek is spread out and lost east of Pomeroy; the great marsh similarly formed by the waters of the Boyne River and Elm Creek, extending 15 miles from west to east, with a width of 3 to 6 miles, overflowing southeastward to the Red River by the Rivière aux Gratias; the Squirrel Creek marsh, lying close south of the White Mud River, between Westbourne and Woodside, formed by Image, Beaver, Squirrel, Pine, and Silver creeks, which come from the northeastern slope of the Assiniboine delta; and the Big Grass marsh, extending more than 20 miles from south to north, with a width of 3 to 5 miles, in which the White Mud and Big Grass rivers are lost or flow sluggishly through a broad, quaking morass, with shallow, rush-filled lakes along its axial portion.

Commonly the water of the marshes is supplied almost wholly by inflowing streams and by rainfall, but in some instances they receive a large part of their water from springs. Multitudes of copious springs of fresh water, issuing from thick beds of sand and gravel which eastward are overlain by till, form the very remarkable boggy tract, a half mile to 1 mile wide, which extends about 9 miles from south to north along the highest shore of Lake Agassiz in Akron and Tanberg, Wilkin County, Minn. Unlike the level marshes before enumerated, this tract lies on a slope which descends 20 to 40 feet upon the width of the marshy ground from east to west. On such a slope the marsh can be maintained only by the constant issuance of spring water through all portions of its bed. (See pp. 286, 385.)

In several other marshes of smaller extent, as on the Salt Cooley and Salt River, near Ojata, tributary to the Turtle River, and on the Forest and Park rivers, it is known that saline springs come up within the area of the marshes, because, although the streams flowing into them are fresh, the outflowing water is brackish.

Throughout nearly all the part of the Red River Valley where brackish water is found by the artesian wells, and where it infrequently outflows in springs, as just noted and as observed in the channels of Two Rivers and other streams, there are noticed also occasional and rare patches of ground, usually no more than a few square rods, or at most a few acres, in extent, on which wheat, oats, or other crops, after germinating and beginning an apparently healthy growth, are soon dwarfed or killed, while closely adjoining land, sometimes scarcely distinguishable in the appearance of the soil, is yet divided from the preceding by rather definite boundaries, as shown by the healthful growth of vegetation and a satisfactory harvest. These peculiar spots fail year after year to produce any crop, and their exceptional character in fields which mainly have a bountiful growth of waving grain is a source of wonder and much conjecture to many farmers. They are very simply explainable, however, as the places to which the saline and alkaline artesian and spring water percolates upward through veins and layers of gravel and sand and somewhat porous or creviced tracts of the till and lacustrine and alluvial beds, until it comes to the surface and is there diffused through the soil of a small or somewhat large area, thus affecting vegetation, though not issuing in sufficient quantity to produce springs.

Although the bowlders of the till within the basin of the Red River are mostly Archean granite, gneiss, and crystalline schists, derived from the northeast and north, with few—probably on an average less than 1 per cent—of magnesian limestone, derived from Silurian and Devonian formations underlying the drift and outcropping northward in Manitoba, the latter forms a very considerable proportion, usually more than half, of the smaller rock fragments inclosed in the till and of the gravel in modified drift and alluvial deposits. Owing to the greater prevalence of joints in the limestone, it has been reduced more readily to the size of gravel, and it probably has contributed at least as much as the Archean rocks to the sandy and clayey matrix of the till, pulverized by the grinding action of the ice-sheet. The powdered limestone is one of the most important ingredients of the drift. Dissolved in the water of wells and springs, as noted in the preceding chapter, it makes them hard, diminishing their desirability for washing and for use in the boilers of steam engines, but not for drinking and cooking. On the other hand, this element contributes a large share toward making the very fertile soil of this district and producing the magnificent harvests of wheat which are its principal export and source of wealth.

A still larger proportion of the drift upon the prairie district of Lake Agassiz was supplied from the Fort Pierre, Niobrara, and Fort Benton shale formations of the Cretaceous series. They are mostly soft shales, however, and therefore have supplied no bowlders; nor are they usually represented conspicuously by pebbles of the till and in gravel deposits, excepting near the western border of the ancient lake, where the Pembina Mountain escarpment and plateau, the basal part of the Tiger Hills, and the Riding and Duck mountains, consist of these shales. Many streams flowing down from these highlands have cut deep ravines and valleys in their frontal escarpment, and have spread much shale gravel outward for several miles along the watercourses on the Red River Valley plain. The till or glacial drift on this western margin of the lacustrine area and on all the plateau country extending thence westward has also a considerable ingredient of shale gravel. But the greater part of the material contributed from these shale beds to the glacial drift is mingled with the pulverized Archean granite and gneiss and Paleozoic limestones, doubtless generally far surpassing these as a constituent of the finely comminuted rock flour which is the most abundant element of the bowlder-clay or till.

The portion of the till thus received from the Cretaceous beds has given to its soil the somewhat alkaline character which is perhaps the most noteworthy quality distinguishing the soil of this district and of the plains on the west, in contrast with the soil of the Northern States and Canadian provinces east of Lake Agassiz. The sulphates of magnesia and soda, with other soluble salts, together termed "alkali," which are present in considerable amount in the glacial drift of the Red River Valley and the western plains, are almost wholly due to the contribution of the Cretaceous shales to the drift. This soluble mineral matter was contained in the Cretaceous ocean, and much of it became imprisoned and stored up in the very fine clayey sediments of that time. On the areas of these shale formations beyond the limits of the glacial drift the soil is far more alkaline than within this region, where Archean, Paleozoic, and Cretaceous strata have joined in making up the drift through the grinding and kneading action of the ice-sheet

Foregoing descriptions and analyses of the waters of wells, lakes, and streams have sufficiently indicated the effects of this alkaline matter of the soil upon the water supply. At the same time, the result of evaporation from the soil during droughts, often producing on previously moist tracts a saline and alkaline efflorescence, was also noticed. Shallow and flat depressions, into which the alkaline matter is brought by drainage from higher adjoining land, thus may have many times more of the soluble salts in their soil than the average of the district; and when these tracts become dry and their moisture from a considerable depth is drawn upward and evaporated at the surface it leaves a whitish-gray alkaline incrustation. These low alkaline lands are unfit for agriculture until they have been well drained during several years, which may frequently be done by ditches only a few feet deep, leading into lower watercourses. Excepting such depressions and the marshes and sloughs before described, all the land of this district has at least the very slight slopes necessary for free drainage, and is well adapted for the cultivation of wheat, oats, and other cereals, and of the common garden vegetables and small fruits that are suited to the climate. The proportion of alkaline matter in the till soils wherever they have natural drainage is not prejudicial but rather advantageous for wheat and other grains.

Along the axial belt of the Red River Valley plain alluvial clayey silt usually borders the river to a distance of 5 to 10 miles on each side, and other tracts are covered by fine lacustrine sediments of nearly the same character, bordering the prominent delta plateaus. These areas have a somewhat porous soil, composed mostly of very fine sand or rock flour rather than true clay, being thus similar to the bowlder-clay or till; but they have a somewhat less proportion of the soluble alkaline salts, which in the process of aqueous deposition of these beds were partially removed and carried away by the rivers into the sea.

The deltas of sand and gravel, mainly modified drift washed away from the melting ice-sheet and amassed in the margin of Lake Agassiz by its tributary glacial rivers, also contain less alkaline matter than the till.

They have a large ingredient of limestone gravel, sand, and fine detritus, so that their soil is usually fertile, while the very porous subsoil permits early sowing and is favorable for the rapid growth and early maturing of crops.

The unique tracts of dunes, however, consisting of bare sand drifted by the winds, or partly or wholly covered with grasses and other herbage, bushes, and small trees, which occupy extensive portions of the Sand Hill, Sheyenne, and Assiniboine deltas, are themselves worthless for agricultural uses, and even afford only scanty pasturage. But many well-grassed patches of ground lie in the hollows among the dunes, where herds find good forage.

Probably the parts of this district that are worthless to the farmer, comprising the sand hills, the alkaline undrained depressions, permanently wet sloughs, the steep bluffs or banks of the watercourses, and very stony morainic tracts, amount together to no more than a fiftieth of the whole country. Elsewhere all this vast area is fertile and easily cultivated, with considerable diversity in the soils of its different portions, dependent on the nature of the drift, lacustrine, and alluvial formations, and on their conditions of drainage. The black soil has usually a thickness of 1 to 2 feet, this color being due to enrichment by the decaying vegetation of all the years and centuries since these deposits were formed during the Ice age and at its close.

Looking forward to no very distant time, it may be foreseen that nearly all the land here will be brought under successful cultivation, and that a farming population of probably a million people, perhaps even twice or thrice this number, will live on the prairie area of Lake Agassiz. Many of them will come as immigrants, and in their selection of this rich farming region for their future homes the most important inquiries next after those concerning the native quality of the land will relate to climate. The rainfall and the temperature not only affect very closely the health and comfort of the people, but they also determine whether the crops sown or planted in a naturally productive soil and tended with patient and faithful care shall bring forth an abundant or a scanty harvest.

### CLIMATIC CONDITIONS.

Six stations at which continuous series of weather observations have been made are here selected for the purpose of exhibiting by their records the general climatic conditions of the southwestern part of the area of Lake Agassiz, which is fast becoming occupied by a dense population engaged in agriculture. Five are stations of the United States Signal Service, namely: St. Paul, where observations were begun November 1, 1870; Duluth, also having records since November 1, 1870; Moorhead, since January 1, 1881; St. Vincent, since September 5, 1880; and Bismarck, since September 15, 1874.[1] With these are also inserted the records of observations at Winnipeg for the Meteorological Bureau of the Dominion of Canada, beginning with the year 1871 and published up to the year 1887, inclusive.

#### RAINFALL AND SNOWFALL.

At these stations, of which three are situated on the Red River, the combined amount of rainfall and snowfall are as follows for their series of years, with the resultant means deduced from each series:

*Annual and mean annual precipitation, in inches.*

| Stations. | 1871. | 1872. | 1873. | 1874. | 1875. | 1876. | 1877. | 1878. | 1879. | 1880. | 1881. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| St. Paul | 30.63 | ........ | 34.75 | 35.51 | 30.66 | 23.67 | 28.80 | 22.78 | 32.39 | 29.76 | 39.16 |
| Duluth | 31.20 | 30.12 | 38.73 | 36.43 | 26.93 | 32.27 | 34.31 | 28.09 | 45.28 | 38.11 | 37.56 |
| Moorhead | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | 29.48 |
| St. Vincent | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | 15.51 |
| Winnipeg | 20.17 | 30.17 | 17.04 | 18.31 | 16.85 | 29.18 | 24.61 | 29.52 | 25.23 | 27.17 | 18.09 |
| Bismarck | ........ | ........ | ........ | ........ | 27.52 | 30.92 | 17.68 | 20.23 | 22.61 | 19.75 | 15.76 |
| Mean for entire district | 27.33 | ........ | 30.17 | 30.08 | 25.49 | 29.01 | 26.35 | 25.15 | 31.38 | 28.70 | 25.93 |

| Stations. | 1882. | 1883. | 1884. | 1885. | 1886. | 1887. | 1888. | 1889. | 1890. | Mean annual. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Years. | Mean. |
| St. Paul | 23.14 | 26.70 | 26.11 | 25.33 | 22.89 | 25.85 | 25.86 | 16.96 | 23.38 | 19 | 27.60 |
| Duluth | 38.02 | 23.20 | 35.85 | 19.96 | 33.37 | 28.56 | 27.31 | 32.04 | 24.09 | 20 | 32.07 |
| Moorhead | 34.01 | 24.96 | 28.50 | 22.68 | 26.76 | 21.97 | 16.50 | 17.07 | 21.79 | 10 | 24.37 |
| St. Vincent | 22.48 | 17.88 | 21.81 | 16.58 | 15.04 | 18.47 | 17.22 | 14.44 | 22.09 | 10 | 18.15 |
| Winnipeg | 20.75 | 19.22 | 25.13 | 16.52 | 14.84 | 17.98 | ........ | ........ | ........ | 17 | 21.81 |
| Bismarck | 21.33 | 15.66 | 23.36 | 13.08 | 13.26 | 16.33 | 16.51 | 11.03 | 15.75 | 16 | 18.80 |
| Mean for entire district | 26.62 | 21.68 | 27.13 | 19.53 | 22.26 | 22.24 | 20.68 | 18.31 | 21.42 | ........ | 23.80 |

[1] Annual Reports of the Chief Signal Officer, United States Army. (In the year 1891 the Weather Bureau was transferred to the United States Department of Agriculture.)

The amounts of the average or normal precipitation for each month at the five stations in the United States from the date of their establishment to the end of 1886, and at Winnipeg during the fifteen years 1871 to 1885, are noted in the following table:

*Normal precipitation, in inches, for each month of the year.*

| Stations. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| St. Paul | 1.03 | 0.97 | 1.52 | 2.25 | 3.34 | 4.85 | 3.26 | 3.67 | 3.38 | 2.05 | 1.37 | 1.30 |
| Duluth | 1.06 | 1.14 | 1.56 | 2.26 | 3.74 | 5.33 | 3.90 | 3.41 | 4.53 | 2.95 | 1.79 | 1.31 |
| Moorhead | .77 | .98 | .88 | 2.38 | 3.04 | 4.47 | 4.59 | 3.42 | 2.42 | 2.77 | 1.25 | .78 |
| St. Vincent | .36 | .40 | .50 | 1.36 | 2.22 | 2.59 | 2.66 | 2.68 | 2.13 | 2.28 | .56 | .52 |
| Winnipeg | .57 | .97 | .89 | 1.56 | 2.37 | 3.62 | 2.87 | 3.08 | 1.91 | 1.51 | .86 | 1.00 |
| Bismarck | .54 | .64 | 1.05 | 2.78 | 2.91 | 3.40 | 2.28 | 2.60 | 1.24 | 1.19 | .75 | .77 |
| Mean for entire district | .72 | .85 | 1.07 | 2.10 | 2.94 | 4.04 | 3.26 | 3.14 | 2.60 | 2.12 | 1.10 | .95 |

From these tables it is seen that the mean annual precipitation of moisture as rain and snow at different places in this district ranges from 18 to 32 inches. It is most upon the wooded country east and northeast of the Red River Valley; on that valley plain its average is about 22 inches; but westward it decreases to 19 inches at Bismarck.

The most plentiful precipitation is during the season of the growth of crops, increasing, on an average for the whole district, from about 2 inches in April to 3 inches in May and 4 inches in June, which is usually the most rainy month; and decreasing to about 3 inches in July, nearly the same in August, and 2½ inches in September. But many years depart widely from these averages, there being sometimes during several consecutive years an excess and during other isolated or consecutive years a deficiency of rainfall. During the fifteen to twenty years since agricultural settlements were first made in the Red River Valley south of the international boundary, the rainfall and temperature, though showing marked contrasts in different years, have always been so favorable for farming that there has been no instance of failure on this valley plain to secure at least a generally remunerative harvest; while most of the years have yielded very abundantly.

A large portion of the rainfall is brought by thunder showers, which may occur at any hour of the day or night. Terms of cloudy and more or less rainy weather, due to broad storms that sweep from west to east, occasionally occupy one, two, or three days, or very rarely a whole week; but on the average, in all seasons of the year, this region has a large majority of clear days with bright sunshine.

In addition to the recorded rainfall, seasons that have a considerable supply of rain, with at least a moderately humid atmosphere, receive much moisture in the form of the nightly dews, which greatly help the growth of crops; but in seasons of drought, with an arid atmosphere, when all vegetation gasps for moisture, the nights condense little or no dew.

In winter the snow is commonly about a foot deep during two or three months, from December or January to March. Sometimes it comes earlier or stays later, and very rarely it attains an average depth of 2 or 3 feet. Nearly every winter has from one to three or four severe storms, called blizzards, in which the snowfall is accompanied by a fierce wind and often by very low temperature. The air is filled with flying grains of snow, by which the view to any considerable distance is obscured and the traveler finds his eyes soon blinded in attempting to move or look in the direction from which the storm comes. The earliest snows, which, however, are likely to be soon melted away, usually fall during November, but very rarely they come as early as the middle of September; and the latest snows vary in time from March to May.

During a series of years of prevailingly copious rainfall and snowfall, extending from 1871 or earlier to 1884, agriculture was partially or generally successful upon a large area reaching westward from the southwestern borders of Lake Agassiz to the Missouri River. Then a series of five prevailingly dry years, with long terms of severe drought, extended to 1889, during which the crops of that area were mostly very scanty and for large tracts were several times an utter failure, bringing great distress and dismay to the people, many of whom were compelled to abandon their lands and homes and to remove to more favored portions of the country. A new cycle of plentiful rainfall appears to have begun in 1890, 1891, and 1892, giving again magnificent harvests in the region from Devils Lake to Bismarck and southward, which had suffered most severely by drought.

*Fluctuations of lakes and streams.*—Through the past hundred years maximum and minimum stages of the great Laurentian lakes have alternated in cycles of about a dozen years, during which comparatively scanty average rainfall for several years was followed by unusually abundant rainfall.[1] These fluctuations are similar with those just noted in the rainfall of North Dakota. Besides such short cycles, important secular changes of the mean annual precipitation in this State, occupying considerably longer periods, have caused remarkable changes in the levels of numerous lakes which have no outlets.

Devils Lake[2] thus shows evidence of having attained, about the year 1830, a level 16 feet higher than its low stage in 1889, reaching at or near the former date to the line that limits the large and dense timber of its bordering groves. Below that line are only smaller and scattered trees, of which Capt. E. E. Heerman informed me that the largest found by him and cut a few years ago had fifty-seven rings of annual growth. Within the twenty-five years since the building of Fort Totten this lake has fallen 9 or 10 feet, and it has fluctuated 4 feet under the influence of the changes in the average annual precipitation of rain and snow during the past dozen years.

The high stage reached by this lake about sixty years ago appears to have been limited by an avenue of discharge eastward into Stump Lake, which rose at the same time to within about 3 feet of this height. The latter and smaller lake, receiving no large tributary and lying in a basin that nowhere extends many miles from the lake, was prevented by evaporation from rising quite so high as Devils Lake, which during years of abundant rains and snows receives a large tributary, the Mauvaise Coulée, draining a broad area that stretches 60 miles northwestward to the Turtle Mountain. The outlet from Devils Lake into Stump Lake was nearly due eastward from Jerusalem, situated on Lamoreaux Bay at the most eastern portion of the entire lake shore. With an overflow at this point, Devils Lake may many times have been raised to this beach by the periodic variations in rainfall during the many centuries since the Ice age.[3]

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[1] Charles Whittlesey, "On fluctuations of level in the North American lakes," in Smithsonian Contributions to Knowledge, Vol. XII, 1860, pp. 25, with 2 plates. G. M. Dawson, in Nature, Vol. IX, pp. 504–506, April 30, 1874. Bela Hubbard, in Popular Science Monthly, Vol. XXXII, pp. 373–387, Jan., 1888. G. K. Gilbert, in The Forum, Vol. V, pp. 417–428, June, 1888.

[2] See pp. 169–171, with Pl. XVIII.

[3] Compare with Mr. Gilbert's hypothetic explanation of the Stansbury shore-line of Lake Bonneville, U. S. Geol. Survey, Monograph I, p. 186.

At the time when the last ice-sheet retreated, however, the confluent waters of Devils and Stump lakes were raised to a shore-line which now has a slight ascent from west to east, lying 21 to 25 feet above the low stage of Devils Lake in 1889. This shore is traceable around both lakes, passing above the watershed that now divides them. At the same height, as shown by leveling, a well-marked watercourse is found running across the present watershed between the west part of Stump Lake and the Sheyenne River, in section 19, township 151, range 61. This glacial channel of outflow has a nearly flat bottom 150 feet wide, and is bordered on both sides by moderately steep morainic hills 50 to 75 feet high.

While the ice border was retreating across these lake basins the inflow from its melting produced a large outflowing stream, but there is no proof that any time since the departure of the ice has been so humid as to raise the lakes to this channel. The heavy growth of timber which in many places borders the lakes extends across the highest beach ridge or line of erosion to the next shore, which, as before noted, is the limit of the forest, and therefore is believed to have been the lake margin since the beginning of this century. Though the climate so lately had during a considerable term of years more rainfall than now, it was yet surely less than the average amount in the region of the Laurentian lakes and in New England, else the levels of both lakes must have been raised to overflowing—that is, to the continuous highest shore-line and channel of discharge southwest of Stump Lake.

The following are notes of the elevations of these lakes, of their former shore-lines above their present levels, and of this outlet. A slight differential uplifting, like that which gave to the beaches of Lake Agassiz their northward and eastward ascents, is shown by the glacial shore-line, which is now level through its western 18 miles from Minnewaukan to the city of Devils Lake, but thence rises eastward about 3 feet in a distance of 16 miles to Jerusalem, and 1 foot more in the next 6 miles southeast to the channel of outlet.

*Notes of leveling in the vicinity of Devils and Stump lakes.*

| | Feet above the sea. |
|---|---|
| Railway at passenger station, city of Devils Lake | 1,464 |
| Railway at passenger station, Minnewaukan | 1,461 |
| Devils Lake, surface of water August 8, 1887 | 1,431.6 |
| Devils Lake in 1889 | 1,430 |
| Devils Lake, highest and lowest stages during the years 1880 to 1889 | 1,434–1,430 |
| Stump Lake, surface of water August 12, 1887 | 1,417 |
| Former shore-lines of Devils Lake at Minnewaukan and the city of Devils Lake | 1,451, 1,446, 1,439 |
| Former shore-lines at Jerusalem on Lamoreaux Bay | 1,454, 1,446, 1,439 |
| Former shore-lines of Stump Lake | 1,455, 1,443, 1,433, 1,426 |
| Bottom of channel of outflow from Stump Lake to the Sheyenne River | 1,454.6 |

The elevations of the former shores of Stump Lake were determined by leveling on the northern slope of a promontory of till, which was an island at the time of the higher shore-lines, rising to 1,458 feet, in the east part of section 21, township 151, range 61. Postglacial deposition of alluvium, brought from slight ravines gullied by rains on the adjoining morainic hills, may have raised the bed of the channel of overflow 1 to 3 feet, or possibly more. The outflowing river, like the River Warren, was evidently shallow during the greater part of each year, corresponding to the general level of Devils and Stump lakes, then confluent; and while the glacial melting was most rapid during the summer months, this somewhat extensive body of water and its outlet were probably raised no more than a few feet above their minimum winter stage.

Besides the formerly higher stages of these and other neighboring lakes, it is also known that they have stood continually lower than now, at least by several feet, during a long period, sufficient for the growth of large forests on the shores of Stump Lake, and of the North and South Washington lakes and Lake Coe, in township 149, range 63; for this is proved by submerged logs and stumps, the latter standing rooted in the soil where they grew. Many of these logs and stumps have been hauled out of the southeastern bay of Stump Lake by the neighboring farmers for use as fuel. This prolonged epoch of comparative desiccation may have coincided with the yet more arid conditions in the Great Basin, which, as shown by

Russell, appear to have entirely dried up Pyramid, Winnemucca, and other lakes of Nevada about three hundred years ago.[1] On the other hand, the high stage of Devils Lake before mentioned was near the time of the highest known flood of the Red River, in 1826, when its water rose 5 feet above the surface where Winnipeg is now built. Likewise it should be noted that the highest known stage of the Laurentian lakes was in 1838, when Lake Erie stood 6 feet above its lowest recorded stage, which was in the winter of 1819–20.

### TEMPERATURE.

Owing to the geographic position of the basin of Lake Agassiz, in the central part of a large continent and nearly equidistant between the equator and the north pole, the difference between the mean temperatures of summer and winter is great, the winters being very cold and usually some portions of the summers very hot. The temperature, however, is mostly cool and invigorating through the six or seven months in which the land is worked and its harvest gathered.

In summer there are commonly only a few excessively hot days (80° to 100° F.) in a single heated term, which is preceded and followed by longer terms of agreeable coolness, even at midday. It is also important to note that, however hot the days may be, the nights, almost without exception, through the whole summer are cool and favorable for refreshing sleep.

In winter, though the temperature is continuously below zero of the Fahrenheit scale, even at midday, while the sun shines brightly, during days and occasionally weeks together, the dryness of the air makes the extreme cold (10° to 40° below zero) no more difficult to endure than a temperature 25° to 50° higher with the moist air of the region about the Laurentian lakes and on the Atlantic coast. Usually there is no considerable thawing at any time during two or three months of the winter. The ordinarily scanty snowfall, which gives a sheet of snow seldom exceeding a foot in average depth, is likely to serve well, if not too much drifted by gales at the time

[1] Geological History of Lake Lahontan, U. S. Geol. Survey, Monograph XI, pp. 223–237, 252. Compare G. K. Gilbert's Lake Bonneville, Monograph I, p. 258.

of its fall, for sleighing and sledding through this whole period of steady cold. This season, too, is more sharply demarked than in most other parts of the United States. It is begun by a sudden cold wave, generally during the first half of November, which freezes the ground and stops the late autumn work of plowing; and the return of warmth in spring is by a sudden transition which rapidly melts away the snow and soon thaws and dries the land sufficiently to prepare it for the seeding of the broad wheat fields.

The following table shows the mean temperatures at the six stations before noted. In the United States they were computed from the daily extremes of temperature during a period of nine years preceding the end of 1888. At Winnipeg, Manitoba, the average is drawn from observations begun in 1871 and extending through fifteen years.

*Normal temperature, in degrees Fahrenheit, for each month and for the whole year.*

| Stations. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. | Year. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| St. Paul | 7.9 | 15.6 | 27.4 | 46.2 | 58.6 | 68.1 | 72.4 | 69.6 | 60.1 | 48 | 31.3 | 18 | 43.6 |
| Duluth | 6 | 12.4 | 21.9 | 37.7 | 48.6 | 58 | 66 | 64.2 | 56.1 | 45.2 | 29.4 | 16.7 | 38.5 |
| Moorhead | —4.8 | 4.2 | 18.6 | 40 | 53.8 | 64.3 | 67.8 | 65.3 | 56.2 | 43.1 | 24.8 | 9.7 | 36.9 |
| St. Vincent | —9.6 | —0.6 | 13.2 | 36.2 | 52 | 62.2 | 65.2 | 62.8 | 53.4 | 40 | 20.6 | 5 | 33.4 |
| Winnipeg | —5.7 | —0.1 | 11.5 | 33.7 | 52.1 | 61.5 | 65.8 | 63.6 | 51.7 | 39 | 16.7 | 2 | 33.2 |
| Bismarck | 1.4 | 9.6 | 20.8 | 41.4 | 55.7 | 65 | 69.5 | 67.2 | 57 | 43.9 | 27.4 | 13.8 | 39.4 |
| Mean for entire district | —0.8 | 6.8 | 18.9 | 39.2 | 53.5 | 63.2 | 67.8 | 65.4 | 55.7 | 43.2 | 25 | 10.9 | 37.5 |

Ice on the Red River closed the season of navigation at Moorhead and Fargo in the years 1881 to 1888 at dates which range from the 11th to the 25th of November; and navigation was opened, with the breaking up and departure of the ice, at dates from the 12th to the 24th of April. Throughout the years 1889 and 1890 navigation was suspended because of the low stage of water.

The first severe frosts, destroying tender vegetation, occurred at Moorhead and Fargo in the years 1881 to 1890 at dates from August 25 to September 20; and the last severe frost there in spring during the same years ranged from May 2 to June 8. At St. Vincent these dates for the first were from August 4 to September 20, and for the last from April 29 to June 8.

WINDS.

The nearly level vast prairies are fully exposed to all currents of the air, and during the most windy months, which are in the spring and autumn, they seem very bleak to one who has previously lived only in districts where the surface mostly receives a partial shelter from the force of winds by the undulations of hills and vales and by the presence of forests and trees cultivated for ornament and shade. The movements of the atmosphere on the prairie district of Lake Agassiz do not appear, however, to exceed in their aggregate amount those on its wooded district, or on the basins of the Laurentian lakes, or on the Atlantic seaboard. Exposed places throughout these areas, as the tops of hills, are quite as severely swept by gales as the prairies, where they are so much more observed in the common experience of the people. One of the most desirable improvements of the prairie homestead is the cultivation of rows of trees, called wind-breaks, about the buildings.

Winds, usually light, but on many days heavy, are moving almost continually over this area, with variations in their direction to every point of the compass. From the hourly records of the velocity of the winds as measured by self-registering anemometers during the seven years from 1883 to 1889, inclusive, their mean velocity for this whole period was 6.58 miles per hour at St. Paul, 7.28 miles at Duluth, 8.81 miles at St. Vincent, and 8.39 miles at Bismarck.

With these means it will be instructive to compare the records of several stations in other parts of the country during the same time, which show for Boston, Mass., a mean velocity of 11.18 miles per hour; New York City, 9.30 miles; Washington, D. C., 5.39 miles; Savannah, 7.12 miles; Chicago, 9.01 miles; Cincinnati, 6.55 miles; St. Louis, 10.56 miles; New Orleans, 7.26 miles; Omaha, 8.05 miles; Denver, 6.99 miles; Salt Lake City, 5.18 miles; Portland, Oreg., 4.94 miles; San Francisco, 8.94 miles; and San Diego, Cal., 5.61 miles. Among sixty-six stations of the United States Signal Service thus tabulated, the maximum mean velocity of the wind is at Dodge City, Kans., 11.48 miles per hour, and the minimum is at Lynchburg, Va., 3.76 miles. The least windy station of the

United States, however, appears to be Phœnix, Ariz., where the records of the years 1879 to 1881, inclusive, showed a mean velocity of only 2.37 miles.

## FLORA OF THE BASIN OF THE RED RIVER OF THE NORTH.

Upon every portion of the land area of the globe, the flora, or assemblage of species constituting its mantle of vegetation, is a very sensitive register of its aggregate climatic conditions and of the value of its soil for agriculture. In almost an equal degree, also, the fauna, or representation of animal life, testifies what the capabilities of the country will be for pasturage and stock raising, and what crops will be successfully cultivated by the farmer, even before the coming of the axman to fell the forest and of the plowman to draw the first furrow on the prairie. The vast herds of buffalo[1] and the frequent droves of antelope and elk which roamed over this district previous to the advent of the white man were a prognostication of the present ranchman's wealth of cattle, horses, and sheep, feeding in the valleys and on the plains from which the native tall game and the aboriginal huntsman have so recently vanished. The nutritious and abundant grasses and other herbage on which the wild herds fed are now succeeded by luxurant fields of grain, or, growing in the yet unbroken sward, they now fatten the beef, rear the broncho and thoroughbred horses, and produce the wool, which are exported to Chicago and more eastern markets.

Though no strongly defined line of division can be drawn between different portions of the flora and fauna of the country from the Atlantic to the Rocky Mountains and from the Gulf of Mexico to the Arctic Sea, it is

[1] The early immigrants found the bones of buffaloes scattered here and there throughout the whole prairie region. On account of their commercial value for sugar refining and for the manufacture of superphosphate, these bones were collected and sold at the railway stations during the first two or three years after the railway was built into any new part of the country. A heap of buffalo bones which I saw beside the railway awaiting shipment at Langdon, N. Dak., in August, 1889, measured 100 feet by 20 feet in area, with an average height of 4 feet, representing probably two or three thousand animals. During the same month I saw a much larger pile of bones at Minot, in the same State, its contents being estimated as equal to 200 feet by 30 feet by 4 feet. The dealer informed me that the weight of this pile was about 600 tons, and that during the preceding part of the year he had purchased and already shipped some 1,200 tons, the average price paid being $8 per ton. During the one forenoon when I was there, ten or more wagonloads of bones were brought in by the farmers from the region around. Probably nearly all that could be found in the vicinity were collected during that year. (Compare page 139, and Geology of Minnesota, Vol. II, p. 516.)

nevertheless true that great contrasts exist between the eastern region, with its plentiful rainfall, and the dry western plains, as also between the almost tropical southern margin of the United States and the tundras beneath the Arctic Circle. In traveling from the once wholly forest-covered country of the eastern States across the prairies to the far western plains, bearing cacti and sagebrush, there is observed a gradual change in the flora, until a very large proportion of the eastern species is left behind, and their places are taken by others capable of enduring more arid conditions. Likewise in going from St. Augustine or New Orleans to Chicago, St. Paul, Winnipeg, and Hudson Bay and Strait, the palmettoes, the evergreen live oak, bald cypress, southern pines, and the festooned Tillandsia or "Spanish moss," are left in passing from the southern to the northern States; and instead we find in the region of the Laurentian lakes the bur or mossy-cup oak, the canoe and yellow birches, the tamarack or American larch, the black spruce, balsam fir, and the white, red, and Banksian pines, while farther north the white spruce, beginning as a small tree in northern New England and on Lake Superior, attains a majestic growth on the lower Mackenzie in a more northern latitude than a large part of the moss-covered Barren Grounds which reach thence eastward to the northern part of Hudson Bay and Labrador. Thus, although no grand topographic barrier, like a high mountain range, impassable to species of the lowlands, divides this great region, the transition from a humid to an arid climate in passing westward, and the exchange of tropical warmth for polar cold in the journey from south to north, are accompanied by gradual changes of the flora by which in the aggregate its aspect is almost completely transformed.

In the central part of this large area, the basin of the Red River of the North, with my geologic exploration during a half dozen summers, I have given careful attention also to the geographic limits and relative abundance of the species making up the flora. It has been interesting to find there the intermingling and the boundaries of species whose principal homes or geographic range lie respectively in the directions of the four cardinal points, east and west, south and north.

### FOREST TREES AND SHRUBS.

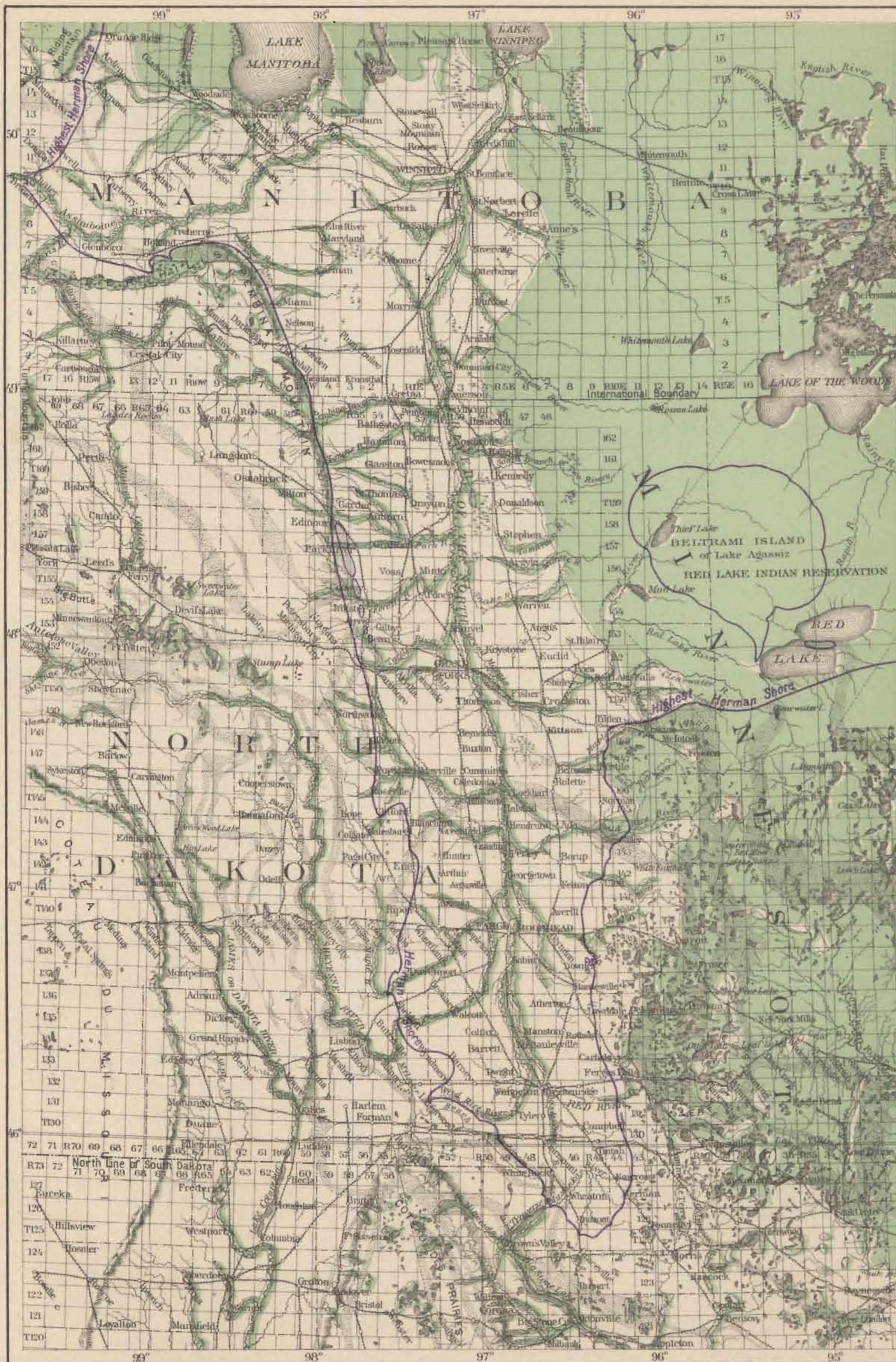
Many species of trees which together constitute a large part of the eastern forests extend to the Red River basin, reaching there the western or northwestern boundary of their range. Among these are the basswood, sugar maple, river maple, and red maple, the three species of white, red, and black ash, the red or slippery elm, and the rock or cork elm, the butternut, the white, bur, and black oaks, ironwood (*Ostrya virginica* Willd.), the American hornbeam (*Carpinus caroliniana* Walt.), the yellow birch, the large-toothed poplar, white and red pine, arbor-vitæ, and the red cedar or savin. A few species of far northern range find in this district their southern or southwestern limit, namely, our two species of mountain ash, the balsam poplar, Banksian or jack pine, the black and the white spruce, balsam fir, and tamarack.

Some of the eastern shrubs which make the undergrowth of our forests also attain here their western limits; but a larger proportion of these than of the forest trees continues west along the stream courses to the Saskatchewan region, the upper Missouri, and the Black Hills. Among the shrubs that reach to the borders of the Red River basin, but not farther westward, or at least southwestward, are the black alder or winterberry, the mountain holly, the staghorn sumach, the hardhack, the huckleberry, the dwarf blueberry and the tall or swamp blueberry, leatherwood, and sweet fern. Shrubs and woody climbers that have their northern or northwestern boundary in this basin include the prickly ash, staff tree or shrubby bittersweet, frost grape, Virginian creeper, and the four species of round-leaved, silky, panicled, and alternate-leaved cornel. On the other hand, shrubs of the north which reach their southern or southwestern limits in the Red River basin include the mountain maple, the few-flowered viburnum and withe-rod, several species of honeysuckle, the Canada blueberry, the cowberry, *Andromeda polifolia* L., *Kalmia glauca* Ait., Labrador tea, the Canadian shepherdia, sweet gale, the dwarf birch, green or mountain alder, beaked hazel-nut, *Salix balsamifera* Barratt, and *S. myrtilloides* L., var. *pedicellaris* Anders., black crowberry, creeping savin, and the American yew or ground hemlock.

No tree of exclusively western range extends east to the Red River basin, and it has only a few western species of shrubs, of which the most noteworthy are the alder-leaved Juneberry or service berry (in Manitoba commonly called "saskatoon"), the silverberry, and the buffalo-berry. To these are also to be added the shrubby *Œnothera albicaulis* Nutt., which occurs chiefly as an immigrant weed, and the small-leaved false indigo, which abounds on moist portions of the prairie. The silverberry (usually called "wolf willow" in the Red River Valley) is common or abundant from Clifford, N. Dak., and from Ada, Minn., northward, forming patches 10 to 20 rods long on the prairie, growing only about 2 feet high and fruiting plentifully, but in thickets becoming 5 to 10 feet high. Its silvery whitish foliage and fruit make this shrub a very conspicuous and characteristic element of the Red River flora.

The single species of true sagebrush belonging to this basin (*Artemisia cana* Pursh) extends east in North Dakota to the Heart Mound, 6 miles northwest of Walhalla, or 35 miles west of the Red River at Pembina, and to a hill close west of the Sheyenne River, about 8 miles south of Valley City, growing in both places on outcrops of the Fort Pierre shale. It attains a height of 1 to 3 feet, and the tough wood of its base is 1 to 1½ inches in diameter. *Artemisia frigida* Willd., called "pasture sagebrush" by Macoun, is abundant throughout a wide area westward, extending east locally to "the ridge" east of Emerson, Manitoba, the Falls of St. Anthony, and Lake Pepin.

*Causes of limitation of the forest.*—The boundary between the forest and the prairie, shown by Pl. XXXVIII, and the similarity of the two regions in their topographic features and drift deposits, have been noted in Chapter II (pp. 44–46). The usually abrupt transition from the timbered to the prairie country and the general absence of trees and shrubs in the prairie region have been often attributed to the effect of fires. Through many centuries fires have almost annually swept over these areas, generally destroying all seedling trees and shrubs, and sometimes extending the border of the prairie by adding tracts from which the forest had been burned. Late in autumn and again in the spring the dead grass of the prairie burns very rapidly, so that a fire within a few days sometimes spreads 50 or 100




MAP OF THE SOUTHERN PORTION OF LAKE AGASSIZ, SHOWING AREAS OF FOREST AND PRAIRIE.

Scale, about 42 miles to an inch.

Forest Area, and belts and patches of Timber on streams and lakes ▭ Prairie ▭

miles. The groves that remain in the prairie region are usually in a more or less sheltered position, being on the borders of lakes and streams, and sometimes nearly surrounded by them, while areas that can not be reached by fires, as islands, are almost always wooded. If fires should fail to overrun the prairies in the future, it can hardly be doubted that much of that area would gradually and slowly be changed to forest.

Yet it does not appear that fires in the western portion of our great forest region are more frequent or destructive than eastward; and our inquiry must go back a step further to ask why fires east of the Appalachian Mountains had nowhere exterminated the forest, while so extensive areas of prairie have been guarded and maintained, though not apparently produced, by prairie fires here. Among the conditions which have led to this difference we must undoubtedly place first the greater amount and somewhat more equable distribution throughout the year of rain in the Eastern States.[1]

Evidence that an increase of moisture in the ground suffices to produce a heavy growth of forest trees in a principally prairie region, even without protection from the incursions of prairie fires, is afforded by the bluffs of the opposite sides of the valley of the Minnesota River, which was the course of the River Warren, outflowing from Lake Agassiz. Timber is found in a nearly continuous though often very narrow strip bordering this stream through almost its entire course, but generally leaving much of the bottom-land treeless. The bluffs on the northeast side of the river have for the most part only thin and scanty groves or scattered trees. The southwestern bluffs, on the contrary, are heavily wooded through Blue Earth and Brown counties, excepting 2 or 3 miles at New Ulm. They also are frequently well timbered in Redwood and Yellow Medicine counties, but in Lac qui Parle County they are mostly treeless and have only

[1] The dependence of forests on a greater supply of rainfall than is needed by the grasses and other herbaceous vegetation of the prairies is ably stated by Prof. James D. Dana, "On the origin of prairies," Am. Jour. Sci. (2), Vol. XL, 1865, pp. 293–304; and by Dr. George M. Dawson, with discussion of prairie fires and the benefits to be derived from tree culture, Geology and Resources of the Region in the Vicinity of the Forty-ninth Parallel, 1875, pp. 311–324. Effects of drought and of cold to set limits to forests, and, on the other hand, extension of prairies into formerly timbered areas through the agency of annual fires, kindled by the Indians for the purpose of driving the game toward the hunters or providing a better growth of grass on which buffaloes and deer would feed, are noted by Prof. N. S. Shaler, Aspects of the Earth, 1889, pp. 282–290. Other views which had been advanced by Whitney, A. Winchell, and Lesquereux, previous to Dana's paper on this subject, seem untenable.

occasional groves. The greater abundance of timber on the southwestern bluffs appears to be due to their being less exposed to the sun, and therefore more moist, than the bluffs at the opposite side of the valley. Above Montevideo the timber is mainly restricted to a narrow belt beside the river and to tributary valleys and ravines.

### PRAIRIE GRASSES AND FLOWERS.

Among the fifteen hundred, more or less, indigenous species of herbaceous plants inhabiting the Red River basin, probably half are deserving of note for attaining their geographic limit upon this area, or at least the limit of their abundant or frequent occurrence. But thorough and detailed botanic exploration of all the great interior region of our continent westward to the Rocky Mountains and far northward will be requisite before we can speak with certainty concerning many of the less conspicuous species of our flora. We may here notice briefly some of those plants whose geographic range is best known, especially such as are useful for pasturage and hay.

In general, the flora of the prairie area of Lake Agassiz is mostly made up of species that are familiar to residents of the Eastern and Southern States, occurring also commonly or abundantly there; but many of these plants reach their western and northern limits along the Red River of the North.

On the other hand, seventy-six species[1] of northern range, some of them plentiful beneath the Arctic Circle, are known to extend south of the forty-ninth parallel in the Red River Valley, or on the east to the Lake of the Woods or into northern Minnesota, but not to the southern end of this valley at Lake Traverse. This northern element of the Red River flora includes thirteen species of Carex, and nine grasses, the latter being *Deyeuxia langsdorffii* Kunth, *Trisetum subspicatum* Beauv., var. *molle* Gray, *Danthonia intermedia* Vasey, *Poa alpina* L., *P. laxa* Hænke, *Agropyrum*

[1] Lists of these species and of the western species extending into this district, also a list of the weeds (troublesome to the farmer) observed in the district, both indigenous and introduced, with notes of their range and relative abundance, are given in my paper, "Geographic limits of species of plants in the basin of the Red River of the North," Proc., Boston Soc. of Nat. Hist., Vol. XXV, 1890, pp. 140-172.

*dasystachyum* Vasey, *A. tenerum* Vasey, *Elymus sibiricus* L., var. *americanus* Watson, and *E. mollis* Trin.

Another list of one hundred and two species comprises plants which are known to attain their eastern limits within the Red River basin, being common thence westward on the plains and often in the Rocky Mountains and to the Pacific. In this list are twenty Compositæ, most of them abundant and showy; four species of Carex; and twelve grasses, namely, *Beckmannia erucæformis* Host, var. *uniflora* Scribner, *Stipa spartea* Trin., *S. viridula* Trin., *Sporobolus cuspidatus* Torr., *Avena pratensis* L., var. *americana* Scribner, *Schedonnardus texanus* Steud., *Bouteloua oligostachya* Torr., *Distichlis maritima* Raf., var. *stricta* Thurber, *Poa tenuifolia* Nutt., *Festuca scabrella* Torr., *Agropyrum glaucum* R. & S., var. *occidentale* V. & S., and *Elymus sitanion* Schultes.

The most plentiful and valuable grasses in this northeastern part of the great prairie region of the continent are as follows, with notes of their habit of growth and comparative importance:

*Spartina cynosuroides* Willd., the prevailing and often the only grass of sloughs (which is the term commonly applied to miry depressions of the prairie), making good hay; also largely used as fuel by immigrants in many districts remote from timber and railways, and as thatch by Mennonite colonists in Manitoba.

*Beckmannia erucæformis* Host, var. *uniflora* Scribner, frequent or common on wet ground, where water stands a part of the year, from Port Arthur, Lake Superior, to the Rocky Mountains, extending northeast to Hudson Bay and Lake Mistassini.

*Panicum capillare* L., common along streams, and in sandy cultivated fields.

*Panicum virgatum* L., frequent, often abundant, on somewhat moist portions of the prairie, especially in southwestern Minnesota and South Dakota.

*Andropogon furcatus* Muhl., abundant on rather dry tracts in South and North Dakota, where it is usually called "blue joint," and is highly esteemed for hay; less common in Manitoba; whitish and glaucous, not abundant, among the sand dunes of the Sheyenne delta of Lake Agassiz.

*Andropogon scoparius* Michx., abundant, occupying drier land than the last.

*Chrysopogon nutans* Benth., common or frequent in the Dakotas; less so farther north; much cut for hay, with *Andropogon furcatus* and *Panicum virgatum.*

*Phalaris arundinacea* L., abundant in marshes.

*Hierochloe borealis* R. & S., very common on moist ground and along rivers and lakes throughout this northern prairie region.

*Stipa spartea* Trin., deservedly named "porcupine grass," but more commonly called "wild oats" in Minnesota and the Dakotas; abundant on the dry prairie, especially in South Dakota.

*Stipa viridula* Trin., extending east, on sandy alluvial soil of bottom-lands, to the Red River; also common westward on the general prairie.

*Muhlenbergia glomerata* Trin. (chiefly the var. *ramosa* Vasey), plentiful on moist land; frequently persisting as a weed in wheat fields and other cultivated ground.

*Sporobolus cuspidatus* Torr., common on dry portions of the prairie in the Dakotas, Manitoba, and Assiniboia.

*Sporobolus heterolepis* Gray, also plentiful from Nebraska to northwestern Manitoba.

*Agrostis alba* L., var. *vulgaris* Thurber, indigenous and common on moist land, especially northward.

*Agrostis scabra* Willd., abundant along rivers, so that in late summer the wheel ruts of roads are often filled with its dead panicles, broken off and blown thither by the wind.

*Deyeuxia canadensis* Hook. f. (*Calamagrostis canadensis* Beauv.), abundant on wet meadows bordering streams, especially in the forest region.

*Deyeuxia neglecta* Kunth (*Calamagrostis stricta* Trin.), plentiful on similar ground throughout the prairie region west of Winnipeg.

*Ammophila longifolia* Benth. (*Calamagrostis longifolia* Hook.), which binds the sand dunes along the south shore of Lake Michigan, is generally abundant on sandy ridges through all the prairie region from the Red River west to the Rocky Mountains.

*Avena pratensis* L., var. *americana* Scribner, common from Portage la Prairie westward.

*Danthonia intermedia* Vasey, common from the Red River to the sources of the Qu'Appelle; also found at the east in Anticosti and Gaspé, extending west to Vancouver Island.

*Bouteloua oligostachya* Torr., the most valuable and widely spread of the "buffalo grasses," observed as the main species of grass on large tracts of the prairie between Devils Lake and the Souris River; described by Vasey and Havard as the commonest species on the great plains, surpassing all others in its importance as pasturage for stock of all kinds, even in winter, when its dried tufts or bunches still retain their nutritive quality.

*Phragmites communis* Trin., abundant, often 10 to 15 feet high, in the edges of lakes. A prostrate stem 20 feet long, rooting at the joints, was observed at Red Lake, Minnesota.

*Kœleria cristata* Pers., very abundant on the drier portions of the country, affording good pasturage; estimated by Lieberg as constituting fully half of the entire growth of grass along the Northern Pacific Railroad between the James and Yellowstone rivers.

*Distichlis maritima* Raf., var. *stricta* Thurber, very abundant on the borders of saline and alkaline marshes.

*Poa tenuifolia* Nutt., one of the much-prized "bunch grasses," common from Brandon westward to the Rocky Mountains, and the most important pasture grass of British Columbia, Vancouver Island, and southward.

*Poa nemoralis* L., forming much of the pasture northward.

*Poa serotina* Ehrh., plentiful in swampy places on lakes and rivers.

*Poa pratensis* L., the famous "blue grass" of Kentucky, indigenous and abundant, rapidly taking the place of other species westward, and destined, according to Macoun, to be the chief pasture grass of this region.

*Glyceria distans* Wahl., var. *airoides* Vasey, abundant in saline marshes from Winnipeg westward.

*Festuca scabrella* Torr., a valuable "bunch grass," abundant at Brandon and westward to the mountains.

*Bromus kalmii* Gray, abundant northward.

*Agropyrum glaucum* R. & S., var. *occidentale* V. & S., common on moist land, especially where the soil is somewhat saline and alkaline; in Montana, according to Scribner, the most highly valued of the native grasses for hay.

*Agropyrum tenerum* Vasey, abundant, with the preceding, from Winnipeg to Edmonton and southward; one of the best grasses for hay. Dr. Vasey remarks that in southwestern Minnesota and South Dakota, wherever the ground has been broken and not cultivated, *Agropyrum glaucum* and *A. tenerum* have commonly taken possession.

*Agropyrum caninum* R. & S., plentiful in the northern prairie region, from Winnipeg to Edmonton.

*Hordeum jubatum* L., a worthless species, well named "squirrel-tail grass" and "tickle grass;" very abundant by roadsides and on slightly saline, moist land.

*Elymus canadensis* L., a conspicuous species, common on the banks and bluffs of rivers.

Besides the grasses, the prairies bear multitudes of native flowers of showy red, purple, blue, yellow, and orange hues, and pure white, which bloom from early spring till the severe frosts of autumn. Earliest of all is the pasque flower, named for its blooming at Easter, common over all the prairie region. With this, or later in the spring, are other species of windflowers, the wild columbine, indigenous buttercups, violets, and many more.

During the summer the prairies are decked with species of larkspur, Psoralea, Amorpha, Petalostemon, Astragalus, Oxytropis, Vicia, Lathyrus, Geum, rose, evening primrose, many Compositæ, nearly all conspicuous by their flowers, the harebell, gentian, phlox, Pentstemon, Gerardia, Orthocarpus, Pycnanthemum, Monarda, Spiranthes, Sisyrinchium, Uvularia, Smilacina, lily, wild onion, spiderwort, etc. Often I have seen large tracts of the natural prairie yellow with sunflowers or golden-rod; other areas purple with Petalostemon, Liatris, or Gerardia, or blue with asters; and still others white with the profusely flowering *Galium boreale* L. Several yellow-flowered species of the Compositæ, blooming in the middle and later portions of summer, resemble each other by growing frequently in clumps or bunches, as the Grindelia, Aplopappus, Chrysopsis, and Gutierrezia in the list of western plants, here noted in the declining order of their height.

Numerous species of plants prefer the sandy beaches of Lake Agassiz and grow there in greater abundance and luxuriance than elsewhere, among these being the pasque flower, *Psoralea argophylla* Pursh, and *P. esculenta* Pursh, two varieties of *Potentilla pennsylvanica* L., *Rosa arkansana* Porter, *Liatris punctata* Hook., *Chrysopsis villosa* Nutt., *Lepachys columnaris* Torr. and Gray, *Gaillardia aristata* Pursh, *Lilium philadelphicum* L., and *Ammophila longifolia* Benth. Near Arden, Manitoba, one of the beaches of Lake Agassiz has been named by the settlers Orange Ridge, from its orange-red lilies, and another is called the Rose Ridge.

## DEVELOPMENT OF AGRICULTURE.

The aboriginal tribes of Ojibways and Dakotas, living on the southern portion of the area of Lake Agassiz, had made little progress toward a system of agriculture which would provide their principal food during the whole year. Like the other tribes of hunting Indians who inhabited all the area of the United States, excepting its southwestern borders, their dependence was chiefly on the chase and entrapping of game and on fishing. But even their rude and very limited efforts in agriculture yielded an important and valued portion of their sustenance. In pre-Columbian times and onward to the present day the Indians have cultivated small patches of land, carefully tending their crops and storing up the harvest for gradual use during the rigors of winter and until the next harvest, supplementing thereby their principal diet of game and fish. Such aboriginal agriculture, untaught by white men, yet far from being despicable, I saw in September, 1885, at the Ojibway village a mile southeast of the Narrows of Red Lake. This largest village of the Ojibways in Minnesota consists of thirty or forty permanent bark lodges, scattered on an area which reaches a half mile from northwest to southeast, and is 40 to 60 rods wide. Adjoining the village were fields of ripening maize or Indian corn, amounting to about 50 acres, besides about 5 acres of potatoes and probably an acre or more of squashes. These crops showed a luxuriant growth and abundant yield, and the weeds among them had been held in check by hoeing. During the spring, summer, and autumn, most of the one hundred and fifty or two hundred inhabitants of this village are usually absent in expeditions for hunting, and in successive portions of the season to make maple sugar, to gather Seneca snakeroot for sale, to pick cranberries, and to reap the natural harvest of wild rice (*Zizania aquatica* L.) which grows plentifully in the streams and shallow lakes and forms the most substantial part of the provisions laid up for the winter.[1] In the prairie country the place of the wild rice is partially supplied by the very nutritive, turnip-like root of the pomme de terre (*Psoralea esculenta* Pursh), which is dried, pulverized, and used as flour by the Dakotas.[2]

At an earlier time, of which no distinct tradition is preserved by the hunting tribes of Indians inhabiting this region, other tribes, who built the mounds and probably lived more by agriculture and less by the chase, overspread all the prairie district of Lake Agassiz, extending also east in the wooded country to Rainy Lake. The enduring earthworks erected by this people testify of their formerly wide extension throughout the Mississippi and Red River basins, and show that the sites of their villages were chosen usually on the banks and bluffs which overlook the food-giving rivers and lakes, often commanding an extensive and beautiful prospect. Most of the mounds within the area of Lake Agassiz are round and have the form of a dome, their height ranging from 3 to 10 feet or rarely more

[1]The Flora of Minnesota, in the Twelfth Annual Report, Geol. and Nat. Hist. Survey of Minnesota, for 1883, p. 159.

[2]Ibid., p. 42.

above the general surface, with a diameter of 30 to 100 feet or more at their base. Nearly all of them were made by the people for the burial of their dead, and the relics found with their bones prove that they surpassed the present Indians of this region in having skill to make rude pottery; but the superiority was very slight, and there are no evidences of the development of handicrafts to a degree at all comparable with the aboriginal arts of Mexico and Peru. There was some commercial interchange from great distances, but it was probably limited to a few articles which were highly valued for beauty or regarded as mysterious and sacred. Thus in the mounds on the bluffs of the Souris River and Antler creeks, in southwestern Manitoba, Prof. George Bryce found ornaments made of sea shells, others of copper from Lake Superior, and pipes from the sacred red pipestone quarry at Pipestone, Minn., which Longfellow has described in "The Song of Hiawatha."

Further notes of the mounds of the area of Lake Agassiz and the adjoining country on the west are given in Appendix B.

The first immigration of white men to colonize the fertile basin of the Red River of the North, bringing the civilized arts and agriculture of Europe, was in the years 1812 to 1816, when, under Lord Selkirk's far-sighted and patriotic supervision, the early pioneers of the Selkirk settlements, coming by the way of Hudson Bay and York Factory, reached Manitoba and established their homes along the river from the vicinity of Winnipeg to Pembina. In its beginning this colony experienced many hardships, but, in the words of one of these immigrants, whose narrative was written down in his old age, in 1881, "by and by our troubles ended, war and famine and flood and poverty all passed away, and now we think there is no such place to be found as the valley of the Red River."[1]

Fifty to sixty years after the founding of the Selkirk colony the margin of the advancing wave of immigration in the United States reached the Red River Valley. In a few places on the Red, Wild Rice (of North Dakota), and Sheyenne rivers small bands of immigrant farmers had begun the settlement of this rich agricultural area a few years before the building

[1] Manitoba: Its Infancy, Growth, and Present Condition, by Prof. George Bryce, London, 1882, p. 166.

of railroads across it; but the main tide of immigration came after the railroads had provided means of sending the staple product of the country, wheat, to the markets of St. Paul, Minneapolis, and Duluth. The Northern Pacific Railroad was built from Duluth to Moorhead and Fargo during the years 1870 to 1872, and the next year it was extended to Bismarck. Within the next three years a line of the Great Northern Railway (then the St. Paul and Pacific) was built to Breckenridge, and another line to Crookston and St. Vincent. From 1875 to 1885 the settlement of the Red River Valley and of a large contiguous area of North and South Dakota went forward very rapidly, nearly all the land in this valley being taken up during these ten years by homestead and preemption claims from the Government and by purchase from the railroad corporations which had received land grants.

The wise policy of the United States Government was to parcel out its land in small farms to actual settlers, selling none to non-residents, and allowing to no one rights to secure more than three-quarters of a section, or a total of 480 acres. This large amount was possible to be obtained from the Government only by use of three separate rights, each securing a quarter section, according to the respective laws for homesteads, preemption, and tree culture. Most of the farms received from the Government comprise only 160 acres; and these were deeded, upon payment of small fees at the land offices, to any citizen, including naturalized foreigners, those affirming their intention to become naturalized legal voters, and widows and unmarried women, all of whom were required to take the land to be their permanent homes. For these free gifts of the fertile prairie of the Red River Valley, surpassed by no other area of the world in its natural value for agriculture, multitudes came, bringing housekeeping equipments in their emigrant wagons ("prairie schooners"), which passed in long processions through St. Cloud and Alexandria, Minn., on their way from the older portions of that State and from other States farther east and south. Many also came directly from the Old World, especially from Sweden and Norway, being carried from the eastern seaports by railroads to the Red River and James River valleys and other parts of North and South Dakota, there being welcomed and soon established on their own freeholds in near neighborhood with others of their countrymen who had come to the United States many years earlier.

A considerable number of very large farms were acquired, however, by discerning capitalists, who saw the capabilities of this district for the convenient employment of large companies of laborers, marshaled with almost military order, in the various operations of farming, as in plowing, seeding, harvesting, and thrashing, and who, at an early stage in the rapid progress of settlement, foresaw the profits of wheat raising on a grand scale. These "bonanza farms," as they were afterward called, were made up in great part by purchasing from the railroad corporations the odd-numbered alternate sections which had been given as Government subsidies to foster the early railroad enterprises that opened the region to settlement. But the railroad lands formed no compact tract, being in square miles touching each other only at the corners, like the spots of a single color on a checkerboard. To remedy the difficulty and fill out continuous tracts, many of the intervening portions were obtained by purchase from settlers who had received the land from the Government in good faith, with the full intention of continuing to live on it; but in some instances claims also were obtained from the Government by fraudulent agents, who professed their intention to comply with this legal requirement in taking land by preemption.

Among the most famous and successful of these extensive farms are the Lockhart and Keystone farms, in Minnesota; that of the Messrs. Dalrymple, comprising some 30,000 acres, in the vicinity of the station of this name on the Northern Pacific Railroad, 18 miles west of Fargo; the lands of the Grandin Farming Company, about 40,000 acres, in eastern Traill County; and the Elk Valley Farm, near Larimore. Nine establishments of farm buildings have been erected by the Grandin Farming Company, and these are connected with the headquarters (Hague post-office) by 25 miles of telephone lines, the farthest set of buildings being at a distance of 12 miles. About 280 horses and mules are used by this company, and 200 to 300 men are employed during the summer, distributed somewhat equally in the nine divisions; but in winter, when comparatively few men are retained, the horses are stabled at only two or three places. One stable at the headquarters has 180 stalls. In some fields of this great farm the teams plow 3 or 4 miles straight forward, being interrupted only by roads on the section lines, where the plow is thrown out of the ground for a few rods. The first breaking on both the Dalrymple and Grandin farms was in 1875, the same year in which the land was mostly purchased, and their first crop of wheat was harvested in 1876. During every year since that time the harvests on these lands and in general throughout the Red River Valley have been good, with no failure on account of drought, which for several years (from 1885 to 1889) was very severe upon many portions of the Dakotas west and southwest of this valley.

### WHEAT AND OTHER CEREALS.

One man, if very industrious, with two pairs of horses and ample "farm machinery"—that is, plows, harrows (here often called drags), seeders, a self-binding harvester, etc.—can cultivate 100 to 150 acres in wheat. An intelligent and energetic farmer in Traverse County, Minn., with whom I conversed in June, 1886, informed me that during the preceding autumn, beginning after the harvest and working daily until the ground froze, he plowed 130 acres, walking behind the plow. In the spring of 1886 the seeding of his crop of 210 acres was done entirely by his wife, not an especially strong woman, who rode on the seeder, driving a pair of horses, while he with another pair was dragging (harrowing) the plowed lands to prepare them for seeding. He expected to harvest the whole with one harvester, estimating that this would occupy fifteen days, working from the time when the dew would be mostly gone in the morning until it would gather heavily in the evening. The amount of work accomplished, however, by most farmers with their hired men is no more than to cultivate 50 or 75 acres in wheat for each man laboring through the season.

The seedtime for wheat, oats, and barley is shortly after the ground is thawed in the spring, usually occupying the second half of April and the first week or two of May. The harvest comes during August, northward extending somewhat into September, after which follow stacking, thrashing, and plowing, until winter arrives. Harvesting is the busiest part of the farmer's work, since the crop ought to be secured as soon as it is ripe. Delay permits much of the wheat to be shelled out of the heads and scattered on the ground. There is also much liability to loss at this time from the occurrence of rainy weather, and hail may destroy or greatly damage the crop at any time after it has attained a considerable height until it is cut.

Usually, if the season is favorable, the first crop from newly broken prairie land is somewhat more bountiful than any to be obtained in the following years, which range from 10 to 20 bushels of wheat on an average per acre. The same fields have in many instances been successfully cultivated in wheat ten to fifteen years or more in the Red River Valley south of the international boundary, and twice as long in other parts of Minnesota and in the Selkirk settlements of Manitoba, without the use of any manure, and yet without exhibiting any noticeable impoverishment of the soil. The time must come, however, after a few decades of such unrequited cropping, when fertilizers will be needed to restore and sustain the original productiveness.

A rotation of crops and diversity of farming, with stock raising and butter making, will doubtless be found more advantageous than the production of the cereals only, when a long series of years is considered. The growth of villages and towns in this district, affording near markets for miscellaneous farm produce, and the tendency, with the increase of population, toward subdivision of the large farms, and even of the ordinary homesteads, into two or four farms in each quarter section, indicate for the future an increasing diversification of agriculture. Wheat and other cereals will probably continue to be the chief crops for exportation, but many other crops will attain more importance than now, and there will be a greater average expenditure of labor for each acre cultivated, with proportionally enhanced profits.

Comparatively few Indians were able to derive their subsistence by hunting and fishing upon the area of Lake Agassiz or in any other region. Probably their numbers living at any time upon the portion of this lake area within the United States did not exceed 5,000. But now that the land is occupied by white immigrants and is sown with wheat, the present yearly product is about 285 bushels apiece for each man, woman, and child of the

161,049 enumerated by the census of 1890 in the twelve counties which lie mainly within the Red River Valley.

Six of these counties are in Minnesota and six are in North Dakota. Tabulations of their population in 1880 and in 1890, and of their production of wheat during the same years in Minnesota and during 1879 and 1891 in North Dakota, are here presented, for the purpose of exhibiting the rapid progress in the agricultural development of the district. The ratio of the wheat yield to the population in 1880 was 69 bushels for each person, or less than one-fourth as much as in 1890 and 1891. The latter high ratio of 285 bushels for each person is probably near the maximum which this ratio can attain, from which it will decrease relatively to the increasing population, the place of wheat cultivation being destined to be partially taken by other crops, by stock raising, and by other industries.

An equally prosperous development of the agricultural resources of Manitoba has been going forward during the same time, as is also exhibited by the similar statements of the population and wheat production of that province.

*Population of counties in Minnesota lying mainly within the Red River Valley.*

| Counties. | 1880. | 1890. |
|---|---|---|
| Wilkin | 1,906 | 4,346 |
| Clay | 5,887 | 11,517 |
| Norman[1] | ......... | 10,618 |
| Polk | 11,433 | 30,192 |
| Marshall | 992 | 9,130 |
| Kittson | 905 | 5,387 |
| Total | 21,123 | 71,190 |

[1] Organized in 1881 from part of Polk County.

*Population of counties in North Dakota lying mainly within the Red River Valley.*

| Counties. | 1880. | 1890. |
|---|---|---|
| Richland | 3,597 | 10,751 |
| Cass | 8,998 | 19,613 |
| Traill | 4,123 | 10,217 |
| Grand Forks | 6,248 | 18,357 |
| Walsh[1] | ......... | 16,587 |
| Pembina | 4,862 | 14,334 |
| Total | 27,828 | 89,859 |

[1] Organized in 1881 from parts of Grand Forks and Pembina counties.

The population of Manitoba, according to the census of 1881, was 69,954; and in 1891 it was estimated to be 150,000. About a third part of these and a small fraction of the population noted in the Minnesota and North Dakota counties are outside the boundaries of Lake Agassiz; but the total inhabitants within the lake area are nearly a quarter of a million people. Approximately three-fourths of this population are engaged in farming, the other fourth being resident in the villages and large towns and engaged in commercial and manufacturing pursuits.

*Wheat production of counties in Minnesota lying mainly within the Red River Valley.*

| Counties. | 1880. | | | 1890. | | |
|---|---|---|---|---|---|---|
| | Acres. | Bushels. | Bushels per acre. | Acres. | Bushels. | Bushels per acre. |
| Wilkin | 9,871 | 144,424 | 14.60 | 42,212 | 474,050 | 11.20 |
| Clay | 28,444 | 479,833 | 16.87 | 93,568 | 1,284,551 | 13.70 |
| Norman | | | | 84,188 | 1,293,429 | 15.30 |
| Polk | 63,135 | 1,035,428 | 16.40 | 222,223 | 3,002,754 | 13.50 |
| Marshall | 1,121 | 17,367 | 15.49 | 88,819 | 1,056,425 | 11.80 |
| Kittson [1] | | | | | | |
| Total | 103,363 | 1,692,183 | 16.37 | (531,010) [2]600,000 | (7,111,209) [2]8,000,000 | 13.33 |

[1] Not reported. [2] Including estimated addition for Kittson County.

*Wheat production of counties in North Dakota lying mainly within the Red River Valley.*

| Counties. | 1879. | | | 1891. | | |
|---|---|---|---|---|---|---|
| | Acres. | Bushels. | Bushels per acre. | Acres. | Bushels. | Bushels per acre. |
| Richland | 9,086 | 184,753 | 20.33 | 156,631 | 3,195,680 | 20.40 |
| Cass | 51,727 | 1,012,565 | 19.57 | 527,070 | 9,939,034 | 18.86 |
| Traill | 13,707 | 333,409 | 24.32 | 269,426 | 6,441,546 | 23.88 |
| Grand Forks | 4,978 | 98,352 | 19.76 | 262,992 | 6,881,624 | 26.17 |
| Walsh | | | | 241,673 | 6,202,940 | 25.67 |
| Pembina | 2,398 | 63,676 | 26.55 | 218,066 | 5,202,332 | 23.86 |
| Total | 81,896 | 1,692,755 | 20.67 | 1,675,858 | 37,863,156 | 22.59 |

*Wheat production of Manitoba.*

| | 1883. | | | 1891. | | |
|---|---|---|---|---|---|---|
| | Acres. | Bushels. | Bushels per acre. | Acres. | Bushels. | Bushels per acre. |
| Whole province | 208,674 | 4,549,093 | 21.80 | 916,664 | 23,191,599 | 25.30 |

Summing these figures, and deducting the estimated portion belonging outside the boundaries of the glacial lake, we find the present annual wheat crop upon the prairie area of Lake Agassiz to be approximately 50,000,000 bushels. This is about 200 bushels apiece for each inhabitant, when the populations in the United States and in Manitoba are considered together; and if the wheat were distributed among all the people of the United States, it would supply nearly a bushel for each individual. But no more than a quarter part of the arable prairie land of this lacustrine area is now under cultivation in all crops, the proportion being greater in the United States and less in Manitoba. When all this area shall be brought into agriculture, the wheat product will probably be almost or quite 200,000,000 bushels yearly, but the ratio to the population of the Red River Valley will be smaller than now.

All the wheat raised in this district is sown in the spring, none being "winter wheat," sown in the fall. The kernel is plump and hard, yielding in the "roller mills," with the present perfected processes of manufacture, the finest, whitest, and most salable flour of the world. Nearly every city and large village in Minnesota, North Dakota, and Manitoba, has one or more flouring mills; but far the greater part of the wheat crop is shipped eastward, by way of Duluth, Superior, and Port Arthur, to milling cities on the Great Lakes, excepting the large fraction which is marketed in Minneapolis, whose flouring mills have a daily capacity of about 30,000 barrels.

*Production of oats in the year 1890 in counties of Minnesota lying mainly within the Red River Valley.*

| Counties. | Acres. | Bushels. | Bushels per acre. |
|---|---|---|---|
| Wilkin | 10, 004 | 238, 285 | 23. 80 |
| Clay | 23, 609 | 659, 738 | 27. 90 |
| Norman | 18, 694 | 585, 785 | 31. 30 |
| Polk | 38, 839 | 1, 044, 406 | 26. 80 |
| Marshall | 11, 438 | 256, 569 | 22. 40 |
| Kittson[1] | ---- | ---- | ---- |
| Total | 102, 584 | 2, 784, 773 | 27. 15 |

[1] Not reported.

*Production of oats in the year 1891 in counties of North Dakota lying mainly within the Red River Valley.*

| Counties. | Acres. | Bushels. | Bushels per acre. |
|---|---|---|---|
| Richland | 24, 355 | 901, 135 | 37 |
| Cass | 70, 695 | 2, 777, 303 | 39. 29 |
| Traill | 33, 689 | 1, 494, 949 | 44. 37 |
| Grand Forks | 38, 334 | 1, 854, 940 | 48. 40 |
| Walsh | 33, 341 | 1, 476, 215 | 44. 28 |
| Pembina | 34, 546 | 1, 579, 246 | 45. 71 |
| Total | 234, 960 | 10, 083, 788 | 42. 90 |

*Production of oats in the year 1891 in Manitoba.*

| | Acres. | Bushels. | Bushels per acre. |
|---|---|---|---|
| Whole province | 305, 644 | 14, 762, 605 | 48. 30 |

*Production of barley in the year 1890 in counties of Minnesota lying mainly within the Red River Valley.*

| Counties. | Acres. | Bushels. | Bushels per acre. |
|---|---|---|---|
| Wilkin | 1, 961 | 45, 784 | 23. 30 |
| Clay | 3, 842 | 104, 955 | 27. 30 |
| Norman | 2, 925 | 80, 145 | 27. 40 |
| Polk | 14, 120 | 298, 017 | 21. 10 |
| Marshall | 13, 043 | 145, 950 | 11. 10 |
| Kittson[1] | | | |
| Total | 35, 891 | 674, 851 | 18. 80 |

[1] Not reported.

*Production of barley in the year 1891 in counties of North Dakota lying mainly within the Red River Valley.*

| Counties. | Acres. | Bushels. | Bushels per acre. |
|---|---|---|---|
| Richland | 4, 900 | 158, 136 | 32. 27 |
| Cass | 12, 915 | 416, 508 | 32. 25 |
| Traill | 11, 094 | 402, 157 | 36. 25 |
| Grand Forks | 18, 359 | 682, 343 | 37. 17 |
| Walsh | 14, 397 | 559, 883 | 38. 89 |
| Pembina | 22, 950 | 826, 200 | 36 |
| Total | 84, 615 | 3, 045, 227 | 35. 99 |

*Production of barley in the year 1891 in Manitoba.*

| | Acres. | Bushels. | Bushels per acre. |
|---|---|---|---|
| Whole province | 89, 828 | 3, 197, 876 | 35. 60 |

Rye is only sparingly cultivated in this district. The total area of this grain in the six Minnesota counties in 1890 was 423 acres, yielding 6,541 bushels, an average of 15.46 bushels per acre. In the six counties of North Dakota 774 acres of rye were reported in 1891, with a yield of about 19,139 bushels, or an average of nearly 25 bushels per acre.

The season between the last severe frost of spring and the earliest in autumn is often too short for the maturing of maize, or Indian corn, which, therefore, will never be raised extensively in the Red River Valley. In the same counties of Minnesota 2,026 acres were planted with maize in 1890, the yield being 44,125 bushels, averaging 21.78 bushels per acre; and in the North Dakota counties there were 5,685 acres of maize in 1891, yielding 148,217 bushels, or 26.07 bushels per acre.

### HAY, POTATOES, FLAX, AND OTHER CROPS.

The principal grasses cultivated for hay in the prairie region of Lake Agassiz are the Italian millet, or Hungarian grass (*Setaria italica* Kunth), and timothy (*Phleum pratense* L.). In Minnesota these are not kept separate by the report of the commissioner of statistics, but in North Dakota the returns to the State department of agriculture show that the millet crop far exceeds that of all other cultivated grasses (here known as "tame grasses"). The Minnesota reports state the quantity of wild hay made on the unbroken prairie, which in the Red River Valley often yields a ton of very good hay per acre on the somewhat dry general surface and 2 to 3 tons of an inferior quality on marshy ground. The wild hay gathered in the North Dakota counties is not reported, but doubtless surpasses the figures of Minnesota, which has only about one-third, while North Dakota has about two-thirds of the width of the Red River Valley. With the prospective increase of attention to stock raising and dairying, the cultivation of hay will become more prominent. Timothy, redtop, and other choice perennial species will probably then come more into favor, displacing in part the present coarse fodder supplied by the annually sown fields of millet.

*Production of hay in the year 1890 in counties of Minnesota lying mainly within the Red River Valley.*

| Counties. | Cultivated hay. | | | Wild hay. |
|---|---|---|---|---|
| | Acres. | Tons. | Per acre. | Tons. |
| Wilkin | 990 | 1,616 | 1.63 | 11,757 |
| Clay | 2,840 | 4,642 | 1.64 | 40,114 |
| Norman | 5,113 | 11,286 | 2.21 | 32,395 |
| Polk | 5,082 | 6,840 | 1.35 | 72,733 |
| Marshall | 1,883 | 2,798 | 1.49 | 26,104 |
| Kittson[1] | | | | |
| Total | 15,908 | 27,182 | 1.71 | 183,103 |

[1]Not reported.

*Production of hay in the year 1891 in counties of North Dakota lying mainly within the Red River Valley.*

| Counties. | Millet (Hungarian grass). | | | Other cultivated hay. | | |
|---|---|---|---|---|---|---|
| | Acres. | Tons. | Per acre. | Acres. | Tons. | Per acre. |
| Richland | 3, 942 | 8, 672 | 2. 20 | 936 | 1, 248 | 1. 33 |
| Cass | 12, 870 | 31, 102 | 2. 42 | 3, 965 | 7, 731 | 1. 95 |
| Traill | 8, 235 | 19, 215 | 2. 67 | 3, 959 | 5, 938 | 1. 50 |
| Grand Forks | 15, 901 | 37, 632 | 2. 37 | 3, 147 | 5, 114 | 1. 62 |
| Walsh | 10, 827 | 24, 360 | 2. 25 | 2, 782 | 4, 868 | 1. 75 |
| Pembina | 8, 313 | 19, 397 | 2. 33 | 690 | 1, 044 | 1. 60 |
| Total | 60, 088 | 140, 378 | 2. 34 | 15, 479 | 25, 943 | 1. 68 |

The crops of oats, hay, and potatoes raised in the Red River Valley are almost all consumed by the farmers themselves, excepting the part sold for use in the villages and cities of the district. It seems probable, however, that the cultivation of potatoes for exportation to Minneapolis and St. Paul, to Duluth and West Superior, and to the mining towns of Montana, would be on the average as remunerative as wheat raising.

*Production of potatoes in the year 1890 in counties of Minnesota lying mainly within the Red River Valley.*

| Counties. | Acres. | Bushels. | Per acre. |
|---|---|---|---|
| Wilkin | 202 | 17, 527 | 86. 77 |
| Clay | 1, 174 | 119, 934 | 102. 16 |
| Norman | 579 | 84, 401 | 145. 77 |
| Polk | 3, 081 | 174, 657 | 56. 69 |
| Marshall | 476 | 30, 894 | 64. 90 |
| Kittson[1] | | | |
| Total | 5, 512 | 427, 413 | 77. 54 |

[1] Not reported.

*Production of potatoes in the year 1891 in counties of North Dakota lying mainly within the Red River Valley.*

| Counties. | Acres. | Bushels. | Per acre. |
|---|---|---|---|
| Richland | 1, 972 | 247, 305 | 126 |
| Cass | 1, 645 | 251, 685 | 153 |
| Traill | 654 | 103, 550 | 158 |
| Grand Forks | 1, 157 | 243, 697 | 211 |
| Walsh | 1, 545 | 346, 767 | 224 |
| Pembina | 1, 146 | 319, 243 | 279 |
| Total | 8, 119 | 1, 512, 247 | 186 |

In Manitoba 12,705 acres were planted with potatoes in 1891, yielding 2,291,982 bushels, or an average of 180.4 bushels per acre.

Flax is considerably cultivated in the Red River Valley, chiefly south of the international boundary, the seed being sold for the extraction of linseed oil. None of the flax of this country is used for the manufacture of linen, although it seems wholly suitable for that industry.

*Production of flaxseed in the year 1890 in counties of Minnesota lying mainly within the Red River Valley.*

| Counties. | Acres. | Bushels. | Per acre. |
|---|---|---|---|
| Wilkin | 1,005 | 7,761 | 7.70 |
| Clay | 515 | 4,987 | 9.60 |
| Norman | 475 | 3,594 | 7.50 |
| Polk | 289 | 2,749 | 9.50 |
| Marshall | 210 | 1,161 | 5.50 |
| Kittson[1] | | | |
| Total | 2,494 | 20,252 | 8.12 |

[1] Not reported.

*Production of flaxseed in the year 1891 in counties of North Dakota lying mainly within the Red River Valley.*

| Counties. | Acres. | Bushels. | Per acre. |
|---|---|---|---|
| Richland | 2,079 | 24,717 | 11.89 |
| Cass | 1,745 | 19,195 | 11 |
| Traill | 1,703 | 20,436 | 12 |
| Grand Forks | 1,559 | 22,818 | 14.64 |
| Walsh | 4,927 | 77,994 | 15.83 |
| Pembina | 38 | 494 | 13 |
| Total | 12,051 | 165,654 | 13.76 |

The light, sandy soil best adapted for buckwheat is found within the prairie area of Lake Agassiz only on its deltas, and this crop has been very scantily raised.

Sorghum, which is much cultivated for the manufacture of sirup in southern Minnesota, requires a longer season than is free from frosts in the Red River Valley.

Most of the common garden produce, as peas, beans, tomatoes, beets, carrots, turnips, cabbages, squashes, melons, etc., can be successfully grown in this district; but in the heavy labor given to the staple crops, as wheat and oats, these valuable additions to the farmer's household fare have been too generally forgotten or neglected. There is, however, an evident increase of attention to these crops, both for home use and for sale in the cities.

The winter climate is too severe for apples, pears, peaches, plums, and grapes; but many hardy small fruits, as currants, gooseberries, raspberries, blackberries, and strawberries, thrive and yield bountifully wherever they receive proper care.

STOCK RAISING AND DAIRYING.

During the early years of rapid development of wheat raising, little labor or thought was given to stock and the dairy. Most of the farmers bought for their work imported horses which had been raised in Iowa or adjoining States. Butter also was imported from the same States, and the majority were willing to live without fresh meat or milk. Nowhere, however, can more favorable climate and natural conditions be found for the successful raising of all the stock needed by the farmer in diversified agriculture and for the dairy than in the Red River Valley. Recently, therefore, many enterprising farmers have secured the best blooded stock of horses, cattle, sheep, and hogs; and this portion of the farming interests of the district bids fair to assume its due importance. In the near future probably the sale of butter and cheese will form one of the principal sources of income in many townships. Poultry and eggs are also coming to be considered a needful part of every provident farmer's resources.

The following tables give the numbers of live stock in the counties of the Red River Valley in Minnesota and North Dakota. By the kindness of H. T. Helgesen, commissioner of agriculture and labor for North Dakota, the assessed valuations of the horses and cattle in the counties of that State are also noted.

*Live stock in 1891 in counties of Minnesota lying mainly within the Red River Valley.*

| Counties. | Horses, mules, and asses. | Cattle. | Sheep. | Swine. |
|---|---|---|---|---|
| | *Number.* | *Number.* | *Number.* | *Number.* |
| Wilkin | 3,373 | 5,485 | 1,387 | 1,143 |
| Clay | 6,405 | 13,201 | 6,601 | 2,326 |
| Norman | 5,682 | 13,595 | 4,656 | 2,009 |
| Polk | 13,108 | 30,214 | 9,136 | 5,720 |
| Marshall | 4,425 | 10,433 | 2,180 | 2,007 |
| Kittson | 3,917 | 7,666 | 2,042 | 1,268 |
| Total | 36,910 | 80,594 | 26,002 | 14,473 |

*Live stock in 1891 in counties of North Dakota lying mainly within the Red River Valley.*

| Counties. | Horses. | | Cattle. | | Mu les and asses. | Sheep. | Swine. |
|---|---|---|---|---|---|---|---|
| | Number. | Valuation. | Number. | Valuation. | | | |
| | | | | | *Number.* | *Number.* | *Number.* |
| Richland | 7,522 | $369,640 | 12,055 | $136,439 | 585 | 3,172 | 2,945 |
| Cass | 15,193 | 758,629 | 14,630 | 148,662 | 1,469 | 5,621 | 4,991 |
| Traill | 9,335 | 571,996 | 9,834 | 107,043 | 952 | 3,011 | 3,285 |
| Grand Forks | 12,160 | 629,454 | 13,251 | 152,548 | 712 | 10,479 | 3,594 |
| Walsh | 10,405 | 535,211 | 11,533 | 133,201 | 267 | 6,716 | 4,114 |
| Pembina | 10,280 | 501,550 | 10,147 | 118,243 | 244 | 5,697 | 4,034 |
| Total | 64,895 | 3,366,480 | 71,450 | 796,136 | 4,229 | 34,696 | 22,967 |

## GEOLOGIC RESOURCES.

The grand agricultural capabilities of the soil having been stated, as in the preceding pages, there remains little to be added relative to the more strictly geologic resources of the Red River Valley. All its outcrops of building stone, which are magnesian limestone, used also for the manufacture of lime, are situated in Manitoba. Bricks of the best quality are made from the clayey alluvium which borders the Red River along nearly its entire course after it turns northward at Breckenridge and Wahpeton. These constitute the complete though brief list of the commercially important products of the prairie portion of Lake Agassiz which belong to economic geology.

### GOLD.

Within the wooded portion of this lacustrine area gold occurs and can perhaps be profitably mined in the Archean rocks adjoining the Lake of the Woods and Rainy Lake, which also in some places include granite and gneiss valuable for building purposes. These resources have been described by the Canadian and Minnesota Geological Surveys,[1] and need not be further noticed here.

[1] Geol. and Nat. Hist. Survey of Canada, Report of Progress, 1882–83–84, pp. 1–22 K (Report on the Gold Mines of the Lake of the Woods, by Eugene Coste); Annual Report, new series, Vol. I, for 1885, pp. 140–151 CC (Notes on Economic Resources of the Lake of the Woods Region, by Andrew C. Lawson). Geol. and Nat. Hist. Survey of Minnesota, Twenty-third Annual Report, for 1894, pp. 36–105, with map (Preliminary Report on the Rainy Lake Gold Region, by H. V. Winchell and U. S. Grant).

BUILDING STONE.

Quarries of magnesian limestone have been extensively worked at East Selkirk, Stonewall, Stony Mountain, and Little Stony Mountain, partly for lime-burning, but also in large amount for foundations, bridges, and buildings. The East Selkirk stone is beautifully mottled and banded, and is easy to cut when first quarried, but hardens much when its moisture dries out. It contains so much water that newly quarried blocks in winter are damaged by freezing; but after drying no such frost fracture is observed where this rock has been used in masonry. By exposure many years the streaked contrast in color is mostly weathered out, the brown portions losing their darker color. The Volunteers' Monument in Winnipeg is a fine example of the adaptation of this stone for ornamental purposes. The quarry at Stonewall, situated close east of the village, has been opened to an average depth of 6 or 8 feet on an area about 15 rods square. Inexhaustible supplies of stone of the most durable quality, in many portions capable of being quarried in blocks of large dimensions, outcrop there and at Stony Mountain, and have been much used for building in Winnipeg. Similar stone has been slightly quarried on the northeast quarter of section 4, township 15, range 2 east, on land of Allen Bristow, 9 miles north-northeast of Stonewall. The outcrop of Cretaceous limestone on the Assiniboine, in section 36, township 8, range 11, has also been quarried in small amount.

The abundant Archean bowlders of granite, gneiss, and schists in the till or glacial drift are readily collected wherever the till forms the surface, and on these tracts they commonly serve the immigrant for the construction of foundations of farm buildings and for the walls of cellars and wells.

LIME.

The quarry of Little Stony Mountain was actively operated several years ago for burning lime, a spur track about a mile long being laid to it from the Canadian Pacific Railway; but work had been suspended at the time of my survey of the beaches of Lake Agassiz in Manitoba, in 1887.

Besides the outcrops of the bed-rock which thus supply lime, it is conveniently obtained by collecting and burning limestone bowlders that occur in the glacial drift throughout all the prairie district of Lake Agassiz and the adjoining country, having been originally derived from these rock formations and distributed by the currents of the ice-sheet. But bowlders are absent from the lacustrine and alluvial deposits along the Red River, and from the Lake Agassiz deltas.

BRICKS.

Four brickyards in St. Boniface, on the east side of the Red River, opposite to Winnipeg, produced in total in 1887 about 4,000,000 bricks. This business began to be extensively developed there in 1880. The soil is stripped off to a depth of 2 feet, beneath which the next 2 or 3 feet of yellowish, horizontally laminated, somewhat sandy clay is used for brickmaking. It requires no further admixture of sand for tempering. The bricks, which are cream-colored and very durable, are sold at $11 to $12 per thousand, loaded on the cars or delivered in the city of Winnipeg. Another brickyard in St. James, close southwest of Winnipeg, makes about 1,500,000 bricks yearly. The light cream color of these bricks, like those of Milwaukee and of most brickyards in Wisconsin, Minnesota, and North Dakota, is due, as shown by Professor Chamberlin, to the calcareous and magnesian ingredients of these glacial clays, derived in part from magnesian limestone formations, which unite with the iron ingredient to form a light-colored silicate, instead of the ferric oxide which in other regions destitute of magnesian limestone gives to bricks their usual red color.

In the Red River Valley south of the international boundary the most important localities of brickmaking are Moorhead, Crookston, and Grand Forks; but bricks have been made in small amount at numerous other places, as Breckenridge, St. Hilaire, and Warren, in Minnesota, and Grafton, Cavalier, and Pembina, in North Dakota.

A large business in brickmaking is done at Moorhead by Lamb Bros., who began in 1874; Kruegel & Truitt, who began in 1878; and John Early and John G. Bergquist, who began in 1881. Their product in 1887 was as follows: Lamb Bros., about 2,000,000; Kruegel & Truitt, also about 2,000,000; Mr. Early, 700,000; and Mr. Bergquist 125,000. The black soil is removed to the depth of 1 foot or 1½ feet; the next 1 to 2 feet of the alluvial clay is used for brickmaking, its color being dark above and yellowish beneath; the lower continuation of this deposit is unsuited for this use because of limy concretions. No sand is required for tempering. Sand needed for mortar is brought from Muskoda at the cost of about $3 per cubic yard. The bricks are cream-colored and of very good quality, selling at about $10 per thousand. Oak wood, used for fuel, costs $5 per cord.

The brickyards of Crookston, owned by Norris & McDonald, W. A. Norcross, and G. Q. Erskine, supply 2,000,000 to 3,000,000 bricks yearly, which bring an average price of $10 per thousand at wholesale, loaded on the cars. At Mr. Erskine's yard, on the south side of the Red Lake River, a thickness of 13 feet of clay is used, lying next below the superficial 2 or 3 feet of black soil, which is removed. The more sandy lower part of the clay is mixed with the upper part, by which the whole is rightly tempered.

In Grand Forks brickmaking has been carried on by J. S. Bartholomew since 1880, his product in 1887 being 1,200,000. The upper foot of soil is stripped off and the next 7 feet of clay are used, requiring no intermixture of sand.

### SALT.

The description of the artesian wells of this district given in the preceding chapter has included nearly all that needs to be stated concerning its saline well water and springs. In the early times, when the Hudson Bay Company's trading posts and the Selkirk colonists comprised all the white inhabitants of the region, the expense of importation of salt was much greater than now, and considerable quantities of it were yearly made by evaporation of the water of salt springs. One of these springs from which much salt was made for the Hudson Bay Company is situated in the channel of the South Branch of Two Rivers, about 1½ miles above its junction with the North Branch and some 6 miles west of Hallock. It is exposed only when the river runs low, and in such portions of the summers the work of salt-making was done.

The principal product of salt then used in this district, however, was from brine springs and wells on the low, flat land bordering the west side of the south end of the southeast arm of Lake Winnipegosis. This brine is so strong, according to Hind, that 30 gallons yield a bushel of salt. The product in 1874, as reported by Spencer, was about 500 bushels, sodium chloride forming 95 per cent of the manufactured salt.[1]

Brine about a third as strong as that of the salt wells of the Saginaw district in Michigan was found by the artesian wells of Humboldt, Minn., and Rosenfeld, Manitoba (pages 537 and 538). Though very pure brine, it can not be utilized in competition with the salt manufacture in Michigan, especially when the cost of fuel at the salt works there, using refuse from sawmills, is almost nothing, while on this prairie tract its cost would be about $5 per cord. A sample of salt made from the Humboldt well was exhibited at the New Orleans Exposition in 1884–85.[2]

### LIGNITE.

Thin layers of lignite coal, seldom exceeding a foot in thickness, are contained in the Cretaceous shales, probably belonging mostly to the Fort Benton formation, which are scantily preserved beneath the thick drift sheet, and are occasionally exposed in outcrops, throughout the western two-thirds of Minnesota. Here and there fragments of lignite derived from these beds are found quite plentifully in the till, and also sometimes in gravel and sand deposits of the modified drift, so that hundreds of little pieces, up to 3 or 4 inches in length, and very rarely a larger mass, are obtained in digging a well or cellar, or may be found in the ravines of streams or on lake shores. But more commonly a well dug 30 or 40 feet deep in the till encounters none or no more than two or three of these fragments. Where they abound in the drift, Cretaceous shales bearing lignite had been doubtless eroded by the ice-sheet within a moderate distance to the north, and remnants of them may still exist.

[1] H. Y. Hind, Narrative of the Canadian Exploring Expeditions, London, 1860, Vol. II, pp. 43–45. J. W. Spencer, Geol. and Nat. Hist. Survey of Canada, Report of Progress for 1874–75, p. 69.

[2] N. H. Winchell, Geol. and Nat. Hist. Survey of Minnesota, Thirteenth Annual Report, for 1884, pp. 41–46.

Within the area of Lake Agassiz lignite fragments have been thus found plentifully in many localities, among which the following may be specially noted: In digging a cellar close south of the Mustinka River, in section 32, township 127, range 47, near its entrance into the north end of Lake Traverse; in wells near Tintah and at Campbell, Minn.; in a ravine which intersects the Herman and Norcross beaches, in sections 32 and 31, Keene, 8 miles north of Muskoda, Clay County; in the sand of the artesian wells on the Lockhart Farm, Norman County, at the depth of 141 to 157 feet; similarly in sand between 161 and 165 feet below the surface in artesian wells at Carman, Polk County; along the channel of the South Branch of Two Rivers, in the southwest part of township 160, range 44, at a distance of a half mile to 2 miles east of its crossing by the Roseau Lake trail, as reported by Mr. Charles Hallock and Maj. S. Holcomb, the largest piece found being about 1½ feet square and 4 inches thick; and on the Roseau River, in Manitoba, about 20 miles east of Dominion City. Pieces of lignite are somewhat frequent on portions of the shores of Red Lake, Lake Winnebagoshish, and Namekan Lake, the last lying on the international boundary, next southeast of Rainy Lake. They also occur in gravel beds of the Pembina delta of Lake Agassiz, having been especially noticed at the springs in the south bluff of the Pembina River, 2 miles south of Walhalla.

It is not advisable, however, that any search should be made for discovery of lignite beds in remnants of the Cretaceous strata still existing within this lacustrine area; for, while the lignite is of poor quality for fuel, all its numerous known deposits thus occurring in several counties in Minnesota, and on the Sheyenne and in the Turtle Mountain, North Dakota, are too thin to be worked. On the upper portion of the Souris River, in Manitoba and North Dakota, from the vicinity of Minot northward, and on the Northern Pacific Railroad, 40 miles west of Bismarck, beds of similar lignite, but belonging, as in Turtle Mountain, to the Laramie series, the highest of the Cretaceous, ranging up to 8 feet in thickness, have been successfully mined, their product being used for fuel by many settlers in this vast prairie region.

## NATURAL GAS.

A few years ago, after the wonderful discoveries of natural gas in Pennsylvania and Ohio, many people held the delusive hope and belief that it could be obtained in valuable amount by boring deeply in almost any locality or geologic formation. In the Red River Valley this hope was fostered by the occurrence of combustible gas issuing from wells in the drift in Arthur Township, Traverse County, at Argyle, and in section 10, Wanger, Marshall County, Minn., and near Argusville and Gardner, at Hillsboro, near Cummings, and near Mayville, in North Dakota. These flows of gas, though readily ignited and burning for a time with considerable flame, are of small amount, and are probably derived from fragmentary lignite and other vegetal matter very scantily contained in the drift.

To test the questions whether either artesian water or gas could be obtained from the rock formations underlying the drift at Moorhead, a well was bored there in 1889 to the depth of 1,750 feet (page 556). Below the depth of 365 feet this boring, which was done at public cost by order of the city government, was in Archean granitoid and gneissic rocks, in which a large expenditure was wasted after the State geologist, Prof. N. H. Winchell, had informed the mayor that the samples of the drillings forbade "any hope of obtaining artesian water or other product of value."[1] It is well-nigh certain that nowhere in this lacustrine area can either lignite or natural gas be found in such quantity as to be practically utilized.

## WATER POWER AND MANUFACTURES.

Very valuable water powers, some of which are now used, while many others have not been improved nor surveyed, exist on the head stream of the Red River above Breckenridge, on its tributary, the Pelican River, on the Red Lake River and its tributary, the Clearwater, on the Rainy and Winnipeg rivers, at the Grand Rapids of the Saskatchewan, and on the Nelson. There are also small and less constant water powers, several of which are utilized, on the Buffalo and Wild Rice rivers, in Minnesota, on the Sheyenne, Goose, Turtle, Forest, Park, and Pembina rivers, in North Dakota, and on the Souris and Assiniboine rivers, in Manitoba.

[1] Geol. and Nat. Hist. Survey of Minnesota, Bulletin No. 5, 1889: Natural Gas in Minnesota, p. 39.

The Red River (pages 54–56) has four improved powers, varying in head from 10 to 15 feet, in the city of Fergus Falls. Moderate expense in the construction of dams to make Ottertail, Rush, and Pine lakes reservoirs, filled in spring several feet above their present level and drawn down in time of drought, would much increase the available water power of this river at Fergus Falls and along all its extent from Ottertail Lake to Breckenridge. In this distance the river falls nearly 375 feet, averaging 5 feet per mile. Its bed is the hard, stony clay of the glacial drift, affording a good foundation for dams, and along most of this distance the sloping river banks permit the water to be carried in canals so as to furnish any amount of head desired for milling purposes. On the west the wheat of the Red River Valley, and on the east oak, maple, ash, and pine timber, invite the further utilization of this magnificent water power.[1]

A series of lakes that are the sources of the Pelican River, tending to equalize its flow in wet and dry seasons, and the descent of this stream about 200 feet from Lake Lizzie to its mouth, with a channel and banks of glacial drift, make its water power almost equally valuable with that of the Red River.

Large lakes which serve as reservoirs also give a high degree of constancy to the water power of the Clearwater and Red Lake rivers (pages 52–54), already partially utilized at Red Lake Falls and Crookston, and especially to the power of the falls of the Rainy River at Koochiching and Fort Frances (page 50), and to the many rapids and waterfalls of the Winnipeg River (pages 51, 52). These streams will doubtless some day become the sites of large manufacturing cities, where the wheat of the prairies will be made into flour and the timber of the adjoining forests will be manufactured into lumber, paper, furniture, and various wooden wares. While agriculture will be the leading occupation in the prairie region of Lake Agassiz, more diverse industries will grow up in the wooded country of its eastern and northern portions.

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[1] For details of the water power of the Red River and its tributaries, see "The water power of the Northwest" (pp. 104), by James L. Greenleaf, in Tenth Census of the United States, 1880, Vol. XVII.