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UDC: 551.586: 63(712.7)

PRICE: ¢ 50

ABSTRACT

Meteorological information obtained from Hudson's Bay Company archives, explorers and settlers diaries and journals, dendrochronological analysis, and lake level variations has been combined with instrumental data recorded at Winnipeg from 1872 to 1975 to derive a chronological sequence of agricultural weather in the Red River Basin of southern Manitoba over the period 1800 to 1975. The agricultural weather has been broadly categorized as dry, average, or wet. Generally, the climate has been favourable to agriculture for approximately the past thirty five years and especially since 1964. A return to the past dry agricultural climate which occurred in the 1840's, and from 1883 to 1894, or to the generally dry though variable 1920's and early 1930's, or to the wet agricultural climate which occurred in the 1850's and from 1875 to 1881 would have an adverse effect on crop production.

Acknowledgements

References to nineteenth century agricultural weather in the Red River basin were extracted from a collection of weather accounts of early Canadian traders and settlers compiled by the late A.B. Lowe. Apparently Mr. Lowe undertook extensive searches of libraries, the Public Archives of Manitoba and Canada, and the Archives of the Hudson's Bay Company to obtain much of this material.

Background information describing the progress of the development of the Red River Settlement and eventually the province of Manitoba was obtained from the excellent book by J.H. Ellis titled "The Ministry of Agriculture in Manitoba 1870-1970".

Instrumental meteorological data from Winnipeg were extracted from the climatological archives of the Atmospheric Environment Service.

Thanks to Valerie Moore for typing the final manuscript and to Jim Woods for his drafting of illustrations.

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AGRICULTURAL WEATHER IN THE RED RIVER BASIN OF SOUTHERN MANITOBA OVER THE PERIOD 1800 TO 1975

INTRODUCTION

Long range forecasts of climate and weather, annual and seasonal, would be invaluable in agricultural planning and decision making. Computerized models such as the Global Circulation Model might someday provide the necessary predictive methods for successful long range forecasts, however, predictive skills in weather forecasting for any more than a few days are still quite low and no breakthrough appears imminent. An alternative aid to planning might be the use of historical climatological information to select viable scenarios based on the premise that what has occurred before can occur again.

Complete meteorological instrumental data are available since approximately the 1850's in eastern Canada and the 1880's in the Canadian prairie agricultural zone. This constitutes a very small fraction of the present interglacial climatic record. Therefore one has to incorporate "proxy" methods of extending one's knowledge of past climates. Dendrochronological analyses, and lake sediment studies have been used with considerable success in regions of North America, particularly western United States. However, a wealth of climatic information can be extracted by another method. Wherever man has settled, directly or indirectly he has documented weather. For example, in Europe where detailed archives of the last 900 years history are available, frequency references to wine harvest dates have enabled historians

and climatologists (Ladurie, 1971) to derive a chronological sequence of climate fluctuations. Moodie and Catchpole (1975) have interpreted Hudson's Bay Company journals to derive a series of freeze-up and break-up dates of estuaries on Hudson Bay 1714-1871. They attempted to remove the subjectivity factor by using content and contingency analyses on the data.

Some historians and paleoclimatologists have misused this type of information by attempting to verify solutions that they have already hypothesized or by attempting to exact detail too fine; however, by setting broad limits on the data and by not trying to twist the data to accommodate the researcher's views one should be able to obtain meaningful climatic information.

Although the Canadian prairies have been settled barely a century the great fur trade companies of the 18th and 19th centuries knew the region well. Fur traders and explorers set up a network of forts and trading posts from Lake of the Woods to the Rocky Mountains and as far north as Great Slave Lake as early as 1800. The greatest centre of activity took place in the Red River basin of what is now Manitoba. As food supplies were not always readily available these early Manitobans were forced to practice subsistence farming to survive. References to weather contained in the journals and diaries of these early settlers have allowed the derivation of a fairly complete climatological sequence of agricultural weather in southern Manitoba for the last 175 years.

PROCEDURE

A chronological sequence of agricultural weather for the Red River Basin from 1800 to 1871 has been accomplished by piecing together climatic information obtained by sifting through journals, diaries, fragmented meteorological records of early settlers and traders and reinforcing where necessary with data derived from dendrochronological analyses and lake level variations. The agricultural weather from 1872 to 1975 was derived from meteorological observations taken at Winnipeg (table 1). The crop seasons have been typed as dry, average, or wet. In the analysis I have attempted to take into account, where pertinent, pre-growing season soil moisture conditions, spring planting weather, growing season precipitation and heat stress, and harvest weather. Pre-growing season and growing season precipitation were taken as average if the precipitation amounts were within the limits of $\pm$ 15% of the long term average. A crop season is typed according to the parameter which had the most apparent effect. For example if late summer and early fall weather was wet, which adversely affected the harvest, then the agricultural crop season was typed as wet. Similarly, if the growing season precipitation was "borderline" dry but still within the limits of $\pm$ 15% of normal and if heat stress in the growing season was significant, then that crop season was classified dry.

The procedure using these proxy data, although subjective, should be reasonably accurate within the broad limits of the three types of agriculture weather. Also, verbal description of climatic events were compared to instrumental data in the 1870's to determine their relative agreement.

AGRICULTURE AND CROP SEASON WEATHER 1800-1975

The great North West fur trade exploited by the English, who were based at trading posts and forts along the perimeter of Hudson Bay, compelled the French traders and explorers to establish trade routes throughout the Great Lakes. Ultimately, French fur trading posts and forts were constructed in southern Manitoba[1] and bitter strife between the French and English ensued. Subsistence farming was practiced at many of these posts to supplement the food supply normally obtained from hunting and trading with the natives (Ellis, 1971). These establishments were abandoned in 1760 during the English-French conflict in New France. With the capitulation of New France, independent traders began by 1765 to contest the fur trade with the Hudson's Bay Company. More trading posts were constructed and with the founding of the North West Company in 1787 and the rival New North West Company[2] in 1798 the fur trade conflict approached its zenith.

References to weather from 1800 to 1809 in the journals of Samuel W. Harmon and Alexander Henry, employees of the North West Company, suggested a climate marked by extremes such as floods, frost, drought and the incipient grasshopper plagues.

> *1800* *August 28 "The drought has been so great this season that there is no water in this little river". (Plum River near Calf Mountain in southern Manitoba.)*

1. Fort Maurepas was built near the mouth of the Winnipeg River in 1734-35.

2. These companies merged in 1804 to form the North West Company of Montreal.

1803 May 24 "Set off for Portage la Prairie. We found much water on the plains. Mosquitoes by the millions."

May 31 "Too much water on the plains for our horses to proceed."

Henry Journal

1804 July 17 "We already have had so hard a frost as to injure many things in the garden."

October 26 "The canoes go no further up the river due to the shallow water at this season."

Journal of D.W. Harmon (Swan River Department of North West Co.) Fort Alexandria on upper Assiniboine

1805 June 1 "The river is very low as we have not had a drop of rain since last autumn."

Journal of D.W. Harmon, Pine Fort (Assiniboine near Pine Creek)

"The potato crop failed due to the excessive heat which scorched everything early in the season."

Henry Journal, Red River

1806 June 26 "Water extraordinarily high on Red River. Continued storms."

Henry Journal.

July 7 "The travelling was tedious from the heavy rains. In many places we found several feet of water."

Henry Journal (Pembina)

August 13 "The summer's extraordinary rain, having overflowed the low country has caused the buffalo to resort to the highland southward. Famine general amongst the Indians."

Henry Journal

1808 *June 25 "Swarms of grasshoppers have destroyed the greater part of my garden. The very trees are stripped of their leaves."*

Henry Journal (Pembina)

1809 *"The natives affirm that in 1809 the water rose unusually high." (Selkirk Settlement)*

Alexander Ross: The Red River Settlement. Its Rise, Progress and Present.

In order to compete more successfully for the fur trade with the North West Company of Montreal, the Hudson's Bay Company set about to establish a colony at the forks of the Red and Assiniboine Rivers. Besides serving as a western terminus,the settlement would be required to produce a food supply for the traders. A shareholder, Lord Selkirk, was granted a large tract of land (figure 1) for a nominal fee with the stipulation that an agricultural colony of specified size had to be established and a portion of this land had to be reserved for settlement of Hudson's Bay Company employees in retirement. The first settlers arrived in August 1812 and were continually involved in a series of skirmishes with the North West Company until a merger occurred in 1821. References to severe winters from 1812 to 1815 were offset by mention of fair to good crops as a results of beneficial amounts of rain. It should be taken into account that river lot strip farming (figure 2) was practiced allowing the use of the most fertile land for crops. Therefore, weather dependency was partially masked in the crop yields. This subsistence type farming prevailed well into the early 1880's.

1815 *May 25 "The last of the wheat sown. The spring very backward."*

June 2 "The crops sown some time ago come up very flourishing. Water beginning to fall a little."

Journal of Peter Fidler - Selkirk Papers - Manitoba Provincial Archives

A series of dry years began in 1816 lasting until 1819.

1818 *"At Brandon House the barley was destroyed by grasshoppers and the great and almost continuous drought entirely destroyed the potatoes, turnips, etc."*

Historical Society of Manitoba.

Reference to fair to good crops harvested in 1820, 1821, and 1824 suggest generally average weather. In 1825 and 1826 the summer seasons were particularly wet at the Red River settlement and in fact during 1826 the settlement was inundated by a severe flood.

1825 *"The year had been unusually wet; the country was thoroughly saturated. The lakes, swamps, and rivers at the fall of the year were full of water."*

Alexander Ross: The Red River Settlement

1825 *August 20 "Much damage is done to the wheat crops... by the smut and mildew, which are supposed to be the effects of the unusual high waters this season."*

Fort Garry Post Journal kept by Francis Heron, Hudson's Bay Company Archives, London.

1826 *May 4 "The water overflowed the banks of the river and spread so fast that almost before the people were aware of the danger it had reached their dwellings." "The water continued rising until the 21st and extended far over the plains. It was on the 15th of June that the settlers for the first time drew near the sites of their former habitation."*

Alexander Ross: The Red River Settlement.

From 1827 to 1830 good crops were recorded in the Red River Settlement as a result of benign weather. The 1831 census showed that

Assiniboia had a population of 2417 and a cultivated acreage of 2152 which indicated the subsistence farming practice.

Few descriptive accounts of weather are available for the next 15 years but inferences can be made by using additional proxy information such as analysis of tree ring data and records of the variability of lake levels.

Dendrochronological analyses from North Dakota (Will, 1946) which correlate well with instrumental data suggest that the period 1831 to 1836 was generally wet and probably cool.

1836 *"On the 7th of June we had a heavy fall of snow and on the following day the ice was the thickness of a penny piece on the water; but still nothing serious happened to dampen our hopes till the 19th of August when the severity of the frost blasted our fairest prospects by destroying the crops."*

Alexander Ross: The Red River Settlement

North Dakota tree ring analyses (Will, 1946) and declines in the Great Lakes water levels (Hope, 1938) indicate that the years 1837 to 1850 were generally dry. It was during this period (1841) that the District of Assiniboia had been reduced to a 50 mile radius tract of land centered on the forks of the Assiniboine and Red Rivers. The 1846 population 4827 and cultivated acreage 5380, illustrated the slow growth of the District.

Descriptive accounts from Assiniboia are sketchy and cover only the last portion of the period. The 1846 crop was considered a complete failure due to drought and 1847 was referred to as a very dry season in the Red River area by Hind (1859).

1848 August 11 Lake of the Woods "On each side of the river are innumerable small shallow lakes, bearing usually large quantities of rice, but the water in them had sunk so low this season that the Indians were apprehensive of a failure in the crop."

Diary of Paul Kane

It can be easily concluded from the abundance of information available that the period 1851 to 1861 was marked by average to very wet years. Floods inundated the settlement in 1851, 1852 and 1861. The May flood of 1852 was caused by a heavy March snowfall augmented by heavy May rains.

1852 May 3 "Many settlers deserting houses due to rising water."

May 5 "Heavy rain."

May 9 "From Pembina to the Settlement is a vast lake."

May 21 "The water at its height."

Notes of Red River flood .....
Bishop Anderson

1854 August 14 "Owing to dry weather there was every appearance of a failure of the wheat crop but the fields have been plentifully watered since and there is an abundant crop."

Rev. John Black, Red River to James Ross, Toronto.

During the period 1855 to 1859 meteorological measurements (Smithsonian Institution, 1861, Hind, 1859) were taken at the Stone Fort[3] by Donald Gunn, a leading figure of Assiniboia of that era. Probably due to the remoteness of the Red River Settlement from the rest of what was then Canada the measurements were filed with Smithsonian Institution in Washington. In 1855 Gunn measured 15.125 inches of rain in July and 13.500 inches in August,

3 The Stone Fortwas located near the present day site of Selkirk, Manitoba.

amounts which are unequalled in the 1872-1975 meteorological record at Winnipeg. It would be tempting to discount these measurements but for two factors. Perusal of 1855 observations for several nearby U.S. stations discloses high amounts of precipitation e.g. Lac qui Parle (Hazelwood), Minnesota, 45°N 95° 30'W, recorded 10.5 inches in August. It should also be noted that Gunn was an approved Smithsonian observer using rain gauges which were the best available at the time.

Schott (1881) briefly reviewed rain gauges and measuring practices adopted in the 1850's by the Smithsonian Institution.

> *"Rain-gauges adopted by the Smithsonian Institution. The following is an extract from the "Directions for Meteorological Observations adopted by the Smithsonian Institution, for the first-class Observers," in the annual Smithsonian Report for 1855 (Washington, 1856): "The ombrometer, or rain-gauge, is a funnel accompanied by a graduated cylindrical glass vessel, and by a reservoir. It should be placed in an open space. Trees, high buildings, and other obstacles, if too near, may have a considerable influence in increasing or diminishing the quantity of rain which falls into the funnel. The surface of the receiver should be placed horizontally about six inches above the ground." Next follows a simple mode of establishing this gauge, accompanied by a wood-cut of the same. Directions for observing are given as follows: -*
>
> *"To make the observation, remove the funnel and pour the water from the jug into the large graduated glass cylinder. The opening of the funnel being one hundred square inches, one inches of rain in depth gives one hundred cubic inches of water; and each division of the glass containing a cubic inch of rain fallen into the ombrometer. These degrees are large enough to permit us to estimate the thousandths of an inch, etc., etc."*

Conservatively, it can be concluded that the year 1855 was very wet.

1856 *September 8 "The month of July was extremely wet. Our hay land in parks and everywhere else was drowned. The month of August has been dry. If we had hands hay could now be got in the parks in abundance. The harvest season has been beautiful.*

Letter to James Ross from Alexander Ross, Red River

1857 *"A wet spring caused delay in planting wheat. Excellent crop of vegetables in fall."*

The Hind Report [4]

1860 *July 14 "Very wet weather continuing and crops suffering from too much moisture."*

Red River Settlement - the Nor-Wester Newspaper

1861 *May 1 "As we write the waters of the Red River have almost rolled in at our doors; and there is every indication that we are on the eve of a great flood. .....The unusually large quantity of snow which fell during the winter has entirely disappeared within the last fortnight."*

July 1 "We have had very rainy weather during the past three weeks. The crops are suffering somewhat. The spring was long cold and disagreeable."

September "Haymaking a problem due to the quantity of water."

The Nor-Wester Newspaper

Drought and grasshoppers dominated the agricultural scene from 1862 to 1864. There were frequent references to low river levels inhibiting steamboat travel on the Red River and preventing water mills from grinding. 800 bushels of seed grain has to be imported from the United States in 1862 and 1865.

4 See map of Red River Settlement drawn by Dawson or Hind expedition in 1859 (Figure 3).

1863 July 8 "The want of rain is becoming a serious matter with farmers. The season thus far has been a very dry one and cereal crops look parched. On Saturday last the thermometer registered 101° in the shade."

The Nor-Wester

1864 "The heat of the summer of 1864 at Red River was so extreme that nobody in the settlement remembered such another. The thermometer sometimes continued for a considerable portion of the afternoon at 100° in the shade. The river sank and theInternational made only 1 trip, that being the first she had been able to accomplish for nearly 2 years, during which she had lain, unharmed throughout the Indian War at Georgetown and Fort Abercombie. The droughts prevailed until the middle of July when rain for the first time visited the parched ground."

J.J. Hargrave, Red River

The droughts of the early 1860's were relieved by a series of generally good crop seasons 1865 to 1867 but drought returned in 1868.

1866 June 11 "Have had very rainy weather, prospect of good crops if grasshoppers do not devour them."

William Inkster, Red River
to James Ross

September 4 "Heavy crops here."

John Black, Red River
to William Coldwell

1868 "The crop of 1868 was a complete failure - even seeds having to be imported (due to drought and grasshoppers)."

The Nor-Wester February 12, 1869.

In 1869 the Dominion of Canada bought from the Hudson's Bay Company Ruperts Land which included the district of Assiniboia. This also marked the year that James Stewart, a druggist, began taking meteorological observations for Winnipeg. Unfortunately these early records were lost and its not until

1872 that a file of meteorological instrumental data was maintained.

1869 *June 26 "This is a remarkably cool summer for Red River. Many of the old settlers do not remember having seen one so cold. The crops present a very luxurious appearance."*

August 24 "Never before have the crops looked better than they have this summer. In many instances the wheat is 6 feet in height."

The Nor-Wester

By 1870, Winnipeg, which had sprung up outside Fort Garry, had become a village of 215 and consisted of about 30 buildings - 8 stores, 2 saloons, 2 hotels, a mill and a church (Ellis, 1971). Concurrently southern Manitoba became a province of the Dominion of Canada.

Fragmented meteorological measurements and descriptive accounts published in the Nor-Wester and the Manitoban imply that 1870 and 1871 were dry although good crops were reported in 1870.

The Meteorological measurements taken at Winnipeg from 1872 to 1975 are used to type the crop season weather by methods previously explained. The Winnipeg site should be fairly representative of the north Red River Basin. A brief description of the climatic fluctuations is contained in the following paragraphs.

The years 1872 and 1873 were wetter than average. Good crops were alluded to in 1872 although grasshoppers plagued Manitoba in 1873. After an average crop season in 1874 and a dry year with the ever present grasshoppers in 1875 a string of wet years followed which possibly influenced migration patterns in the Canadian west (Morton, History of Prairie Settlement). Some immigrants, discouraged by the heavy spring rains which reduced the land to a quagmire moved westward into Alberta and Saskatchewan and northwestward into the Dauphin region where the climate was drier.

The building of the Pembina Railroad line in 1878 and the Canadian Pacific Railroad line in 1385 was important for two reasons. First, the railroads provided easier transportation to Manitoba; subsequently, immigration rapidly increased. Secondly, the transportation arteries leading to southern Manitoba could be utilized for exporting grain. As a result, the cultivated acreage increased to 250,000 acres in 1881 and rapidly multiplied thereafter. Traditional fallowing practices were initiated during this era. The period from 1883 to 1894 was generally cool and dry with 1890 being an exception when growing season precipitation was 178% of the long term average. Droughts occurred in 1886, 1889 and 1894[5] when the growing season precipitation was 37%, 56% and 44% respectively of the long term average. Although these years were not conducive climatically to agriculture, they were far less severe than those experienced further west. For example, Indian Head in southeastern Saskatchewan received only 3.9 inches precipitation for the entire year 1893.

From 1895 to 1899 the agricultural weather was on the whole cool and of average precipitation other than the wet year of 1896 which stimulated the growth of wheat rust.

The twentieth century opened with a warm dry crop season in which the worst provincial wheat yields ever were recorded (8.9 bushels/acre). A sequence of cool, wet crop years from 1904 through 1906 was accentuated by rust outbreaks in 1904 and 1906. From 1907 to 1910 the crop seasons were average to dry. A warm dry growing season in 1910 resulted in provincial wheat yields of only 12.4 bu/acre. The period from 1911 to 1919 in the Red River basin of Manitoba was unique in that the crop seasons were of varying degrees of dryness or wetness. Climatically, no years could be classified as being average. Rust

5 1894 was a particularly hot summer, the June to August mean daily temperature averaged 2.6°F above normal.

in 1916 and 1919, both warm wet years, lowered crop yields substantially.

Much has been said of the drought and depression years 1929 to 1937 in the Candian west but climatically speaking the 1920's were just as unconducive to agriculture in the Red River Valley. From 1920 to 1936 6 crop seasons can be classified as wet, while 11 crop seasons can be classified as dry. As in the 1911 to 1919 period no crop seasons could be typed as average climatically. Wet weather stimulated rust outbreaks in 1921, 1927, and 1935. The two driest growing seasons occurred in 1924 and 1925 when precipitation was only 55% and 45% of the long term average, respectively. Although, taken as a whole, this climatic period was warm and dry it was also a period marked by extremes. There were frequent references to droughts, cold winters, frost, rust, grasshoppers, etc. It is no wonder that crop yields were well below average.

The era from the late 1930's to the present has been called the technological age of agriculture on the prairies. Rust resistant varieties of wheat were developed while land erosion and soil moisture conservation practices had been adopted largely as a result of the effects of the twenties and thirties droughts. Better machinery and increased dressage of soils with fertilizer nutrients all contributed to produce, overall, high wheat yields in the Red River Valley from 1937 to 1975. It can be observed, however, that the climatic pattern is markedly different from that experienced from 1911 to 1936. In that climatic period a dry precipitation regime was experienced with a 58% frequency and a wet regime occurred with a 42% frequency. During the 1937 to 1975 period the frequency of dry crop seasons was 28%, average crop seasons[6] 33%, wet crop seasons 39%. Concurrently, perusal of historical wheat yields in the Red River Basin (Figure 4) shows a distinct trend towards increasing yields in this period.

6 Near normal weather produces the best wheat yields. (Thompson, 1975)

The peak yields from 1941 to 1943 can be downplayed somewhat since acreage was low and production probably from the best croplands. A simple inspection of wheat yields since 1964 seems to indicate the trend has levelled off. This also appears to be an optimum climatic period for crop production (no droughts, ample precipitation, and little heat stress). Briefly, although technology has played a large role in increased yields of grain crops, the importance of benign weather during the period from 1937 to 1975 and especially during the last 12 years cannot be ignored.

SUMMARY

Meteorological information obtained from Hudson's Bay Company archives, settlers diaries and journals, dendrochronological analysis, and lake level variations has been combined with instrumental data recorded at Winnipeg from 1872 to 1975 to derive a chronological sequence of agricultural weather (Figure 5) for the period 1800 to 1975 in the Red River Valley of southern Manitoba.

Perusal of meteorological information from the nineteenth century indicates a highly variable climate in the early 1800's. It appears that the Selkirk settlers were subjected to times of hardship caused by drought from 1816 to 1819 culminated by floods in 1825 and 1826. The cool wet early 1830's were highlighted by reports of snow and ice on the water in June 1836. The little information that is available suggests that the 1840's were predominantly dry. The agricultural climate changed drastically during the 1850's and early 1860's to an anomalously wet climate with floods occurring in 1851, 1852, and 1861. Droughts were documented in 1862 through 1864 and in 1868. Agricultural weather was highly variable in the early 1870's but a wet climate from 1875 to 1881 returned to highly influence the migration patterns in the Canadian west. A cool dry climate with frequent droughts prevailed from 1883 to 1894. Briefly, the climate during the close of the nineteenth century and the first twenty years of the twentieth century was highly variable with no distinctive pattern.

The agricultural climate from 1920 to 1936 was generally warm and dry, although 6 years could be categorized as wet. Wheat rust was prevalent in 1921, 1927 and 1935. The remaining years were typed as dry with several of these of the drought category. These droughts were not as severe as those experienced in southwestern Manitoba and in Saskatchewan.

The climate pattern of the 1937 and 1975 period, especially during the last 12 years, was more favourable to crop production than any decades earlier in the twentieth century. Dry crop seasons occurred with a frequency of 28%, average 33%, wet 39%. This can be compared to the 175 year average frequency of 26% for average crop season weather, 40% for dry crop weather, and 34% for wet crop weather. Therefore, it appears that the agricultural weather from 1937 to 1975 was decidedly better than the long term average. A return to past dry climates or abnormally wet climates would obviously have an adverse effect on crop production.

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TABLE 1

YEAR	Pre-growing Season precipitation (inches) (Oct. thru April)	Growing Season precipitation (inches) (May thru July)	Summer Ave Temp. (^{o}F) (June thru Aug.)	Harvest precipitation (inches) (Aug. and Sept.)
1873	Missing	Missing	65.7	5.99
1874	Missing	Missing	66.4	3.75
1875	6.16	6.71	63.7	2.90
1876	5.73	8.47	64.0	7.84
1877	5.44	14.40	63.8	2.58
1878	9.95	9.54	67.0	1.83
1879	8.30	14.30	64.7	2.54
1880	6.89	10.32	63.2	7.72
1881	6.24	Missing	64.7	3.65
1882	4.91	Missing	63.3	2.30
1883	9.42	6.81	61.6	4.95
1884	11.90	5.17	61.9	10.68
1885	7.07	7.64	60.9	2.73
1886	5.87	3.06	65.3	5.92
1887	6.06	7.97	63.8	3.26
1888	6.33	7.16	62.9	2.62
1889	7.42	4.62	64.7	3.62
1890	7.04	14.73	64.7	6.11
1891	7.73	7.58	61.1	6.10
1892	8.52	6.82	63.9	4.59
1893	9.12	11.52	65.1	2.18
1894	11.66	3.61	67.3	2.97
1895	8.12	9.35	61.3	2.15
1896	11.97	11.29	63.5	3.47
1897	6.96	9.28	62.9	1.34
1898	8.10	8.76	63.1	4.65
1899	13.42	7.84	64.2	4.33
1900	4.74	6.02	66.3	7.88
1901	6.35	13.55	64.8	5.50
1902	5.82	8.66	63.1	2.94
1903	5.75	6.94	62.7	4.77
1904	7.69	11.54	61.9	3.50
1905	5.98	12.32	63.2	2.97
1906	6.29	12.64	65.4	2.84
1907	7.84	6.49	63.5	4.59
1908	7.12	7.88	63.8	4.33
1909	9.15	6.63	66.2	5.35
1910	10.35	4.83	66.6	4.89
1911	8.21	11.61	64.2	4.76
1912	6.05	10.61	63.4	7.13
1913	4.17	5.90	64.9	5.99
1914	4.74	10.25	66.1	4.33
1915	7.20	5.21	62.1	5.02
1916	9.92	9.43	65.2	4.38
1917	6.87	5.43	64.1	3.63
1918	5.81	6.54	63.4	3.80
1919	8.89	10.69	67.7	6.39
1920	8.75	5.67	66.7	5.03

YEAR	Pre-growing Season precipitation (inches) (Oct. thru April)	Growing Season precipitation (inches) (May thru July)	Summer Ave Temp. (^{o}F) (June thru Aug.)	Harvest precipitation (inches) (Aug. and Sept.)
1921	9.11	7.03	67.7	6.09
1922	5.16	9.88	66.1	4.36
1923	9.02	7.57	67.1	1.74
1924	6.13	4.52	62.5	5.01
1925	9.83	3.27	65.0	5.36
1926	4.00	6.37	63.8	6.99
1927	8.68	7.63	63.5	5.39
1928	8.09	11.35	63.7	3.82
1929	5.61	5.16	66.4	2.94
1930	6.37	11.88	68.2	2.27
1931	6.82	6.64	67.1	5.25
1932	8.58	6.10	67.5	3.42
1933	7.86	7.85	67.9	6.32
1934	7.72	6.55	63.2	7.62
1935	7.92	7.79	64.6	6.38
1936	8.04	5.22	67.6	2.55
1937	7.96	7.35	67.1	4.41
1938	7.56	7.00	66.0	1.98
1939	6.25	5.28	65.8	7.13
1940	4.21	7.07	65.0	2.28
1941	7.28	8.76	65.6	9.66
1942	8.81	9.93	63.5	4.12
1943	6.33	10.47	64.9	4.47
1944	4.51	10.23	63.5	6.97
1945	9.27	6.22	63.6	7.34
1946	6.38	4.71	64.5	5.35
1947	8.16	7.47	66.1	5.38
1948	8.52	7.45	65.8	0.99
1949	7.18	6.71	67.2	3.80
1950	13.17	9.91	61.8	4.94
1951	5.63	5.07	62.2	6.24
1952	3.89	8.81	65.0	1.96
1953	7.15	16.82	65.4	3.91
1954	7.40	9.55	64.1	7.90
1955	8.15	8.54	68.3	1.78
1956	12.00	7.54	66.3	6.17
1957	9.67	8.41	65.3	5.90
1958	4.75	8.77	62.9	1.76
1959	8.71	10.53	66.9	7.77
1960	8.84	4.19	66.1	4.02
1961	7.05	3.81	68.8	2.46
1962	6.68	13.43	65.3	7.45
1963	9.01	8.14	68.2	2.72
1964	7.40	6.91	63.5	4.16
1965	5.90	9.12	63.3	3.91
1966	8.06	6.29	65.6	4.85
1967	7.44	7.46	63.2	3.14
1968	6.01	12.82	61.1	7.94
1969	5.69	11.14	63.0	4.65
1970	7.32	8.14	67.0	7.36

YEAR	Pre-growing Season precipitation (inches) (Oct. thru April)	Growing Season precipitation (inches) (May thru July)	Summer Ave Temp. (^{o}F) (June thru Aug.)	Harvest precipitation (inches) (Aug. and Sept.)
1971	7.71	9.37	63.6	2.63
1972	6.29	5.49	63.8	6.47
1973	4.10	12.37	64.6	5.81
1974	8.68	8.10	65.4	6.13
1975	5.89	8.90	65.1	6.86
Avg.	7.39	8.27	64.7	4.67

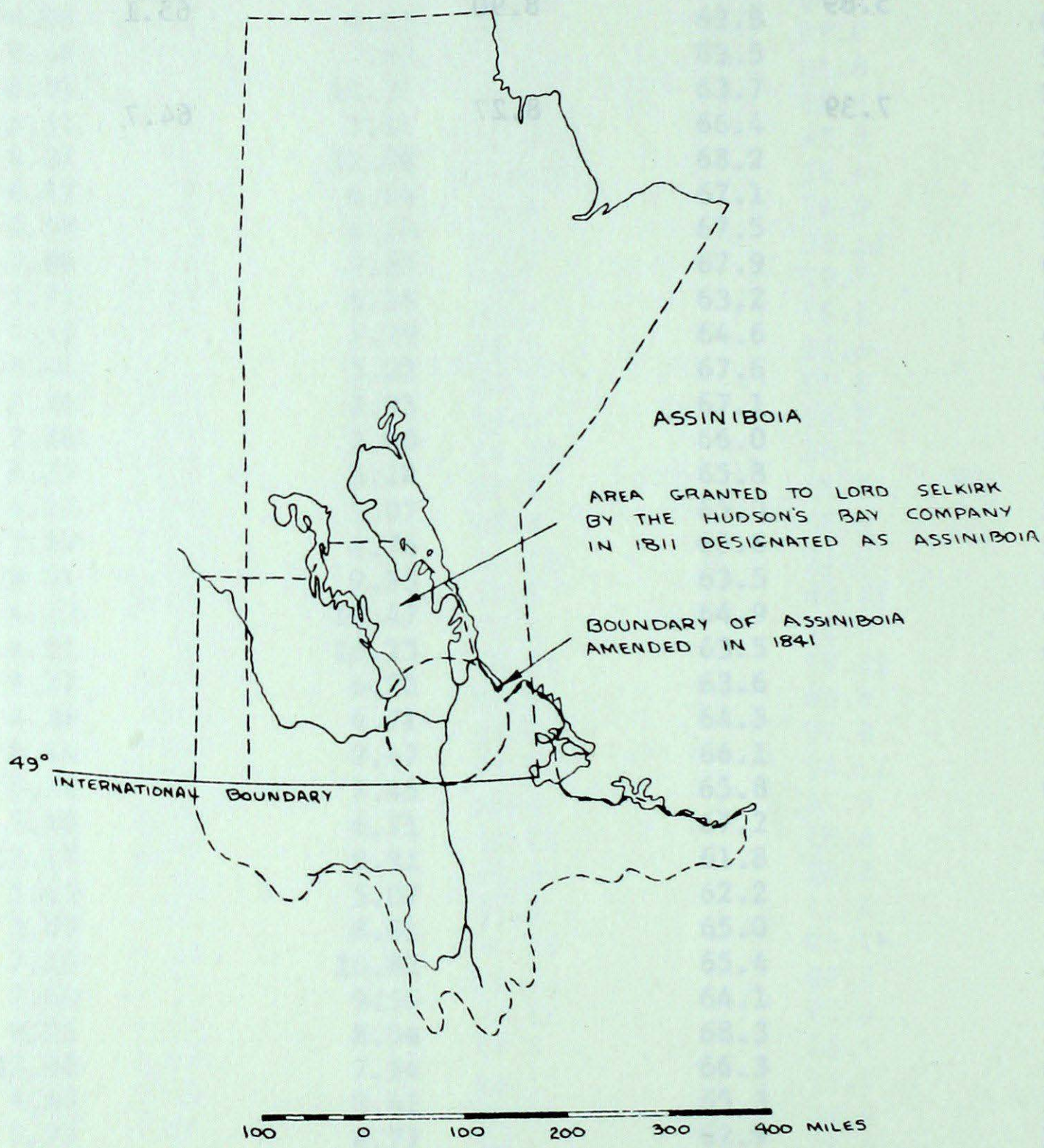

FIGURE 1: ASSINIBOIA (after Ellis 1971)

RED RIVER SETTLEMENT LOTS

SURVEYED BY PETER FIDLER, 1814

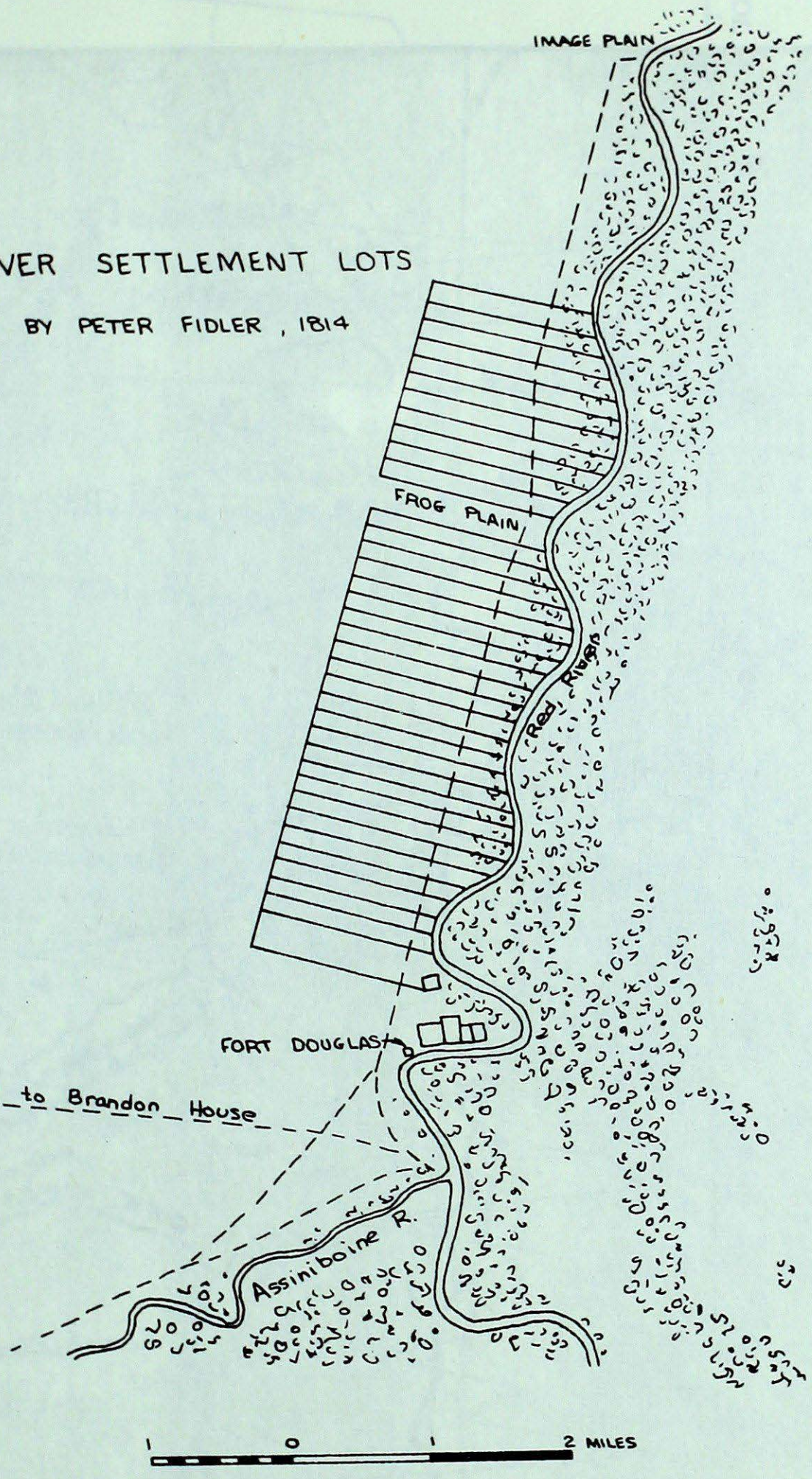

FIGURE 2 (after Ellis, 1971)

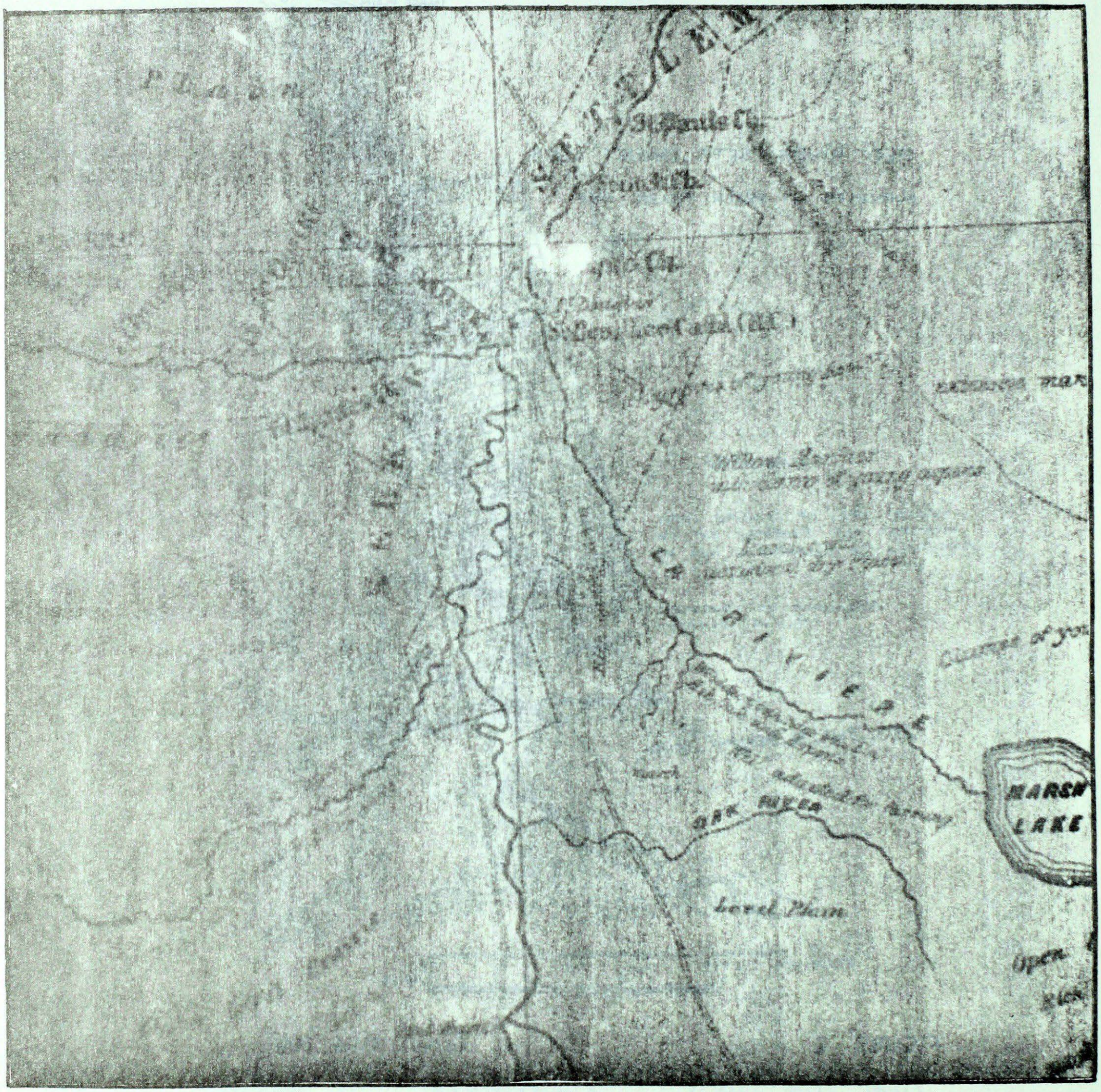

Figure 3: Map of Red River Settlement drawn by Dawson or Hind expedition in 1859

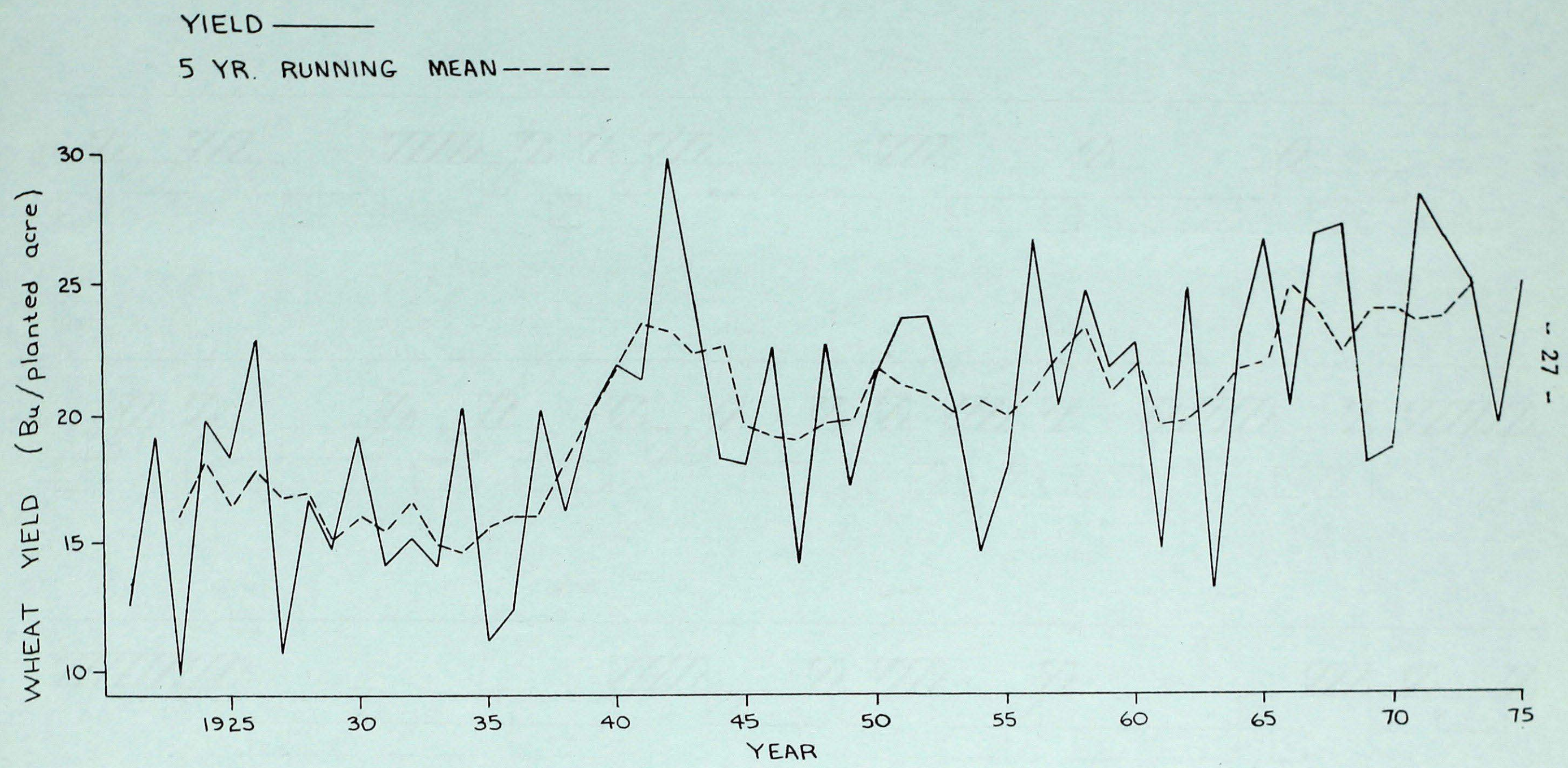

FIGURE 4: WHEAT YIELDS FOR MANITOBA CROP DISTRICTS 3, 4, 5 (RED RIVER BASIN)

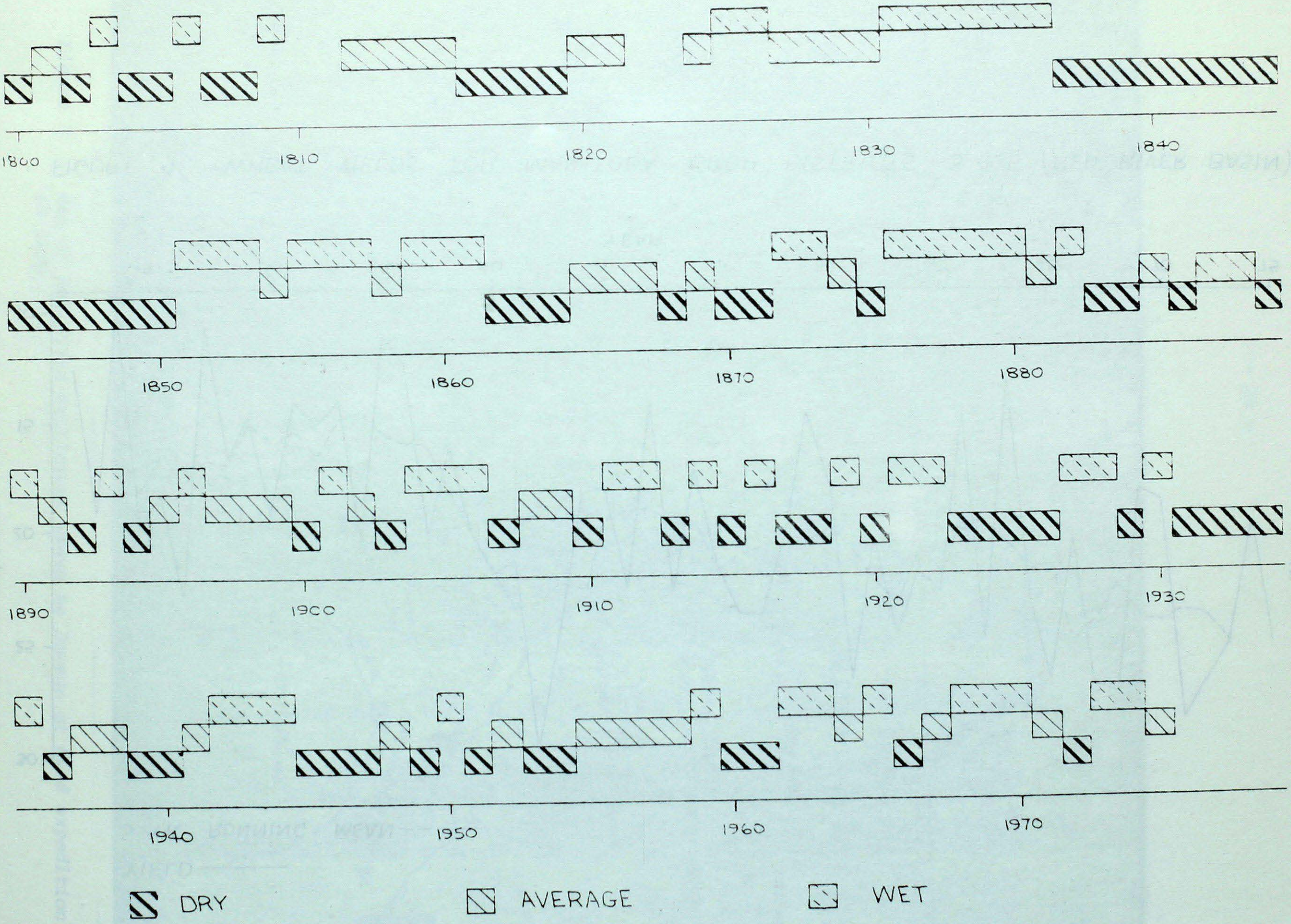

FIGURE 5 : SOUTHERN MANITOBA (RED RIVER BASIN) AGRICULTURAL WEATHER 1800-1975