EXTENSIVE DEVELOPMENT OF THE CANADIAN PRAIRIES

A MICRO ANALYSIS OF THE INFLUENCE OF TECHNICAL CHANGE

By

ANTHONY JOHN WARD

B.A., Open University, 1981
M.A., The University of British Columbia, 1984

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Department of ECONOMICS

The University of British Columbia
Vancouver, Canada

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ABSTRACT

This thesis examines the rate and pattern of settlement of the Canadian Prairies over the period of the 'Wheat Boom'. The principal aim of the work is to explain the economic reasons for the late start to that settlement.

Economic growth of the Canadian Prairies did not begin until almost the turn of the 20th. century, long after the initial occupation of the American West. I hypothesise in this thesis that the delay in the development of the Canadian Prairies was principally due to an initial lack of appropriate technology. The growing season in Canada is shorter than that further south, leaving grain farmers with little time to sow in spring and harvest in the fall. The technology available in 1880 enabled farmers to crop less than 50 acres even in the best areas, making farming uneconomical over most of the Prairie area. The technology available to the Prairie farmer over the period is carefully examined to determine the effects of various changes which occurred.

In order to analyze the implications of technological change, a number of representative Prairie farms are modelled using the technique of dynamic linear programming. Five locations which were first occupied on different dates are analyzed, and for each location the value of capitalised rent for a typical new farm is calculated on four dates. The results of these calculations show that in 1880 most Prairie land was economically worthless. Over time all the hypothetical farms showed increases in value, and settlement appears to have occurred on approximately the date at which the calculated value of the land rose above zero.

The reasons for the increases in the value of the land are examined, and the most important exogenous change appears to have been the improvement of mechanical farming equipment. The development of appropriate 'dry-farming' techniques was also important, but it is argued that this was endogenous to Prairie growth. Wheat prices did not begin to increase until about 1904 and therefore were not a cause of the start of the 'Wheat Boom', although they contribute significantly to farming profits by 1910.

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CHAPTER 1

INTRODUCTION

During the second half of the 19th. Century, social and economic conditions in Europe led to a vast migration to the empty lands of North America. Pushed by demographic pressures in the Old World, and pulled by the economic opportunities of the New, migrants moved to the cities and farms of both Canada and the US to start a new life. The growth of farming on the Canadian Prairies began later than that in the United States, and the difference between the Canadian and US experiences has become a central issue in Canadian economic history. This thesis develops farm level micro-data on costs and revenues for specific dates and places, and uses these data to explain the rate and pattern of settlement during the start of the Canadian 'Wheat Boom'.

The central finding of the analysis is that early settlement on the Prairies was constrained by the short growing season, which limited farmers to seeding and harvesting only a small number of acres. Technological improvements between 1880 and 1900 enabled cereal grains to be planted and reaped more rapidly, thereby enabling settlers to farm more land and earn greater incomes. These increased potential incomes formed the principal incentives which attracted the large numbers of settlers who migrated to the Prairies after the start of the 'Wheat Boom' in about 1896.

In the early 1870s the Canadian Prairies were still virtually empty. The few small fur trade outposts and the relatively small numbers of indigenous Indians made up almost the entire population of this vast area. South of the border the frontier was moving rapidly westward, yet little or no settlement was occurring in Canada's western land. The Macdonald government recognised the disadvantages of the geography of the Canadian west, but still could see no reason why Canada should not participate in economic growth similar to that occurring at that

time south of the 49th parallel. The government had theoretical political control over its vast western lands after Confederation in 1867, but found itself in practice unable to exert any significant influence over the area. Politicians believed that the west possessed immense resources in terms of land and minerals, but lacked the means to exploit them.

The principal instrument by which the government hoped initially to encourage economic growth on the Prairies was the construction of a transcontinental railway. At the time of joining Confederation in 1870 the province of British Columbia had obtained a commitment that a line would be completed as soon as was practical, and the Dominion government had every intention of doing so as quickly as possible. In the 1870s the absence of any significant economic activity on the Prairies was attributed to the lack of suitable transportation facilities, so every effort was directed to getting railway construction started. In the meantime the government drew up the first of its 'Dominion Lands Policies', the purpose of which was to induce occupation and development of the Prairies as quickly as possible.

The basic approach of the Dominion Lands Policy was to survey and lay out for occupancy the entire tract of land from the edge of the Canadian shield in Manitoba to the foothills of the Rockies in Alberta. Well over half the land area of the Prairies was offered to settlers on the basis of "free" 160 acre homesteads, and in the early days homesteaders also had the possibility of 'preempting' an adjacent 160 acre 'quarter section' at a low price. Of the remaining land a large portion was used as grants to railway companies to induce railway construction. That land was subsequently sold to farmers for higher prices, but still at less than the true economic value of the land[1].

The effectiveness of the Dominion Land Policies has never been clear, in that it is difficult to envisage how the Prairies would have evolved in the absence of the institutions which were

[1] See Wogin, G. "The Wealth-Maximizing Behaviour of the Canadian Pacific Railway: Lands, Freight Rates, and the Crow's Nest Pass Agreement." Ph.D. dissertation, Carleton University, 1983, Chapter 3, and discussion in Chapter 2 of this thesis.

in fact employed. The Canadian Pacific Railway connected Manitoba to the Great Lakes by the end of 1881, and there was a short-lived boom which lasted from 1881 until 1883. However, after 1883 the Prairie economy grew extremely slowly until about the turn of the Century, when the 'Wheat Boom' began, lasting then through to the First World War. The reasons for the delay until 1900 have been unclear, particularly since expansion of the American West continued rapidly during the 1880s.

The different rates of development of Canada and the United States are illustrated by Figures 1.1 and 1.2, which show the rates of occupancy of government homestead land in the two countries. In the U.S., western land was being taken up several decades before expansion of the Canadian west began, and the rush continued throughout the 1880s when there was little activity in Canada. The depression of the 1890s reduced activity on both sides of the border.

During the first half of the 19th Century it had been thought that because of inadequate rainfall the agricultural potential of the Prairies was poor. However the explorations of Dawson, Hind and Palliser in 1857 had led to a better understanding of the potential of the land. Palliser noted that whilst there was only a small amount of rain on the Prairies, that rain came mostly during the summer, and therefore a relatively greater proportion of it was available for moisture for crops.

This thesis investigates the reasons why settlement of the Canadian west occurred later than that of the United States. The economic factors facing migrants to the Prairies are analyzed in detail, in order to understand the incentives influencing their decisions as to whether and where to settle. The crux of the hypothesis developed here is that in the 1880s agricultural technology was insufficiently developed to enable farmers on the Canadian Prairies to earn enough income to afford an acceptable standard of living, and that therefore settlers looking

FIGURE 1.1

Canada - Homestead Entries, 1860 to 1920[2]

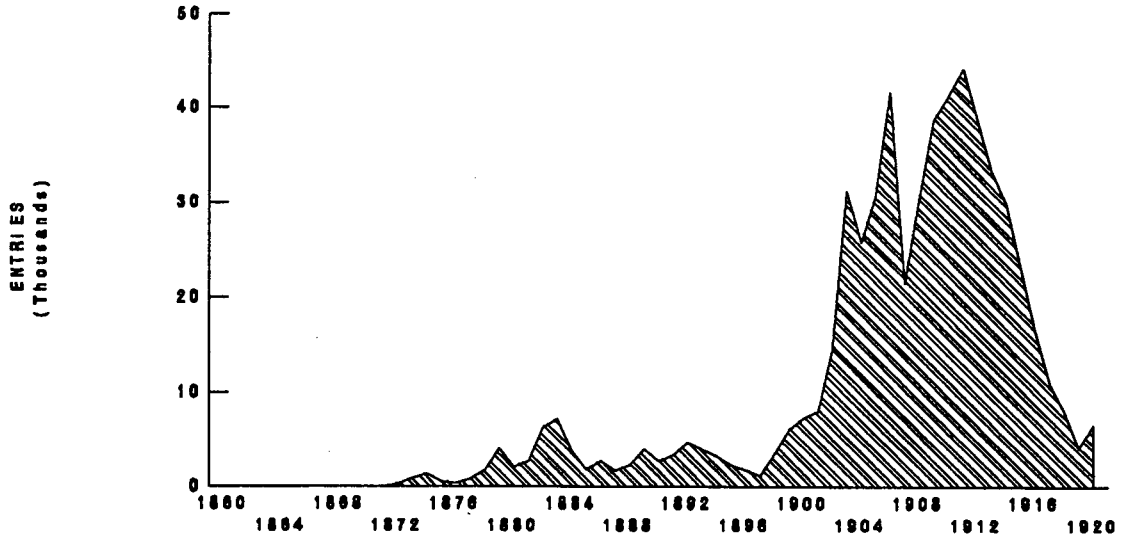
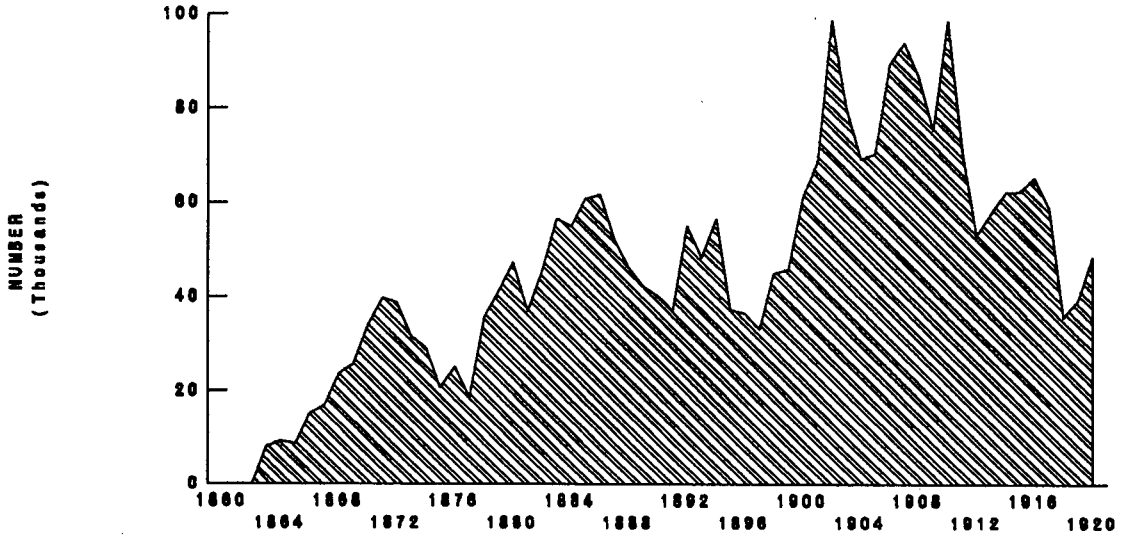


FIGURE 1.2

United States - Homestead Entries, 1860 to 1920[3]



[2] Source: M.C.Urquhart and K.A.H.Buckley, (Eds.) Historical Statistics of Canada., (Toronto: Macmillan of Canada, 1965), Series K36 to K41. Canadian data does not start until 1872.

[3] Source: U.S. Department of The Census, U.S. Department of Commerce, Historical Statistics of the United States. Colonial Times to 1970, Volumes 1 and 2., Series J13.

for a homestead went to the areas such as the Dakotas. I hypothesise that as time went by new agricultural implements were developed and new farming techniques evolved which enabled the settler on the Canadian Prairies to achieve more with his labour, and thus to earn a greater income. As this process of technical change took place the 'feasible region' - the area of the Prairies on which farming was economically viable - expanded, and new settlers arrived to occupy the now feasible land.

HYPOTHESIS AND ANALYSIS

Hypothesis

The hypothesis examined in this thesis is that prior to 1880 the short growing season on the Canadian Prairies restricted farm profitability to levels below those necessary for viability. Between 1880 and 1900 there was a considerable amount of labour augmenting technical change, enabling the labour constrained Prairie farmer to increase the area of land which he could cultivate. Profitability increased, inducing migrants to select homesteads on the Canadian rather than the American Prairies. After the 'Wheat Boom' had started in about 1900, there were significant increases in commodity prices, which increased Prairie farm profitability considerably, encouraging the large numbers of settlers who moved to the area before the start of the Second World War.

This hypothesis is tested by analyzing farm profitability. The assumption of profit maximization as the predominant motive of migrants yields the prediction that settlers choosing where to live would go to the location having the highest expected capitalised value. A major reason for the initial low profitability was the lack of agricultural technology appropriate to the needs of Prairie farming. The same technology was available to Prairie farmers as on the rest of the North American continent. However the shorter growing season on the Prairies meant that only a smaller area of land could be cropped than further to the south, and therefore only a

lower income could be earned. By 1900 this constraint was relaxed, and farming on the Canadian Prairies became sufficiently profitable to attract larger numbers of settlers.

The technical progress which occurred, particularly during the 1890s, enabled each farmer to crop a greater area of land, and therefore to earn a larger income. These increased incomes formed the main incentive for settlers to migrate to the Prairies after 1900, and were the proximate 'cause' of the 'Wheat Boom'. After 1900, there was also a significant increase in the level of agricultural prices, particularly for wheat, which significantly increased this profitability, but was not the principal foundation of the 'Wheat Boom' in that the price increases came after the Boom had begun.

The three principal factors of production - land, labour and capital - were available to the Prairie settler on quite different terms. Only the market for financial capital could be represented as being close to an efficient competitive market, and even in that case it is far from clear that there were no constraints on the supply side. Land was explicitly priced below its maximized capitalized rental value - for his initial quarter section the settler paid only a nominal $10 registration fee, and he could then obtain additional adjacent land at less than its economic rent[4], either through the occasional preemption schemes offered or by buying from railway land grants. In contrast, the supply of agricultural labour was sparse. The presence of free land effectively precluded the existence of a functioning market in hired labour, and the family supply of labour therefore formed a binding constraint on production.

The work involved in the production of any field crop consists basically of the activities of planting, waiting and reaping. In a labour scarce and land abundant environment such as that on the early Prairies the amount of crop which a farmer could grow depended on how much

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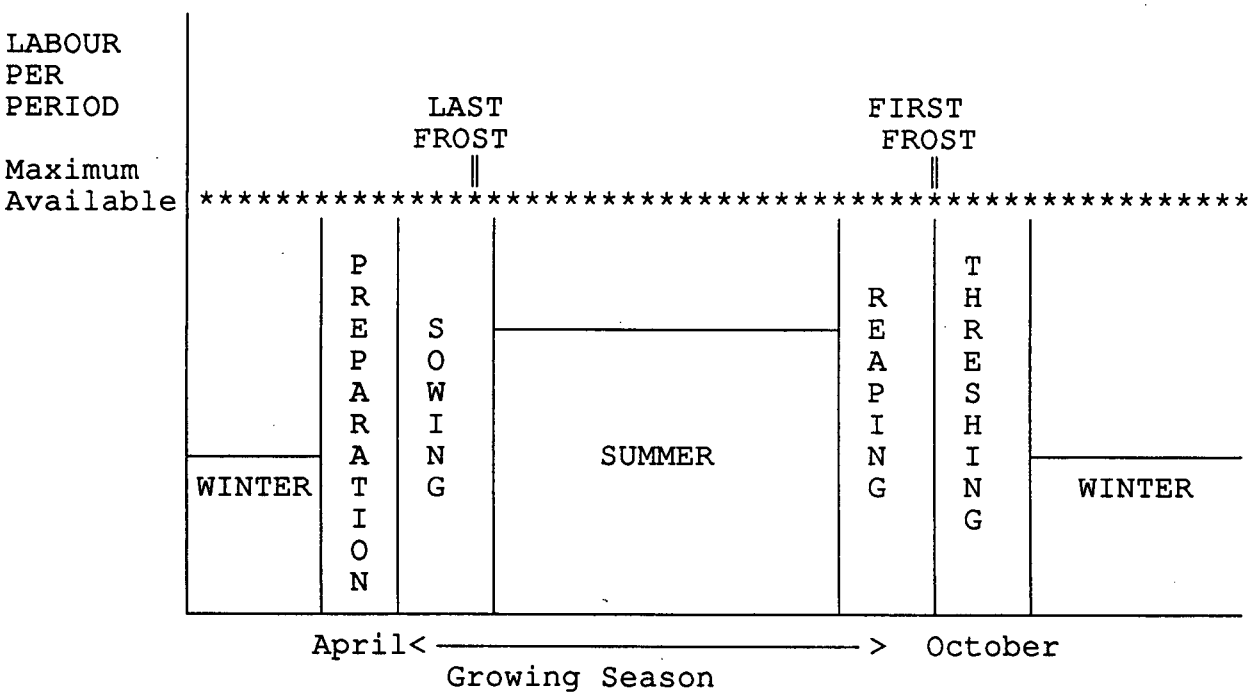
[4] See G.Wogin, "The Wealth-Maximizing Behaviour of the Canadian Pacific Railway: lands, freight rates and the Crow's Nest Pass Agreement". (Ph.D. dissertation, Carleton University, 1983). During the 1880s the system of 'pre-emption' on Dominion Homestead land allowed settlers to obtain a second quarter section adjacent to their homestead at a low price, varying between $1.00 and $2.50 per acre.

land he could sow and reap in the time available. That time was determined primarily by climatic factors - for the Prairies basically the length of summer between the spring thaw and the fall frosts. From that total time must be deducted the length of time needed for the crop to ripen. The time left could be used for both sowing in the spring and reaping in the fall. The amount of crop which could be produced depended on how long it took to perform the operations of planting and reaping.

Figure 1.3 shows in schematic form the labour requirements for the various field crop activities, and the effect of an upper limit on labour availability. For any given technology the area of land which could be worked was determined by the availability of labour at the two critical seasons, and it is this labour

FIGURE 1.3

Annual Labour Requirements for Field Cropping



therefore which decided the quantity of crops which could be grown. The length of the frost free period on the Canadian Prairies varies from over 140 days in the southern Red River valley and

Lethbridge, Alberta areas to less than 100 days in some of the more northern agricultural areas of Alberta[5].

Wheat required an average growing time that ranged from 122 days in Manitoba to 147 days near Lacombe, Alberta. The duration of the critical periods of sowing and reaping, given the available strains of wheat, were limited in the 1880s to 27 days in the Brandon, Manitoba area and to as little as 6 to 8 days in the areas of Scott, Saskatchewan and Lacombe, Alberta. In contrast, the growing season in the Dakotas in the northern US, an area to which many settlers of Canadian origin moved in the 1870s and 1880s, varies from 120 to 150 days, giving farmers there about twice as long to sow and harvest their wheat.

As the analysis of this thesis shows, the typical farmer in Manitoba in 1880 had only a short period in which to sow and harvest his wheat and, with the relatively undeveloped technology available, he could crop only about 50 acres of land. By 1910 technical change had enabled the typical farmer in Brandon to crop about 175 acres and raise four times as much crop. Even without the significant increases in agricultural prices which occurred after 1900, the average farmer would have earned a far greater income. Land further to the west than Manitoba was virtually worthless in the 1880s, since the capitalized value of the income which could be generated on it was less than the opportunity costs of the settler's time and the cost of the capital equipment needed to operate a grain farm.

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[5] W.B.Hurd and T.W.Grindley, Agriculture, Climate and Population of the Prairie Provinces of Canada, (Ottawa: F.A.Acland, 1931), Figure 17, p. 20. (Figure 1.5 in this thesis).

Methodology

The incentive to settle is analyzed by calculating farm profitability at five Prairie locations at ten year intervals between 1880 and 1910. The sites used for the farms are: Brandon, Manitoba; Indian Head, Saskatchewan; Scott, Saskatchewan; Lacombe, Alberta and Lethbridge, Alberta. The geographic influences on settlement are illustrated by the accompanying maps.

The five farm positions chosen are spread out geographically around the perimeter of the arid triangular portion of southern Saskatchewan and Alberta known as 'Palliser's Triangle', in which successful agricultural settlement began after the period in question here due to the poorer quality soil and lower rainfall.

Figure 1.4 shows soil quality on the Prairies. The best agricultural soil[6] is found around the 'Park Belt', within which the farms at Brandon, Indian Head and Lacombe are situated. The soil at Lethbridge and Scott is the lower quality 'Prairie Plains Dark Brown' soil.

Whilst soil quality was important for farming activities, the length of the growing season was also of great significance in determining the extent of agricultural activity at each location across the Prairies. Figure 1.5 shows the average length of time in the summer between the last frost in the spring and the first killing frost of the fall. Several factors have to be taken into account in order to determine the amount of time available to farmers to plant their crops in the spring and to harvest them in the fall[7]. Crops could be planted up to about four weeks before the last frost of spring, but grains had to be harvested before any frost got at them in fall, to avoid damage to the grains. The effects of these factors can be illustrated by the number of days available to the farmer for planting wheat, listed in Table 1.1.

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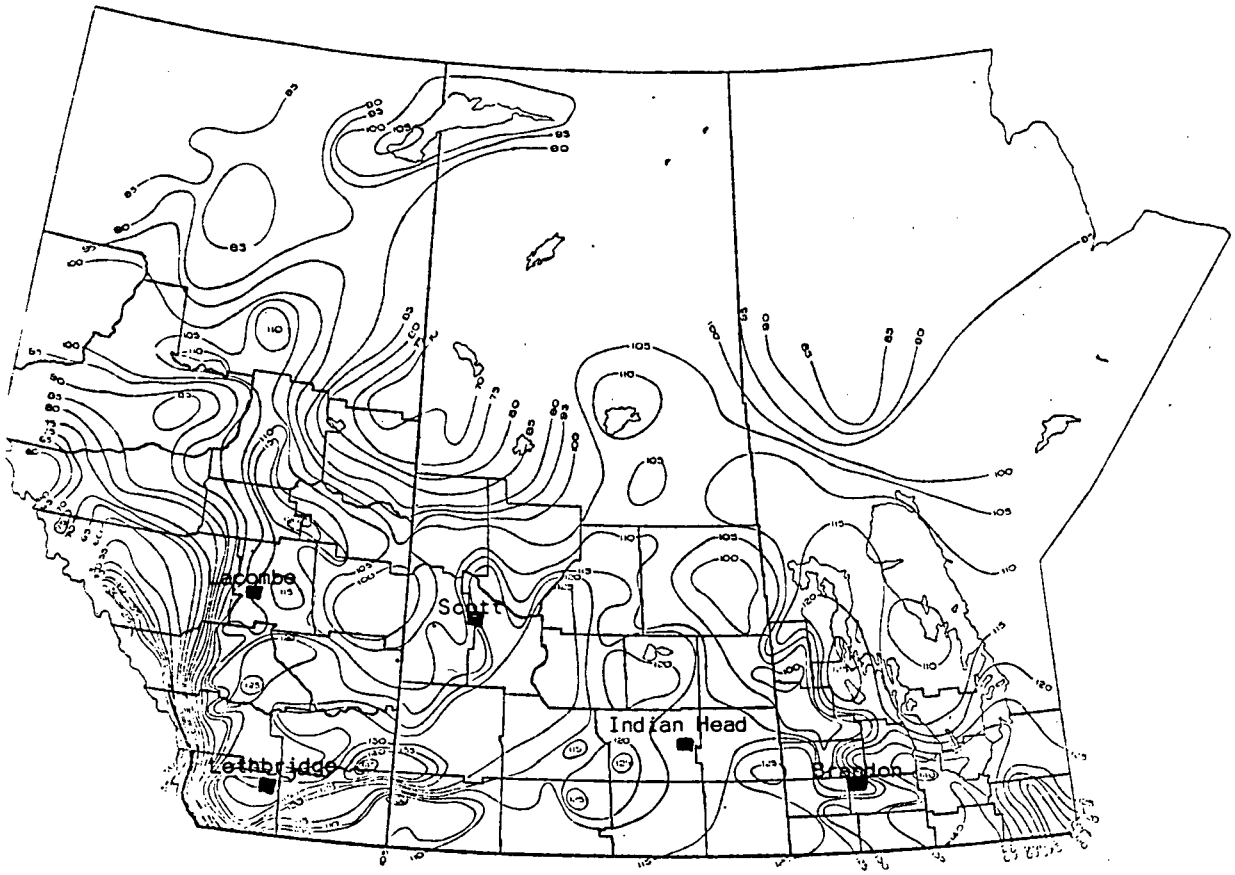
[6] The 'Park Very Dark Brown' soil.

[7] These include the overall duration from the start of spring to the start of winter, the number of frost-free days during summer, the relationship of the frost-free period to the summer period and the time it took for the crops to grow.

FIGURE 1.4

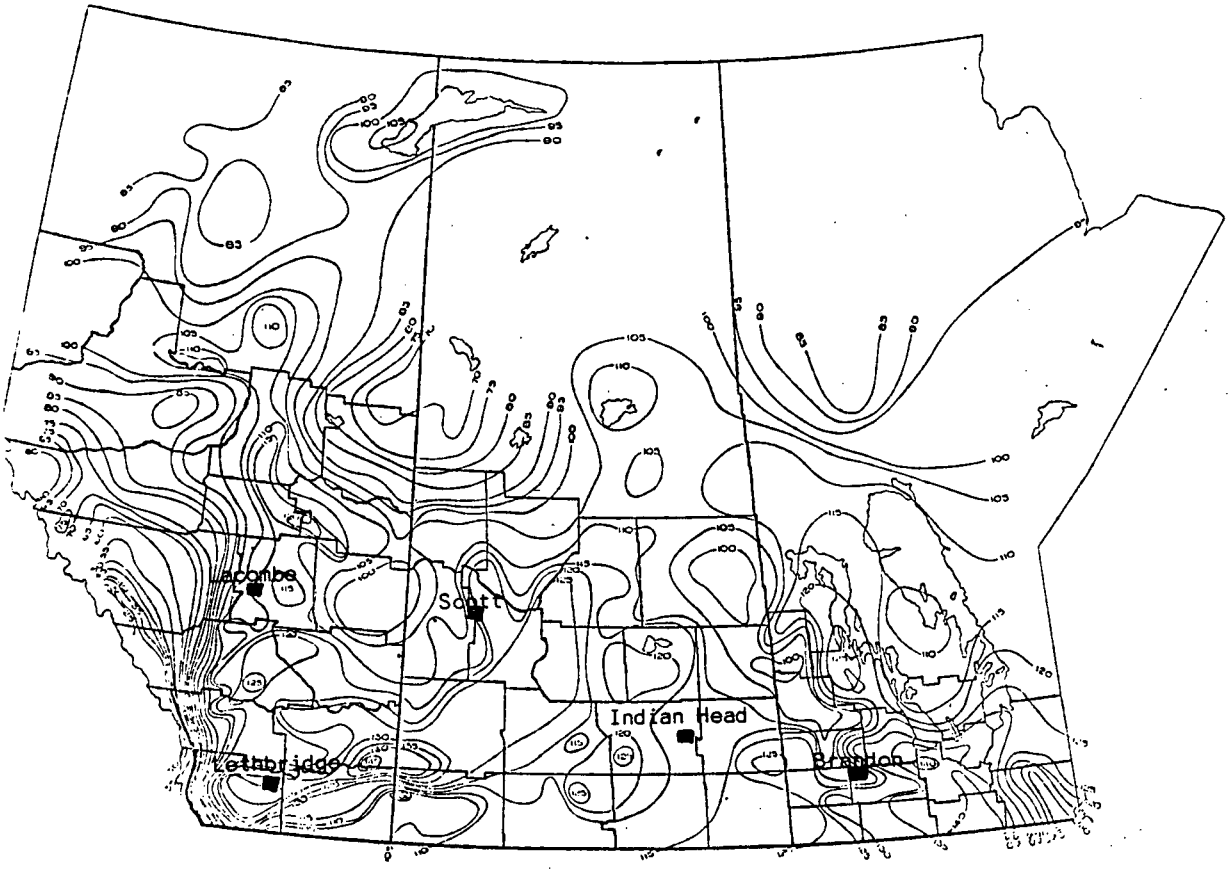
Soils Map[8]



[8] Hurd, W.B. and Grindley, T.W. Agriculture, Climate and Population of the Prairie Provinces of Canada. A Statistical Atlas Showing Past Development and Present Conditions. (Ottawa: DBS, 1931.). Figure 23, p. 24 - "Tentative Generalized Soils Map".

FIGURE 1.5

Average Number of Days Between Last Frost of Spring and First Frost of Fall[9]



The dates on which a typical free homestead at each of these places was settled are listed in Table 1.2:

[9] Hurd and Grindley, (*Op.Cit*), Figure 17, p. 20.

TABLE 1.1

Number of Days Available in 1890 To Plant Wheat[10]

Location	Days
Brandon	27
Indian Head	12
Scott	8
Lacombe	6
Lethbridge	39

TABLE 1.2

Date of First Occupation of a Typical Free Homestead[11]

Location	Date
Brandon	1883
Indian Head	1890
Scott	1907
Lacombe	1890
Lethbridge	1888

The five farms chosen are therefore diverse not just locationally, but also from the aspects of soil, climate, and the resultant dates of settlement. Figures 1.6 to 1.10[12] illustrate the temporal and spatial patterns of occupation of the Prairies, and the relationship of settlement to railway construction. It is apparent from these maps that in the short run settlement was heavily influenced by railway building. The presence of a railway line by no means guaranteed that farmers would follow, however, as is evident from the lack of settlement along the CPR route

[10] Data derived from several sources, including the Reports of The Experimental Farms (for the dates of commencing planting and the duration of ripening) and from Hurd and Grindley (1931) (for the dates of the seasons and of the frosts).

[11] The details of the derivation of these dates are discussed in Chapter 8 of this thesis.

[12] Reproduced from Macintosh, W.A., Prairie Settlement, The Geographical Setting, (Toronto: The Macmillan Company of Canada Ltd, 1934), Figures 31-36, pp. 48-50. The map for 1896 has been omitted here since it contains no demographic data.

across the area of 'Palliser's Triangle'. This relationship is two-way, though. The approximate route of most of these railway lines was known some time before construction started, since a federal government charter had to be obtained by the entrepreneur. In many instances pre-emptive settlement of the better land along the route of the proposed line began before construction, demonstrating to the railway entrepreneur the economic viability of the project. This is clearly visible for example on the settlement maps for 1886, with significant amounts of land along the future routes of the lines to Edmonton and Prince Albert being occupied.

FIGURE 1.6

Railways and Settlement 1886

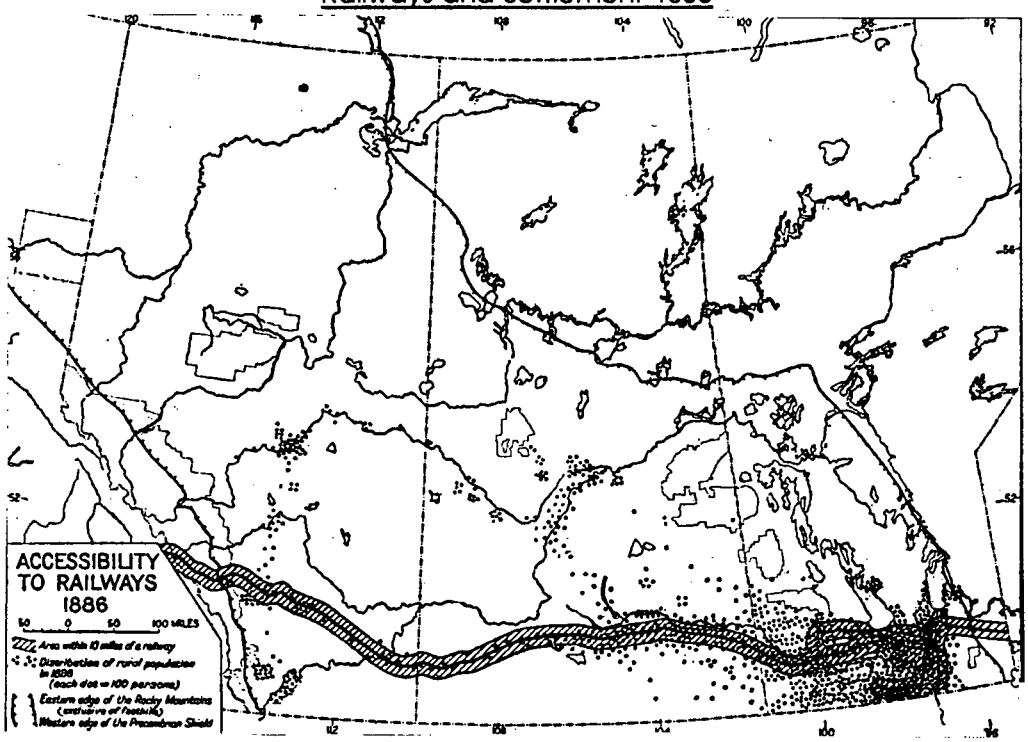


FIGURE 1.7

Railways and Settlement 1891

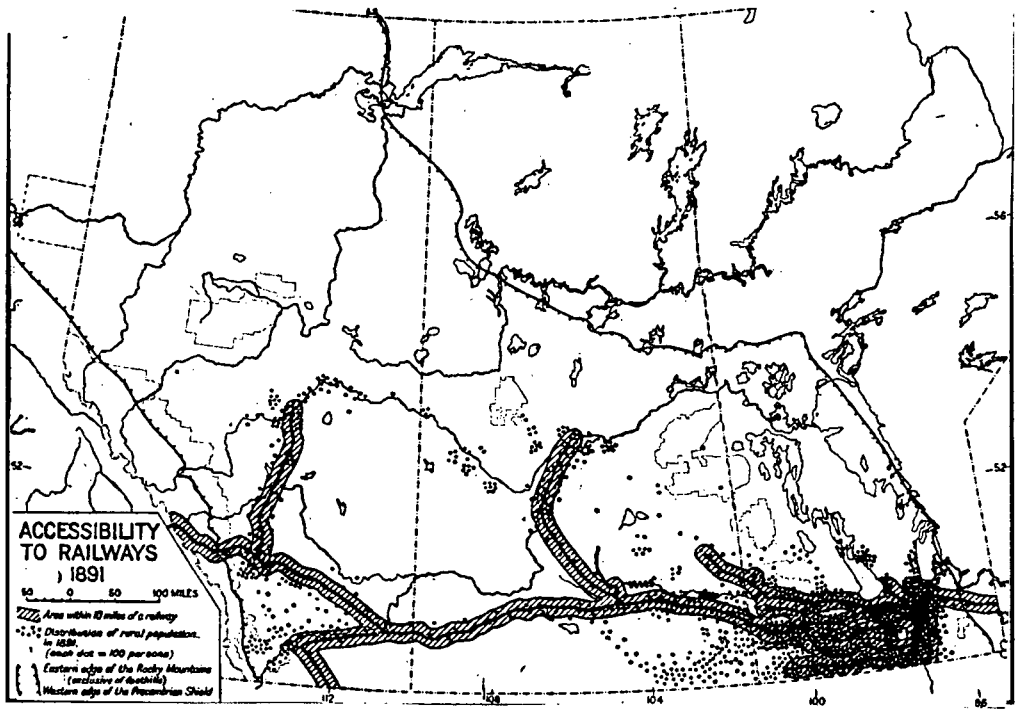


FIGURE 1.8

Railways and Settlement 1901

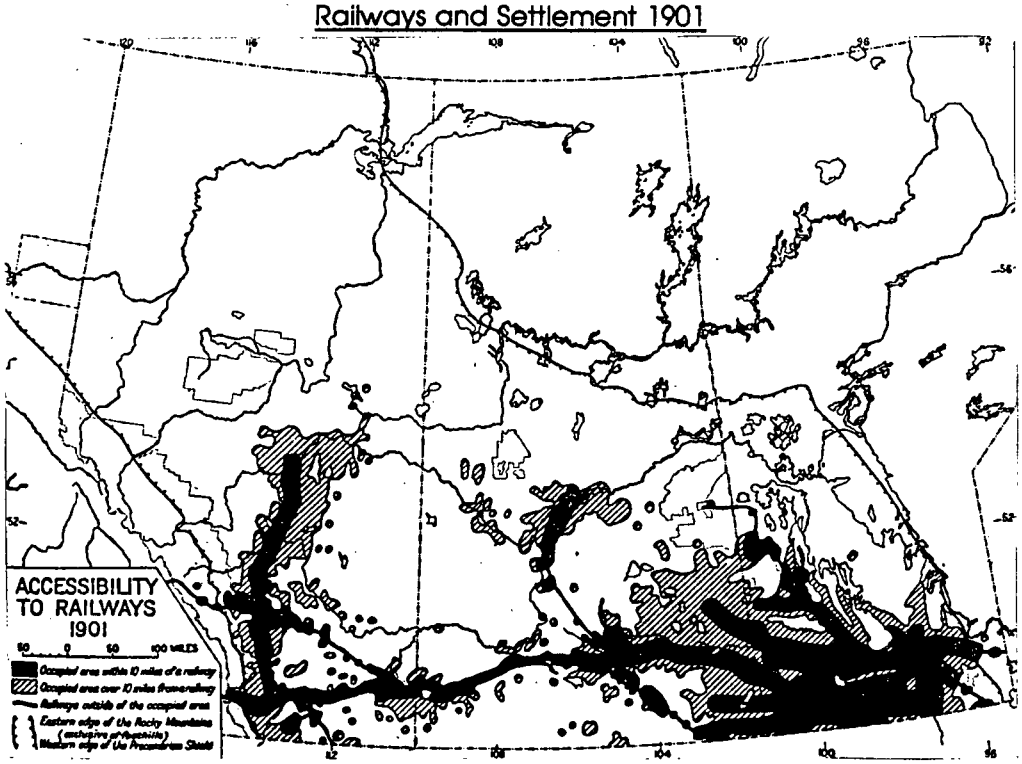


FIGURE 1.9

Railways and Settlement 1906

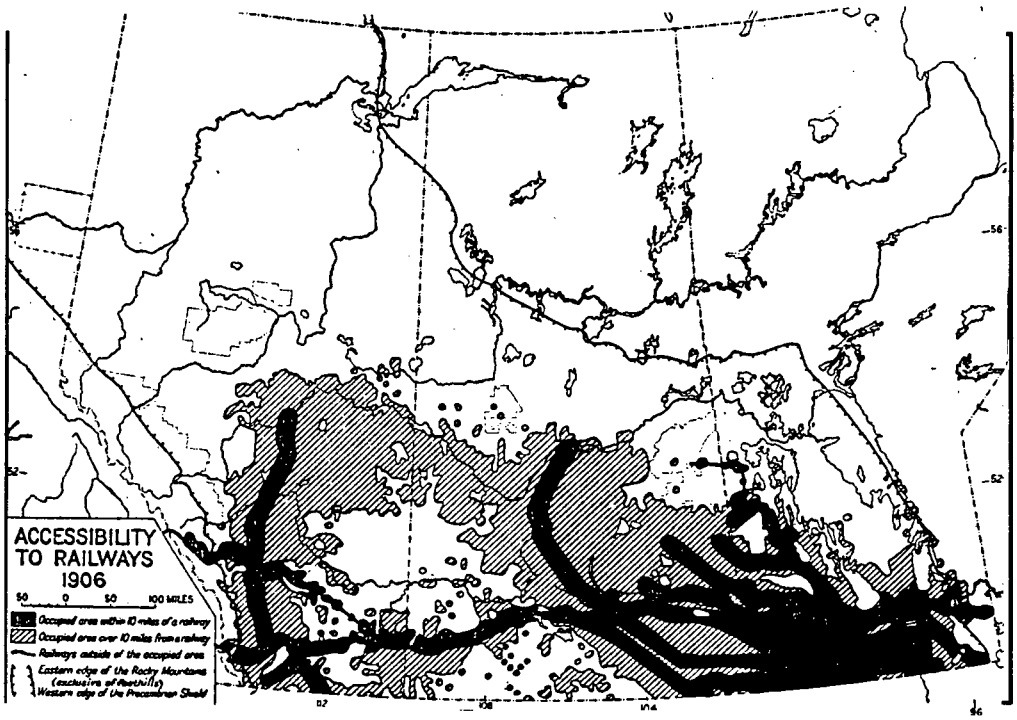
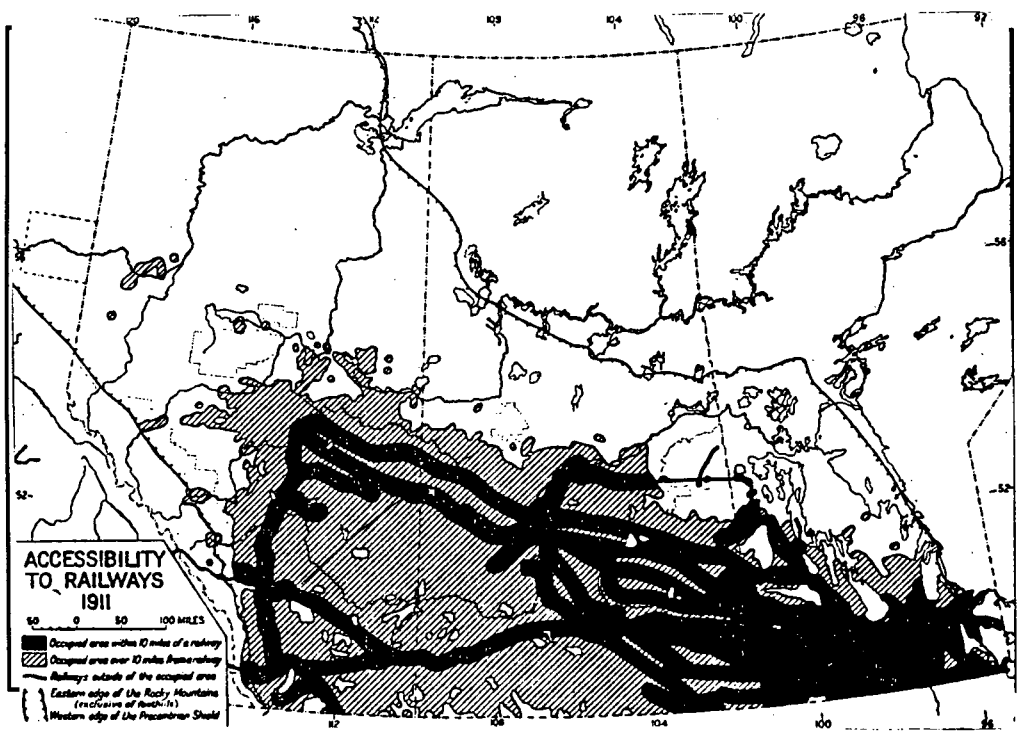


FIGURE 1.10

Railways and Settlement to 1911



Testing of Hypothesis

The basic hypothesis has a number of testable implications. The proportion of the land which had been occupied and which was actually being cultivated (i.e. that land which is reported in the Census as being 'improved'.) should have increased over the period, as technical change enabled settlers to work larger areas of land. The profitability of Prairie farming should also have increased over the period, and there should be some correlation between that increase in profitability at each location and the date on which the land was occupied. By calculating hypothetical profitability under the counterfactual conditions of either the absence of technical change or the absence of price changes, it should be possible also to determine which of these factors was more important in generating the rise in farming profits.

The main factor in the increasing incentives for Prairie settlers was the financial return to farming. Unfortunately there are few if any records available of the monetary accounts of early Prairie farms from which to gather such information. However, some secondary evidence however of increasing profitability can be derived from observation of the amount of land which farmers worked, for which information can be derived from the Census data. Table 1.3 summarizes this Census information of the proportion of land which had been occupied as farms and was actually being used for growing crops, for the relevant times and place.

Figure 1.11 compares the proportions of their farmland which farmers in Manitoba and North Dakota were using during the period. The Figure shows not the proportion of land in each area which was used for farming, but the proportion of the farmland in each area which had been prepared for growing crops. In 1880 the fraction used in North Dakota was three times as great as that in Manitoba, but a proportionately greater increase in Manitoba reduced that discrepancy from 300% in 1880 to 30% in 1910.

TABLE 1.3

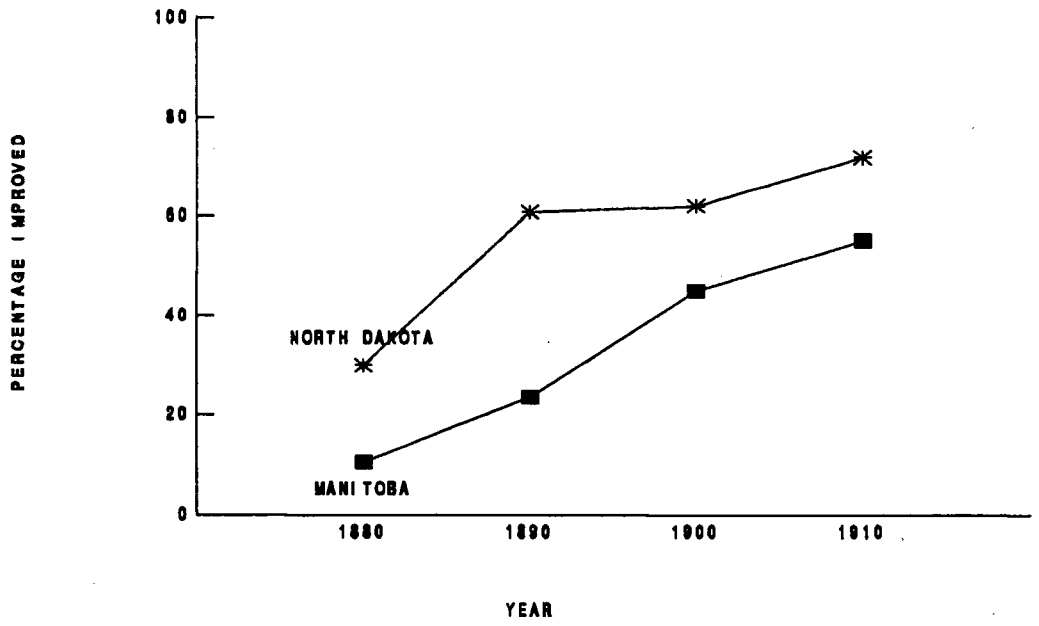
Percentage of Occupied Land which was Improved[13]

	1880	1890	1900	1910
Saskatchewan	7%	8.9%	28.2%	41.4%
Manitoba	10.5%	23.6%	45.2%	55.2%
North Dakota	30%	61%	62.1%	71.9%
South Dakota	N.A.	61%	59.2%	60.8%

FIGURE 1.11

Manitoba and North Dakota, 1880 to 1910

Percentage of Farmland Improved[14]



[13] Derived from information in the relevant US and Canadian Censuses. Improved land is defined in the Census as land which is used for such activities as field cropping, fallowing, orchards, forage, etc. It excludes such areas as natural forests, marshes and natural pasture.

[14] Sources:-Canada: Census of Canada, 1880, 1890, 1900, 1910; United States, Census of the United States, 1880, 1890, 1900, 1910.

The information in Table 1.3 and Figure 1.11 demonstrates first that the proportion of occupied land which was improved was lower on the Canadian Prairies than in the northern States. It also shows that over the period from 1880 to 1910 that proportion increased far more in Canada than it did in the US. One possible explanation for this is the hypothesis of this thesis - that of the initial absence and subsequent development of suitable agricultural technology in Canada. There are however a number of alternative explanations for the proportions observed, and whilst the data support the hypothesis of the importance of technical change, they by no means prove it. Amongst other explanations are the following:-

Land Development Time - breaking in the land on a new farm took several years, which would therefore result in a delay between the initial occupation of a farm and its full development. When the rate of new settlement was increasing, this lag could lead to a high proportion of unimproved land. This factor accounts for some part of the low initial proportions of improved land in the Census data. However if this had been a major factor, the proportion of unimproved land would have increased during the big 'wave' of homesteading at the turn of the Century, rather than decreasing.

Speculation - the deliberate withholding of farmland from production, waiting for its rental value to increase, with the intention of selling the land at that higher price at some future time. From comments in the contemporary literature it is apparent that whilst there was some short term speculation, the amount was probably not large in the aggregate, since under the Dominion Lands Act there were residence requirements on the free homestead land. Railway grant land was relatively expensive, and the CPR actively discouraged speculation, since the unused land yielded them no freight revenues.

Census information on land utilization is partly indicative of increasing agricultural activity, but as discussed is by no means conclusive evidence of it. Since records of Prairie farm accounts are not available, it was not possible to tackle the question of late Prairie settlement directly. Instead, potential profitability had to be calculated by alternative methods. One possible method would have been to use Census data to draw up a list of production on the average farm in each of the Census districts on the Prairies, and then use price data to construct an income statement from those quantities. Unfortunately there are problems with the use of data generated from Census averages. One issue is that for some dates the figures for the particular years on which the Census fell may not be representative of long-run averages. This is true particularly for crop yields, which depend very much on weather conditions in the specific year. In 1900 the weather was disastrous, and yields were at record low levels - about one half of the long run averages for the period 1880 to 1910. Yields were also very poor in 1910, rendering those figures also non-typical. However it is only Census yields which would have been a problem. Planting decisions would have been made before the occurrence of the bad weather, and acreages should therefore from this aspect be representative.

A second problem arises however in that areas calculated as averages of all farms, as would be generated from Census figures, would not give an accurate picture of any particular farm. During the period being examined there were additional farms being established continuously. An average area of a cross-section of farms would therefore include some which had only just been established, and others which had been in existence for some period of time and had been developed to their full potential. To analyze settlement it is necessary to model the marginal farm - the one which was available to be taken by the next settler to arrive, and not an average of existing farms. Settlement occurred at the margin - not at the average.

Information about the changing profitability of Prairie farms therefore had to be acquired in some other manner. The method chosen was to use details of the available technology and yields, of prevailing prices, labour availability, crop and climatic conditions, and from these to

reconstruct the profits which farmers could have earned. The technique chosen was that of linear programming, which is essentially a simple procedure for optimizing a system of relationships in which both the objective function and all the constraints can be expressed in a linear form. It is the planning method still most frequently used today in large farming enterprises to organize annual activities, since it can cope with the relatively large numbers of constraints involved in a farm optimization problem. Most agricultural activities can quite realistically be represented by a linear function, since on the individual farm there are not significant variations in the productivity of labour as scale changes. Yields may vary with the time of planting and the amount of fertilization, but neither of those issues is important in the context of nineteenth century Prairie agriculture.

A series of linear programs have accordingly been compiled, using the information assembled in Chapters 3 to 7 of this thesis. The purpose of these programs is to evaluate the activities of a typical new settler starting a farm in each of the circumstances described. The programs contain detailed information of the technology available to the settler, and they calculate the optimal amount of each crop and each animal husbandry activity which the settler should undertake in order to maximize net income. The hypothetical farmer is offered a choice of several single crops, multiple crop rotations and animal husbandry activities. He is modelled as wanting to maximize the discounted value of future rents, being constrained by prices, technology and the labour available. In order to make the results of the farm models comparable over time and location, all the programs were constructed so as to represent the typical settler starting on a standard 160 acre quarter section homestead. Specific details of the programs run are given in chapter 8 of this thesis.

Calculation of Rental Value of Farm

Calculation of the farmer's future income involves the formation of expectations of future costs, prices, yields, and technology. It is assumed that these expectations were formed using all available information of past values of the variable in question, and that the expected values then remained fixed from the date at which they were made for the entire period of operation of the farm.

a) Crop Revenues

The farmer's annual revenue from the field crops grown is calculated by multiplying the net farmgate price of each of the crops sold by the yield[15] per acre and by the number of acres of the crop grown. Notationally the net farmgate price of crop i (PF_i^E) is represented as:

$$PF_i^E = (P_i^E - C_i^E - F_i^E)$$

Where:
- E is an expectations operator - all expectations being formed at the date of settlement τ and remaining static thereafter.
- P_i^E is the expected price of commodity i at future date t in the market.
- C_i^E is the expected monetary variable cost of producing a unit of the crop i.
- F_i^E is the expected railway freight rate to market per unit of crop i.

This net price per unit is multiplied by the yield per acre (Y_i^E (T^τ)), which is a function of the technology T (which remains fixed from the date of settlement τ for the life of the farm).

The acreage of the crop grown in each year is denoted by (A_i^t (t, L_{si}^t)), where the acreage A devoted to the production of crop i is a function both of time t since the total improved acreage available to the farmer increases over time as more land is broken, and also

[15] Net of seed requirements.

of the amount of labour L which is applied to the production of crop i (Where i = wheat, oats, barley, potatoes, turnips, native hay and cultivated hay) in each season s in each year t.

These crop revenues (RC) are then summed over the seven crops offered in the models, and over the 40 year life of the farm (with future values being discounted at the rate r):

$$\mathbf{RC} = \Sigma_{t=1}^{40} e^{-rt} \{ \Sigma_{i=1}^{7} (Y_i^E (T^\tau) A_i^t (t, L_{si}^t) PF_i^E) \}$$

b) Revenues from Animal Husbandry

Revenues from animal husbandry activities are calculated in a similar fashion. Net revenue from each animal PA_j^E is denoted by:

$$PA_j^E = \{ \Sigma_{k=1}^{8} ((P_{jk}^E - F_k^E) (Q_{jk}^E (T^\tau))) - C_j^E \}$$

Where:

- P_{jk}^E is the expected market price of animal product k from animal j. (Where j = cows, pigs, sheep, hens and their offspring, and k = beef, veal, pork, mutton, lamb, chicken, wool, butter, eggs and milk)
- C_j^E is the expected monetary variable cost of keeping animal j.
- F_k^E is the expected railway freight rate for transporting one unit of product k to the market.
- $Q_{jk}^E (T^\tau)$ is the expected quantity of each product k yielded by each animal j, which is a function of the technology T known at date τ.

The expression is then multiplied by the number of animals of each type which the farmer chooses to keep in each year t:

$$N_j^t (t, L_{js}^t, N_j^{t-1})$$

Where N_j^t is the number of animals of type j which the farmer chooses to keep in year t. This is a function both of time t (since keeping an animal requires the use of improved land for feed production, and the total amount of improved land available is a function of time t, as the farmer breaks his land in), the amount of

labour L which the farmer puts into animal husbandry in each season s in each year t, and also of the number of this type of animal kept in the preceding year.

These animal husbandry revenues (RA) are summed over the eight products k obtained from the four animals j (where j = cows, pigs, sheep and hens), over the forty year life of the farm with future values being discounted):

$$\mathbf{RA} = \Sigma_{t=1}^{40} e^{-rt} \{ \Sigma_{j=1}^{4} (PA_j^E . N_j^t (t, L_{js}^t, N_j^{t-1})) \}$$

c) Capital Costs

From these total net revenues the discounted capital costs of setting up and equipping the farm (CAP) have to be deducted. These costs are denoted:

$$\mathbf{CAP} = \Sigma_{t=1}^{40} e^{-rt} K^{Et} (N_j^{-t} (t, L_{js}^t), A_i^{-t} (t, L_{si}^t))$$

Where K^{Et} is the monetary cost of buying and maintaining the land, buildings and equipment needed by the farm in year t, which is a function of the acreage of each crop i grown and of the number of each type of animal j kept in each year.

d) The Capitalised Value of the Settlement Decision

The farmer is modelled as choosing in each year the acreage utilized for each crop, the number of each type of animal kept, and the amount of labour devoted in each season to each farming activity, in order to maximise the discounted present value of future income.

The capitalized rental value of the homestead at date τ is therefore calculated as:-

$$V^{E\tau} \underset{L_{is}^{-}, L_{js}^{-}, A_i^{-}, Q_j^{-}}{=} \text{Max } \{\mathbf{RC} + \mathbf{RA} - \mathbf{CAP}\}$$

e) Constraints

The constraints facing the farmer were principally those of the available technology and the limited labour supply. Although different in each model, the constraints incorporated are of three principal types:-

i) Labour and Land Inequalities.

The farm year is typically divided up into between 15 and 20 time periods, depending on the particular location. The lengths of these periods vary from 3 to 160 days, depending on the time of year. Within each of these periods, only a particular group of activities is feasible.

For example, for Brandon in 1900 (See Appendix 13), between 21 April and 4 May, the relevant activities include plowing for all small grains (0.433GR##[16]), potatoes (0.533PT##) or turnips (0.533TP##), sowing wheat (whether as a repeated crop (0.267WT##) or in rotations (0.267RTAW##, 0.267RTBW##, 0.267RTCW## and 0.267RTD##)), extra harrowing before planting barley (0.111BRH##) or caring for animals (6.9ANCRAP# and 2.9ANCRMY#). The unit of measurement for each field crop activity is acres, and the total amount of time spent on these activities is constrained to not exceed the total amount of labour time available.

```
 / 2  SEEDING
 / A) 21 APRIL TO 4 MAY - WHEAT ONLY - 14 DAYS GROSS - 9.6 NET
C2161  0.433GR22 0.533PT22 0.533TP22 0.267RTAW12 0.267RTBW12
C2161  6.9ANCRAP2 2.9ANCRMY2 0.267RTCW12
C2161  0.267RTDW12 0.100BRH22 0.267WT12 < 9.6
```

An important constraint is that of the amount of improved land available. Constraints such as C2260 and C2261 from the same program reproduced below ensure that the area of crops sown is no greater than the area of improved land available:

[16] In these constraints, the second number # (Where # = 1, 2, etc.) is an index of the year of operation since the establishment of the farm. A preceding number # had to be used in many constraints when it was necessary to offer the farmer the option of carrying out an activity in more than one season of the year.

```
        / LAND
C2260  -AC2 AC1 BK1 BKC1 BKC2 = 0
C2261  -AC2 RTA2 RTB2 RTC2 RTD2 PT2 TP2 HYC102
C2261  WT2 OT2 BR2 PASA2 = 0
```

ii) Accounting Identities

These define the fixed relationships between variables. In the example below from the same program the variable GR# is the total acreage of small grains to be plowed, which must equal the sum of the areas sown (only 2/3 of the areas of rotations A, B and C had to be plowed in spring - 1/3 was fallowed.

```
 / AREA TO BE PLOWED AND HARROWED
C2150  0.667RTA2 0.667RTB2 0.667RTC2 RTD2 WT2 OT2
C2150  BR2 PASA2 0.333HYC2 -GR2 = 0
```

The relationships between the acreage of each field crop grown and the quantity of grain sold had also to be defined. Constraint C2104 shown below shows that each acre of oats yielded 26.6 bushels, each acre of rotation B yielded 10.8 bushels (because only 1/3 of the area was oats, but the yield in rotation was higher). The oats produced were then used either for animal feed (BUOTFD#) or were sold (BUOT#).

```
C2104  -BUOT2 -BUOTFD2 10.8RTB2 8.1RTD2 26.6OT2 = 0
```

Similarly animal feed requirements are defined in constraints such as:

```
 / ANIMAL FEED
 / GRAINS
C2112  -GRFD2 22CW2 50HS2 9CFA2 10.75CFB2 14CFC2 10PGA2
C2112  0.25PGB2 5PGC2 10PGD2 4MN2 4.3HN2 = 0
```

In many instances, activities could be carried out over a number of different time periods. In such cases additional constraints were necessary to ensure that the correct amount of each activity was carried out. C2114 ensures that the total amount of wheat threshing was done over the four time periods available.

```
 / RECONCILE THRESHING
C2214  -WT2 WT302 WT312 WT322 WT332 = 0
```

iii) Imposed Quantities.

The numbers of draught animals were predetermined, and are defined by constraints such as C2101 and C2102 reproduced below:

```
  / DRAUGHT ANIMALS
C2101  OX2 = 2
C2102  HS2 = 1
```

Minimum numbers of some of the other farm animals were also imposed, as shown in constraints C2290 to C2292 below. The reasons for constraining these quantities are discussed in chapter 6.

```
  / FAMILY CONSUMPTION
  / BEEF, MILK
C2290  CW2 CFA2 CFB2 CFC2 > 1
  / PORK
C2291  PGA2 PGB2 PGC2 PGD2 > 1
  / EGGS
C2292  HN2 > 5
```

CHAPTER 2

LITERATURE REVIEW

The timing and pattern of the settlement of the Canadian Prairies has been of significant interest to Canadian historians since the apparent failure of the 'National Policy' to attract settlers to the region in the 1880s and 1890s.

Agricultural expansion of the American West had begun in the early 19th Century, and the frontier had reached the Prairie regions south of the 49th parallel during the 1860s. The continent was first crossed by a transcontinental railway in 1862, and the Northern Pacific Railway extended the influence of the American economy uncomfortably close to the border with Western Canada in 1868. Whilst the primary motive for the construction of Canada's transcontinental railway was the political one of 'binding the country together', nonetheless it was fully expected that the provision of a transportation link with the Prairies would induce rapid extensive growth of that region.

Pattern of Settlement

The first major studies of the issues of the rate and pattern of Prairie settlement were those carried out in the 1930s by Mackintosh[1], Morton[2] and Martin[3]. These three early works gave us a detailed and well researched picture of the development of the region. They did not however attempt to analyze in any quantitative fashion the reasons for the patterns which were observed. Mackintosh considered that economic motives of settlers were not dominant. He felt that land had to "be suited not just to agricultural production", but had also to be able to "support a density

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[1] W.A.Mackintosh. Prairie Settlement - The Geographical Setting. (Toronto: Macmillan, 1934).

[2] A.S.Morton. History of Prairie Settlement. (Toronto, Macmillan: 1938).

[3] C.Martin. The Dominion Lands Policy (Toronto, Macmillan: 1938).

of population sufficient to maintain economic, social and governmental services"[4]. The principal factor affecting the rate of settlement he saw as the "push from Europe of technological unemployment".

It is certainly the case that the outflow of migrants from Europe was determined primarily by the relative social and economic conditions on the two continents. That does not mean however that economic factors were not important in the decisions of immigrants as to where to settle. International migrants were highly mobile. Given that individuals or families had uprooted themselves from their traditional home, and set off to seek a 'better life', most would then have been prepared to go wherever the best opportunity was available. Slow occupation of one area whilst other places were filling up would tend to indicate that the economic value of taking that unwanted land was lower. Whilst many later migrants sought out their friends or countrymen for social and economic reasons, there is no reason to suggest that such locational decisions were made consciously at the expense of economic success. The initial migrants moving into an area would not have experienced such constraints, and would have chosen their location for its economic suitability.

Macintosh[5] prepared the series of maps reproduced in Chapter 1 as Figures 1.6 to 1.10, which show the relationship between the pattern of settlement and the construction of railway lines. From those maps it is apparent that in many areas settlement preceded the railway, though in most such instances the future route of the railway was probably already known. A government charter had to be obtained prior to construction, and the route was therefore public knowledge, even if the date of construction (and indeed whether the line would ever be built) was uncertain.

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[4] *Ibid.* Introduction, p. xiii

[5] *Ibid.* Figures 31-40, pp. 48-52.

Martin[6] examined the Dominion Lands Policy - the approach taken by the government to the disposal of Crown Lands. He believed that the policies implemented were quite effective in promoting Prairie development, although he did not systematically analyze the attainment of the objectives of the policy. Land grants to the CPR he saw as particularly productive in increasing the pace of settlement[7], though he argued that later grants to branch railway lines were frequently economically unnecessary. Martin considered also that the chequerboard system of alternating free homestead land and railway grant land was highly effective in facilitating the growth of farming, because of the potential for settlers to start a small farm cheaply, yet be able to expand it later by the purchase of adjacent land. By the 1926 Census, which Martin used for his analysis, the average Saskatchewan farm had grown to an area of 389 acres. The alternating blocks of land meant that most farmers had the opportunity to buy additional land immediately contiguous to their initial section, and bring their farm up to an efficient size.

Southey[8] conjectured that by underpricing its land the government distorted the market, resulting in settlement occurring earlier than was optimal. His model predicted complete dissipation of the economic rents, due to settlers taking the land as soon as the present value of its future rents rose to zero. This hypothesis was in fact current before the development of the Canadian Prairies, having originated with Gibbon Wakefield[9]. A colonial administrator in Australia in the mid-19th. Century, Wakefield visited Canada before the wheat boom. He felt that underpricing land led to premature settlement, under-usage of that land, and excessive infrastructure costs. Southey formulated this hypothesis carefully, but did not try to test it

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[6] *Ibid.*

[7] *Ibid.* p. 396.

[8] Clive Southey. "The staples thesis, common property, and homesteading". Canadian Journal of Economics, Vol. XI, No.3, pp. 547 to 559.

[9] Edward Gibbon Wakefield, The Collected Works of Edward Gibbon Wakefield, (Glasgow, Collins: 1969)

empirically. The analysis of this thesis sheds some light on this question, suggesting that initially settlement was in many cases premature.

Rate of Settlement

The first attempt at a quantitative analysis of the reasons for the low rate of settlement on the Prairies in the 1880s and 1890s was by Studness[10], who concluded that farming in the 1890s was more profitable in Manitoba than in North Dakota. Studness then blamed the exodus from Eastern Canada to the American agricultural frontier in part on the Dominion Land policy, which he suggested did not make enough land available in southern Manitoba and southeastern Saskatchewan. He also blamed the government's railway subsidy policy for failing to spur more rapid railway construction[11].

Those conclusions were based on a calculation of the relative profit *per acre* of wheat farming in North Dakota and in Manitoba in about 1890. For 1890, the US and Canadian Censuses give an average cropped area of 55 acres per farm in Manitoba and 169 acres per farm for North Dakota. I suggest that the farm is a more relevant unit on which to conduct such an analysis than an acre. Using the per acre profit figures calculated by Studness[12], multiplying by farm size reverses Studness's conclusions about relative profitability, with farmers in North Dakota earning higher incomes than those in Manitoba. The suggestion that in the 1880s not enough good land was available was probably correct. However the reason for the shortage

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[10] Charles M. Studness. "Economic Opportunity and the Westward Migration of Canadians during the Late Nineteenth Century". Canadian Journal of Economics and Political Science. Vol.30, No.4, November 1964, pp. 570 - 584.

[11] *Ibid.* p. 583

[12] It is not clear in the article by Studness exactly what the calculated profit figures are, since he states explicitly only the difference between the figures for Manitoba and North Dakota. Doubt was cast on the validity of these figures by Norrie (K. H. Norrie, "Economic opportunity and the westward migration of Canadians during the late nineteenth century: a comment", Canadian Journal of Economics. Vol.VII, No.1, 1974, pp. 132-135).

was not that the Dominion Land Policy was holding land back but that, given the current technology, only a small area of the Prairies was economically viable.

More recently, Norrie[13] sought to explain "the lag between the formulation of policies directed toward settling the Prairies and the appearance of any significant agricultural population". He concluded that the rate of settlement was not affected by the completion of the transcontinental line in 1886, but did change in 1896 with the start of the 'Wheat Boom'. Norrie hypothesized that the flow of migrants to the Prairies was influenced by a number of economic variables, and he used econometric techniques to estimate settlers' responses to changes in the wheat price, as a proxy for all economic factors.

It is difficult, as Norrie decided, to support the suggestion that changes in wheat prices were important in determining the rate of settlement over the period from 1881 to 1905, since there was relatively little change. Norrie used a locationally stationary wheat price (in Winnipeg), which as Harley[14] notes is a misspecification when analyzing an inherently mobile phenomenon such as an expanding frontier.

Norrie's primary interest was in testing whether there were structural changes in settlers' behaviour which then affected the rate of settlement during the period from 1879 to 1911. He tested for a change in the rate of settlement in 1886, since he was examining a paper by Stabler[15], who had suggested that date as marking the end of the pre-railway period in the history of Prairie settlement. 1886 is not the most appropriate year to use for the date of the introduction of rail transportation for wheat exports from the Prairies. The lines to the west across

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[13] Norrie, K.H. "The Rate of Settlement on the Canadian Prairies 1870-1911." Journal of Economic History XXXV, No. 2 (June 1975); pp. 410-427.

[14] C.K.Harley. "Western Settlement and the Price of Wheat - 1872 - 1913". Journal of Economic History, Vol 24, No.4, pp. 865-878.

[15] Stabler J.C. "Factors Affecting the Development of A New Region: The Canadian Great Plains, 1870-1897" Annals of Regional Science (June 1973), pp. 75-76.

the Rockies and to the east around the Lakes were not completed until then, but those sections of the CPR were of little relevance for wheat exports. The important section of line was that between the wheat producing areas such as Brandon, and Fort Arthur, at the head of the Lakes. This section was completed by 1881[16], and the first exports by the all Canadian route across the Lakes commenced by 1882[17]. That year would have been a more appropriate break point to examine for the immediate effect of the CPR.

The second break in the rate of settlement for which Norrie tested was in 1896, which by convention has marked the beginning of the "Wheat Boom". Norrie hypothesized that the reason for the break in 1896 was the development of dry farming techniques. The analysis of this thesis is consistent with Norrie's suggestion, although it suggests that the development of dry farming was only one of several aspects of technological change which occurred over the period between 1880 and 1900.

In two subsequent papers[18], Norrie examined the economic implications of the introduction of the summer fallow, one of the important dry farming techniques adapted to Prairie use during this period. He concluded that farmers switched to the use of summer fallow as a means of reducing the income variability which arose from variation in annual rainfall. The system of summer fallow was introduced to the Prairies in the 1890s, and is still highly important today in many of the arid and semi-arid areas of the world. It involves leaving the cropland unused for one season, in order to conserve the rain falling during that year for the following season.

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[16] 15 September 1881. Omer LaValeé, Van Horne's Road. (Montreal, Railfare Books: 1974), p. 301.

[17] The large grain handling facilities at Port Arthur were not completed until 1883, but exports of grain began prior to that time.

[18] Norrie, K.H. "Dry Farming and the Economics of Risk Bearing: The Canadian Prairies 1870-1930." Agricultural History 51 (1977): pp. 134-148, and Norrie, K.H. "Cultivation Techniques as a Response to Risk in Early Canadian Prairie Agriculture." Explorations in Economic History 17, No. 4 (October 1980): pp. 386-399.

Norrie calculated that the costs of fallowing the land exceeded the gains, although he found that fallowing reduced the variability of wheat yields. He therefore attributed the use of summer fallow to risk aversion on the part of farmers. Whilst undoubtedly true that most individuals prefer to minimise unnecessary risks, the analysis of this thesis shows that in fact the direct benefits of fallowing exceeded the true costs. The difference arises because Norrie costed the operations involved in working the fallowed land at the same unit rates as for working cropped land. However all the work involved in maintaining the fallow was done during the relatively quiet summer period when there were few revenue-earning alternatives available to the farmer, and the shadow price of labour was therefore lower than in the spring and fall when most work on crops had to be done.

Marr and Percy[19] corrected a misspecification in Norrie's (1975) analysis, in that Norrie had specified an equilibrium flow of settlers, when his analysis was in fact of an equilibrium stock. They also added railway mileage and government expenditures on the promotion of immigration as additional factors influencing the rate of settlement, and re-estimated a model similar to Norrie's. Their results differed somewhat from those of Norrie, although the conclusion that behaviour changed in 1896 was confirmed. Marr and Percy also found that both the level of investment in railway construction and government expenditures on the promotion of immigration were important determinants of the rate of settlement.

In a later paper, Lewis[20] sought to explain the rate of settlement during the Wheat Boom, for the period from 1898 to 1911. He found that increases in settlement could be attributed to increases in wheat yields and to a decline in railway transportation costs, with a small effect from rising wheat prices. Assuming that the land market was in continuous equilibrium, Lewis used

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[19] Marr, William and Michael Percy. The Government and the rate of Canadian Prairie Settlement Canadian Journal of Economics, November 1978, pp. 757 to 767.

[20] Frank D. Lewis. Farm Settlement on the Canadian Prairies. Journal of Economic History, Vol.XLI 1981, pp. 517 to 536.

the technique of simulation to analyze the movement of the extensive margin of agriculture across an area of southeastern Saskatchewan. The zero-rent frontier was defined as that location at which all excess of revenues from wheat growing had been absorbed by the cost of hauling the wheat from the farm to the railway station. This frontier then moved outwards over time as wheat yields and prices rose, and as railways were built and freight rates fell. In both his simulation and the historical data, a similar rising trend is seen, which Lewis takes to be verification of his analysis.

Whilst Lewis's elegant analysis clearly captured some of the processes involved in settlement, there are many problems with both the methodology and the assumptions used which make it difficult to accept this as an accurate representation of the true historical process. In spite of a slight downward trend in observed mean yields, Lewis contended that the true mean was rising. He considered that the observed downward trend arose because of the continued addition of poorer quality land to the area farmed. It was however this poorer land which incoming settlers had to take. The better land was already occupied, so if Lewis's contention that the true, locationally constant, wheat yield was rising is correct, then the yields on marginal land must have been falling faster than the observed mean and would have acted as a disincentive to settlement.

The suggestion of falling transportation costs is confirmed by such data as are available. It is not clear whether the changes in freight rates were due to market factors[21] or to technological change[22], but falling freight rates and additional railway construction would clearly have induced settlement. The implications of Lewis's assumption of continuous perfect

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[21] As is suggested by Lewis, F.D. and Robinson, D.R. "The Timing of Railway Construction on the Canadian Prairies." Canadian Journal of Economics 17, No. 2 (May 1984): pp. 340-352, and Wogin, G. "The Wealth-Maximizing Behaviour of the Canadian Pacific Railway: Lands, Freight Rates, and the Crow's Nest Pass Agreement." Ph.D. dissertation, Carleton University, 1983.

[22] As is suggested by Green, A.G. "Productivity and Technological Change in the Canadian Railroad Industry." Paper delivered at the Canadian Economics Association Annual Meeting, Vancouver, 1983.

economic equilibrium, with all land being occupied immediately upon becoming economically feasible, are neither examined nor tested.

Lewis took the unit of analysis as the acre, rather than the farm, and thereby failed to capture changes in expected income for the farmer, which is a more pertinent piece of information for a potential immigrant. In that his analysis covered only the period from 1898 to 1911 - a period in which the area he examined was being continuously settled - Lewis cannot address the question of why settlement had not occurred previously, and can therefore give only a qualified analysis of the whole process.

The Lewis model predicted a relatively compact region of settlement, due to the use of a high cost of wagon haulage. One explicit prediction of the linear programming models used in this thesis is that the settled area would be more diffuse. The agricultural year consisted of the two extremely active periods of spring sowing and fall harvesting, with the rest of the year being less busy. During the winter there were very few revenue earning activities available, and farmers, all of whom owned a wagon and either oxen or horses, therefore could and did transport their own grain to market, at a marginal cost of almost zero. As long as there was spare time during the late fall and winter, a farm 20 miles from the railway station would have generated almost exactly the same income as one 1 mile away. A farm closer to the station would undoubtedly have been preferred due to the disutility of winter work, but I suggest that the disincentive to taking the more distant farm was less than the Lewis model assumes.

Lewis (1981) assumed that the rate of railway construction was exogenous. In another useful paper[23], Lewis and Robinson examined carefully the economic motives for Prairie branch line construction. They found that railway entrepreneurs behaved as rent maximizers, choosing both the timing of construction and freight rates to maximize capitalized rents. The analytical

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[23] F.Lewis and D.Robinson. "The Timing of Railway Construction on the Canadian Prairies". Canadian Journal of Economics. Vol.17, No.2 May 1984, pp. 340-352.

technique used was again that of simulation, with the same area of southern Saskatchewan being used to test the model as in the Lewis (1981) paper. Railway entrepreneurs were modelled in this paper as monopolists, since once a railway charter had been obtained, the entrepreneur possessed the exclusive right to build a line through an area. The entrepreneur was therefore in a position to choose both the date of construction and the freight rates charged to maximize profits.

The assumption in the Lewis and Robinson (1984) paper of perfect market efficiency is less problematic than in the Lewis (1981) paper, since railway entrepreneurs are more likely to have possessed the information and resources to wait for the optimal moment to act than are individual immigrants. Since the railways made profits both from the transportation of freight and from the sale of land from their land grants, their optimization problem was quite complex. Higher freight rates not only reduced the quantity of freight carried by the railway, but also reduced the price at which the railway could sell its land. The conclusions reached in this paper are realistic, and are consistent with the results of this thesis, given the restrictions imposed by the use of the Lewis (1981) settlement model.

Wogin[24] carefully analyzed the tradeoff between freight rates and land prices faced by the railway. She examined the net effect on these two variables of the Dominion Lands policy of alternating blocks of free homestead land and railway grant land, and found that the existence of the railway land grants resulted in lower freight rates than would otherwise have been the case, but that for complete economic efficiency the railway would have had to be given all the land. Wogin also made the interesting assertion that the clause in the Crow's Nest Pass Agreement of 1897 which fixed grain freight rates permanently at low levels was not a burden on the CPR, but in fact was a profitable restriction. This conclusion arose from consideration of the price settlers would have been prepared to pay for railway land. Assuming

[24] G.Wogin "The Wealth-Maximizing Behaviour of the Canadian Pacific Railway: Lands, Freight Rates, and the Crow's Nest Pass Agreement". (PhD. dissertation, Carleton University, 1983)

that settlers would have considered any low freight rates offered by the CPR as merely temporary inducements to buy land, they would have expected the CPR to raise those freight charges once all the grant land had been sold. The imposition of government restrictions on the future ability of the CPR to increase freight charges increased the capitalised rental value of the CPR grant land, due to the expectation that the increased profitability of the land due the low freight rates would persist.

Another recent paper on Prairie settlement is that of Borins[25], who found that geographical variables such as rainfall, the length of summer and railroad density as well as economic variables such as wages and prices were important in determining the rate of settlement. Using econometric estimation to evaluate the importance of these various factors, Borins found, as had Norrie (1975) and Marr and Percy (1978), that there was a 'structural break' in 1896 at the start of the 'Wheat Boom'.

The principal contribution of the Borins paper was the explicit recognition of the importance of these geographical factors. He wanted to estimate the number of settlers in each area of the Prairies as a function of the profitability of taking a homestead. Data problems however led him to use an ad-hoc formulation relating the number of settlers in an area to prices, government immigration expenditures, wages, rainfall, the length of summer and railway mileage. The Prairies were divided in the paper into 14 spatial areas with different geographical attributes. The amount of summer rainfall and the number of frost-free days in an area showed as much statistical significance in his estimates[26] as the farm gate price of wheat. With only 14 areas, however, the level of aggregation is still too high to analyze specific profit maximizing behaviour.

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[25] Sandford F. Borins. "Western Canadian homesteading in time and space". Canadian Journal of Economics, Vol XV, No.1, pp. 18 to 27.

[26] Borins, (1982), Table 1, p. 22, regression 1.

Technical Change

The question of the importance of technical change in the expansion of Prairie agriculture was discussed by Dick[27], who found significant increases in productivity over the period from 1900 to 1930, noting that most of the increase came at the start of the period[28]. Dick's analysis consisted of calculating total factor productivity indices for the production of wheat, oats and barley in the three Prairie provinces for five-year intervals between 1900 and 1930. Unfortunately data limitations prevented the extension of this analysis back in time to the 1880s and 1890s, and it therefore cannot shed light on that important period. This paper did not analyze the sources of the productivity gains, but Dick noted[29] that "this (timing of the productivity changes) may reflect that much of this change was once-and-for-all change associated with dry land farming". Dick[30] also made the comment that the application of dry farming techniques "may have been almost coincident with the expansion of prairie farming", but he did not attribute any causation from the technical change to the growth in settlement.

In a second paper on the same topic[31] Dick analyzed the cost reductions which occurred on Canadian and US prairie grain farms during the period 1900 to 1930, and found that costs fell gradually over the period. He regressed the costs of the various inputs on the price of output, at the Provincial/State level of aggregation. Dick found that the acreage harvested was inversely related to cost, although it would appear that he used aggregate acreage per province, rather than acreage per farm, making it impossible to discriminate between a time

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[27] Trevor J. O. Dick, "Productivity Change and Grain Farm Practice on the Canadian Prairie, 1900-1930". Journal of Economic History, Vol.XL, No.1, March 1980, pp. 105 to 110.

[28] *Ibid.* p. 109.

[29] *Ibid.* p. 109.

[30] *Ibid.* p. 109.

[31] Trevor J.O.Dick, "Mechanization and North American Prairie Farm Costs 1896-1930". Journal of Economic History, Vol. XLII, 1982, No.1, pp. 199-206.

trend and technical change. A real price of land was also included in the regression, which again may have captured a major portion of the technical change which occurred, since capitalized rents would have increased in proportion to increased profitability. Dick also unsurprisingly found that cost per acre increased in a statistically significant manner as yield per acre increased and as the wage rate increased. The real price of machines was never statistically significant - however the capability of machines was not constant, making any such relationship ambiguous. Dick[32] speculated whether machines could have been an inferior factor - a possibility which seems unlikely.

Prices

Harley[33] found that the expansion of the extensive region of wheat cultivation in the US was sensitive to the local price of wheat. Previous analyses of the connection between settlement and the price of wheat had failed to find such a relationship, due to the failure to use a specifically local wheat price when examining settlement in a particular area. The price of the principal cash crop would clearly have been of great importance in the formation of potential homesteaders' expectations of the value of their farm. As this thesis shows, however, the farm gate price of wheat on the Canadian Prairies did not rise until after 1900, and whilst important later on, cannot explain the start of the wheat boom at the turn of the century.

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[32] *Ibid.* p. 203.

[33] C.K.Harley. "Western Settlement and the Price of Wheat", Journal of Economic History, Vol.38, No.4, pp. 865-878.

Conclusion

Almost all of the literature on the phenomenon of Prairie settlement has tried to get at the economic motivation for moving to the extensive margin, as represented by the profitability of taking a homestead. All of the published works though balk at the task of collecting the data to calculate that profitability directly. There is a clear need for an attempt to calculate directly the value of a homestead, since this is implicitly or explicitly the economic motivation for homesteading sought in all of the preceding literature.

CHAPTER 3

FIELD CROPS AND SEASONAL PATTERNS

Introduction

Farm activities can be divided into two principal types - field cropping and animal husbandry. Vegetable gardening and fruit growing did not form a major component of early settlers' incomes, and are not included in the linear programming models. Chapters 3 to 6 consider the cropping and animal husbandry activities of Prairie farmers for the period from 1880 to 1910. The purpose of this portion of the thesis is to explain the derivation of the information used in the linear programming models and to show how that information has been incorporated.

Field crops formed the principal element of farm cash income on the Prairies, and in this chapter I outline the basic details of the crops used. The first section examines the basic cultivation requirements of the crops which were available to farmers. I then present the information used for crop yields, which have been derived primarily from Census data, in the second section. The third section describes the source of an equally important but less obvious component of the information needed - the seasonal timing of the various operations needed to grow each of the crops. Chapter 4 describes the field cropping technology -the tools and implements available at each date. Chapter 5 then describes the types of power used to propel the equipment used. Chapter 6 examines the technology involved in animal husbandry activities, and the patterns of production.

Field Cropping Activities

a) Wheat

Wheat was the most important cash producing component of Prairie agriculture throughout the period. In 1880, 1,153,328 bushels of wheat were grown. By 1910 this had increased to 201,899,096 bushels. Valued at Winnipeg prices, this wheat was worth $968,796 in 1880, and $205,937,078 in 1910. Average gross revenue per farm from this source, if all the wheat had been sold, would at these prices have been $137 in 1880 and $943 in 1910.

The Prairie climate is very well suited to wheat growing, with its long days of brilliant sunshine, and short bouts of rain. On average, there was enough rain during the growing season to produce a good crop of wheat, although the variability of that rainfall caused frequent problems. Strange[1] listed data aggregated at the provincial level for both rainfall and wheat yields. For the years 1885-1910, these data yield a correlation of 0.5 between the yield of wheat and the number of inches of summer rainfall. Whilst a gross oversimplification of the relationship, this does confirm a strong interdependence. Other stochastic influences such as the data of the first killing frost of fall have analogous effects on the outcome of grain cultivation. Much of the land of the Prairies can be used for wheat growing, with the exception of the centre of the arid area in southwestern Saskatchewan and southeastern Alberta known as the Palliser triangle. A significant proportion of the Palliser Triangle was in fact occupied for grain growing, but was later abandoned during the droughts of the 1930s.

New techniques and implements had to be developed to cope with conditions on the Prairies - the short growing season, the semi-arid climate and the labour shortage. To a significant extent these changes could be said to be endogenous to Prairie settlement, in that they could probably have been developed at an earlier date if settlement had begun earlier. The same however cannot be said of the implements which were necessary. Most pieces of equipment

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[1] Strange, H.G.L. A Short History of Prairie Agriculture. Searle Grain Co., 1954, Appendices II, III, IV, and V.

such as the threshers, binders, sulky gang plows, steam traction engines, etc. discussed in the following chapters were initially developed for use in other areas, particularly the American Midwest. Engineering and metallurgical developments were needed, which had not taken place at earlier dates. In that these innovations were not developed earlier for use in these other locations, it is not realistic to suggest that they could have been developed earlier for use on the Prairies.

The basic operations involved in wheat growing are firstly the plowing of the land, which can be done either in early spring before seeding or in the fall after the harvest. The ground then needs to be harrowed to break the soil into fine particles, after which the seed is planted. The dates for planting are discussed in the third part of this chapter. If the seed were sown broadcast, the ground would then need to be harrowed again, to bury the seed. After 1890, when dry farming techniques were more developed, the seed was planted using a seed drill, which pushed the seed two or three inches underground. The ground might have to be cross-harrowed once if weeds were a problem, but little else was needed until harvest time.

In the fall the grain had to be cut and bound into bundles, called 'shocks', which were then either left to stand for about seven to ten days in 'stooks' in the field, or were brought immediately to a central point where they were stacked up. Stacking improved the quality of the grain by reducing the water content from about eighty six percent, when freshly cut, to about sixty five percent. The grain was then separated from the straw and chaff, after which it was bagged and either taken immediately to market, or stored and taken later. By 1910 a large proportion of the grain was no longer bagged, but was either loaded directly from the separator into a grain tank (a metal lined box mounted on a wagon), or into a portable granary for short-term storage.

A variety of alternative techniques of wheat growing were worked out over the years. Initially all plowing was done in spring, since this practice gave a slightly greater yield, but from the mid 1880s farmers began to do an increasing proportion of their plowing in the fall. The slight

drop in yield which this caused was more than compensated for by the additional time available for seeding in the spring if the plowing was done after the harvest. The alternative of fall plowing is offered by the model after 1890. Another alternative was to drill the wheat directly into the stubble from last year's harvest. The yield from such a crop was slightly lower even than when plowing in the fall, but again the saving on plowing and labour made this a useful practice in some circumstances.

An important area of change in wheat production was the importation and later the development of new strains of wheat. Prior to 1870 a variety of different wheat seeds were grown, mostly brought up from the U.S.A., and not particularly well suited to Prairie conditions. From 1870-1907 the most important variety was Red Fife, which matured relatively quickly and was suited to the soil and weather conditions on the Prairies. However, as is discussed in the hypothesis section of this thesis, an earlier variety of wheat would have increased farming profitability and reduced the variance of that profitability significantly. A great deal of effort was put into the search for a better strain, mainly at the Experimental Farms on the Prairies.

Several varieties, both of imported seeds and of cross-bred types, were tried, but none was really successful until 1908 when Marquis wheat, first tried experimentally in about 1897, was made available on a commercial scale[2]. The Brandon Experimental Farm data for 1909-1914 show that Marquis wheat yielded 43.0 bushels per acre (sample s.d. 6.1 bu/ac) in an average of 106 days (s.s.d., 7.6 days), whilst for Red Fife the average was 37.83 bu/ac (s.s.d. 8.0 bu/ac) in 115 days (s.s.d. 8.3 days). This result represented a 14% increase in the yield, and more importantly an 8% reduction in the growing time needed. This shorter growing time enabled farmers to crop a larger area of wheat in the time available. Marquis wheat is offered instead of Red Fife in all the 1910 models.

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[2] Many other varieties were also tried, but they tended to suffer from plant diseases such as smut and rust. Marquis was less susceptible to these problems even than Red Fife.

The models include the cost of buying seed for ten percent of all acreage resown in each year - farmers would use a certain amount of each year's crop as seed for the next year, but it was advisable to introduce registered seed on a regular basis, to reduce the proportion of weeds in the crop[3].

b) Oats

Oats were grown on the Prairies principally for animal feed. Each farm sought to become self-sufficient in animal foodstuffs as soon as possible, in order to reduce the need for cash. Established farmers did not supply enough oats to the market to meet the needs of town-dwellers and of new settlers who were not yet self-supporting, since the profits from wheat growing exceeded those from producing oats. There are many references in contemporary newspapers to the importation of oats from Eastern Canada[4], indicating at least temporary shortages of oats on the Prairies.

Oats are somewhat more suitable than wheat for feeding animals, partly because wheat grain is too rich, and partly because the yield of oat grain per acre is considerably higher. The average yield of wheat in Manitoba in the 1890s was 18.45 bushels per acre[5] which at 60 lb per bushel is 1,107 lb of grain per acre. During the same period the average yield of oats in Manitoba[6] was 34.77 bushels per acre, weighing about 50 lb per bushel, a total of 1,738 lb of grain for a similar investment of time and money. The cultivation of oats differed from that of wheat in that oats were planted later in the year, although they were harvested at the same time

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[3] Bracken, J. 'Dry Farming in Western Canada.' Grain Growers Guide Ltd. Winnipeg: 1921, p. 114, pp. 481-485.

[4] See, for example, Manitoba Free Press, January 20 and May 3, 1887, Brandon Weekly Mail, December 18, 1888; Saskatchewan Herald, Battleford, April 23, 1890.

[5] Strange, A Short History of Prairie Agriculture, Appendix II.

[6] *Ibid.*, Appendix IV.

as wheat. Land for oat growing was usually plowed in spring, and it then needed to be harrowed before seeding, and both harrowed and packed after seeding[7].

c) Barley and Rye

Barley is a fairly hardy crop and if a good quality is obtained, can be quite valuable for malting purposes. However its cultivation was more labour intensive than that of the other small grains[8]. The seedbed needed an extra harrowing to ensure that it was fine enough, the stooks had to be carefully capped, and for malting barley, all the harvesting had to be done within three days, to ensure that the entire batch was uniform in colour. The Nor-West Farmer[9] suggested that the cap sheaves should be threshed separately, since the colour would be slightly different.

Barley was planted about ten days after oats, about three weeks after wheat[10]. It was harvested about six days before wheat and oats, and therefore did not conflict much with those crops, but its value was very uncertain. If the weather was exactly right, and the farmer very careful with the threshing, the barley might be of malting quality, which commanded a high price. Usually however barley was fit only for animal feed, at a far lower price. Typically barley was grown only on about four percent of the total area of cropped land on the Prairies[11]. Plowing for barley was done in the fall[12] on heavier Prairie soils, and in spring on the lighter soils. If the barley was for malting, it had to be left until well ripened, and then not threshed too closely,

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[7] Bracken, "Dry Farming in Western Canada.", p. 158.

[8] Nor-West Farmer, February 1886, p. 382.

[9] NorWest Farmer, August 1886, 'Harvesting Barley'.

[10] Experimental Farms' Reports 1889-1913.

[11] Census of Canada, 1880, 1890, 1900, 1910.

[12] Bracken, "Dry Farming in Western Canada.", p. 178.

to avoid damaging the grain. Feed barley was harvested earlier, and threshed quite closely. Only feed barley is incorporated in the linear programming models.

Very little rye was grown on the Prairies - the acreage never exceeded one tenth of one percent of the total cropped area. This crop was therefore not offered in the models.

d) Flax

In the long run, flax was not an important crop on the Prairies. Census data show that the highest percent of land use for flax was in 1910, when 3.2 percent of cropped land was in flax. In earlier years the proportion was far lower.

Flax seed was used to make linseed oil and oilcake (an animal feed). In the 1880s the seed had to be sent for processing to Eastern Canada, but by the early 1890s a linseed oil mill had been set up in Winnipeg, providing a stable market for the seed[13]. The stalk of the flax plant was used for making linen, but this manufacture was never feasible on the Prairies, due to the high cost of transporting the bulky stalks to the East where the linen industry was situated.

The only relevance of flax to the analysis of this thesis is that it was sometimes used as a cash crop in the first year or two after settlement. It could be sown late, up until the end of May, and gave a reasonable yield on freshly broken ground. Preparation of the soil was not critical, although threshing had to be performed carefully, and special screens had to be fitted to the separator for the fine seed. Flax seed also was difficult to transport, since it was fine and very slippery due to its oil content[14].

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[13] Farmers' Advocate, Western Edition, February 5, 1894, p. 48.

[14] Farmers' Advocate (Western Edition), February 5, 1894, p. 48.; de Gelder (1973), p. 36; Bracken (1911), p. 213; Farmers' Advocate, Western Edition, May 18, 1904, p. 721; October 5, 1907, p. 920.

e) Hay and Pasture

Hay was produced on the farm for livestock feed, and can be divided into the two distinct types of native and cultivated. Native hay was cut from the original Prairie grass, in contrast to cultivated grasses such as clover, alfalfa, brome or timothy. Relying on native hay saved the farmer the work of plowing and seeding, but both yield and nutritional value were lower than could be obtained from cultivated hay. During the earlier years many farmers cut native hay from unoccupied land nearby, which involved a great deal of moving of implements around the poor roads, and was a time consuming process, although involving none of the settler's own land. As settlement in each area increased, this option disappeared. Cultivated hays such as clover were available in 1880, but appear to have been little used due to the abundance of native hay. By 1890 clover and brome grass were in use, and by 1900 timothy hay was popular.

The linear programming models incorporate two haying activities and two pasture growing activities. In 1880 native hay is available, which yielded about one ton per acre, and was either cut or pastured. In 1890 this was still available, but clover was also grown, yielding about 2,600 lb per acre[15]. By 1900 timothy grass, yielding 2,500 lb per acre, and with a significantly higher nutritional content was also grown.

Cultivated pasture consisted of field crops which were grown with the intention of turning animals into the field to do the harvesting directly. Such crops included various hays as well as oats, corn, mixed grain or any other suitable crop. Cultivated pasture consisting of a mixture of peas and oats is incorporated in the linear programming models for all animals except sheep, for which a small area of native pasture is allowed, consisting of poor grasses on low quality land which received no cultivation.

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[15] Gehrs, J.H. The Principles of Agriculture. New York: MacMillan, 1919, p. 129.

f) Potatoes

Potatoes provided an excellent source of succulent food, contain many vitamins and starches, and could also be stored longer than many other vegetables. For these reasons potatoes were popular on the Prairies. Although their cultivation was highly labour intensive, most of the operations took place at different times from those of grain growing. Land on which potatoes were to be grown had to be well plowed the previous fall, manured, and then plowed again and harrowed in the spring. Potato planting machines were developed, but were heavy and expensive, and economically viable only for a far larger area than the normal farm would allocate. For the one or two acres grown on the typical farm, planting was done by hand throughout the period.

Potatoes needed cultivating three or four times during the growing season to prevent weeds from swamping the plants. Whilst the plants were still small, this could be done with a horse drawn harrow, but two rounds of cultivation had to be done by hand, as did thinning out. The potatoes were dug up in late September, after the grain harvest, either by hand digging, turning out with a plow and collecting by hand, or with the use of a mechanical digger. Mechanical potato diggers were first developed in the 1880s[16], but were initially heavy and expensive and not worthwhile for most farms. Kranich[17] notes that the draft of a potato digger in 1910 was 734 lb, necessitating a four-horse team. A smaller potato digger, the Aspinall, advertised in the Farmers' Advocate, Western Edition, March 1891, p. 95, could dig five to eight acres per day, pulled by two horses, but Bracken[18] suggested that an output of three to five acres per day using four horses was more realistic. The models are based on the use of hand

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[16] See for example, the Farmers' Advocate, Western Edition, June 1890, August 1891, p. 313.

[17] Kranich, F.N.G. Farm Equipment for Mechanical Power. Macmillan, 1923, p. 195.

[18] Bracken, "Dry Farming in Western Canada.", p. 336.

digging throughout the period, since the typical farm being analyzed produced too small a crop of potatoes to justify the purchase of an expensive mechanical digger.

The yield of potatoes used in the models is taken from the Census data for that district. It is likely also that the variety of potato grown changed over the period from 1880 to 1910, though the linear programming models do not allow for this change since there is no specific information in the contemporary literature.

g) Turnips

Turnips were grown primarily as animal fodder. Their cultivation is similar to that of potatoes, being highly labour intensive. The only identifiable change during the period was again the introduction of planting and digging machines, which are not incorporated in the linear programming models for the same reason as for potato diggers. Once harvested, the turnips were cut up before being fed to the animals, to make them more digestible. There was some improvement in these root cutters over the period, but this development had little effect on the overall costs of turnip growing.

h) Summer Fallow

Summer fallow was one of the more important aspects of the 'dry-farming' technology developed on the Prairies. The technique consisted basically of leaving the land uncropped for one complete season, which had the effect of accumulating that season's rainfall in the soil, where it was available for the crops in the following year.

Fallowing had other advantages as well. Bracken[19] noted that working the fallow land with a plow or harrow not only helped to retain the moisture in the soil, but also killed the weeds and enabled the following year's crop to be planted early, since little further preparation was

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[19] *Ibid.*, p. 108.

needed. The fallow land was usually left bare, but a 'green manure' crop such as peas or rape could be grown and plowed in to fix additional nutrients for future crops. An advantage of fallowing which the linear programming models pick up was that in a context in which the principal constraint on farm production was labour rather than land, the use of summer fallow provided a better organization of the farmer's work. Most of the work on the fallow land could be carried out in the quieter periods of the agricultural year - after the planting season was over, and before the haying season.

The disadvantages of fallowing a portion of land were firstly that that land yielded no revenue for the year in which it was fallow. The topsoil could also become loose and drift, and Bracken[20] also felt that on a heavy soil the use of fallow delayed the ripening of the crop in the following year. In wet seasons the following crop sometimes had a tendency to suffer damage either from the disease 'rust' or from 'lodging' - bent stalks. The overall effects of fallowing were clearly beneficial, at least in the short run, in reducing the danger of crop loss in dry years[21]. However in the long run it may well have contributed to soil erosion and the 'dust bowl' of the 1930s[22].

The systematic use of summer fallow only became prevalent in the 1890s, even though farmers were experimenting with the technique in the preceding decade. This is apparent not only in the contemporary literature, but also shows up clearly in the Census. The proportion of improved land in Manitoba on which crops were being grown in 1880 was 92%, and in 1890 was 99%. Fallowed land was recorded explicitly only by 1910 when it amounted to 14% of all

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[20] Bracken, "Dry Farming in Western Canada."

[21] Norrie, K.H. "The Rate of Settlement on the Canadian Prairies 1870-1911."; Norrie, K.H. "Dry Farming and the Economics of Risk Bearing: The Canadian Prairies 1870-1930." Agricultural History 51 (1977): pp. 134-148; Norrie, K.H. "Cultivation Techniques as a Response to Risk in Early Canadian Prairie Agriculture." Explorations in Economic History 17, No. 4 (October 1980): pp. 386-399.

[22] The danger of exacerbation of soil erosion was noticed as early as 1898. An article in the NorWest Farmer (August 1898, p. 360) notes the problem of drifting soil due to working a vegetable soil too finely.

improved land in Manitoba, but the 1900 Census shows that crops were being grown on only 69% of improved land. This large divergence may have been due in part to the very low rainfall in 1900 which resulted in average yields of about half of their normal levels, and therefore probably a lot of abandonment of sown fields. However it is clear from newspaper and journal articles that the idea of the summer fallow was well established by 1900, and the procedure has therefore been included in the linear programming models from that date. The technique is still important on the Prairies, and about 30% of Prairie land is fallowed each year.

The apocryphal story appearing repeatedly in the literature is that the discovery of summer fallow was accidental[23]. The suggestion is that many Prairie farmers were called away from their land during the spring of 1885 to fight against Riel or to cart supplies to the army. The fields of those farmers therefore remained uncultivated that year, and although the following year was one of relatively poor rainfall, the crops grown on the fields which had been unused were noticeably better than those on other fields.

l) Crop Rotation

The first crops taken from the virgin Prairie land were very heavy, but yields then fell off rapidly, particularly if wheat were grown on the same plot of land repeatedly. The purpose of growing a specific sequence of different crops on the same piece of land is to maintain the fertility of the land and therefore the value of the crops grown. Each crop uses different nutrients from the soil, and repeated growing of the same crop results in a rapid reduction in the yield.

It was difficult to obtain information about the usage of particular crop rotations on the Prairies. The first reference found was in 1894[24], which recommended the following six year rotation for Manitoba:-

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[23] See for example Strange, A Short History of Prairie Agriculture, p. 26.

[24] Farmers' Advocate (Eastern edition) 20 February 1894, p. 67.

Year 1 - Wheat drilled into the sod

Year 2 - Plow and sow oats or barley

Year 3 - Fallow, with a 'green manure' crop of either:-

- harrow and sow rape, or
- plow and sow peas.

Year 4 - Wheat, cultivate after the harvest.

Year 5 - Hay - Timothy or clover with barley or oats.

Year 6 - Pasture, then plow deeply, harrow and roll in the fall.

On 9 September 1902 the Farmers' Advocate[25] noted the following six year rotation on a large (860 acre) farm in Neepwa (Manitoba):-

Year 1 - Plow in previous fall, manure in winter, drill barley in spring, plow after harvest in fall.

Year 2 - Wheat, also sow timothy hay.

Year 3 - Hay crop from timothy.

Year 4 - Pasture. After haying time, plow, pack, harrow and cultivate.

Year 5 - Wheat. Fall plow.

Year 6 - Oats.

This last rotation is unusual in incorporating no summer fallow, which appears in all other rotations found. More common rotations appear to have of the type outlined by MacGibbon[26], which consisted of the three years:-

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[25] Farmers' Advocate (Western edition), 9 September, 1902, p. 212.

[26] MacGibbon, D.A. Agriculture, Climate and Population of the Prairie Provinces of Canada. Ottawa: 1931, p. 461; Farmers'Advocate, 20 January 1902, p50. The same rotation is mentioned in other secondary sources such as Spector, D. Field Agriculture in the Canadian Prairie West, 1870 to 1920, With Emphasis on the Period 1870 to 1920. Ottawa: Parks Canada, Department of Indian and Northern Affairs, National Historical Sites and Parks Branch, Manuscript Report No.205, 1983, p. 133.

Year 1 - Fallow

Year 2 - Wheat

Year 3 - Wheat, oats or barley.

This barely qualifies under the term of rotation, one of the purposes of which is to use alternative crops in different years to avoid exhausting a particular set of nutrients from the soil. However the purpose of using of summer fallow in one year was to increase the expected yield of wheat in the following year, and it is only in the context of such intertemporal considerations that fallowing makes any sense. The three rotations of this type are therefore offered in the linear programming models from 1900 onwards, and are selected in several of the solutions.

The other rotation offered in the models was noted in the NorWest Farmer[27], and consists of :-

Year 1 - Wheat

Year 2 - Wheat

Year 3 - Oats

Year 4 - Fallow with green manure

The purpose of using these rotations was to increase the expected yield of the various crops, and the available data substantiate that this expectation was correct. The yields incorporated in the linear programming models for the crops grown in rotations are therefore greater than the yields from growing one crop repeatedly on the same land.

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[27] NorWest Farmer 20 February 1907, p216; NorWest Farmer 20 July 1907, p. 714.

Crop Yields

The yield information used in the linear programming models is derived principally from Census data, supplemented by the information in the appendices to Strange[28], which include data at the Provincial level on wheat, oats and barley yields from 1878 to 1930. These were the only systematically recorded sources of useable data. The extremely detailed yield data in the Annual Reports of the Experimental Farms run by Federal Department of Agriculture and Immigration were unfortunately unusable, due to the unrepresentative experimental nature of the farming.

In 1886, the Federal Government decided to establish a series of Experimental Farms across Canada, in order to encourage the improvement of agriculture. Modelled on the famous Rothamstead Experimental Station in England, the intention was that these farms would experiment with all aspects of agriculture, in order to ensure that the most suitable crops were grown using the best techniques possible. The first of these Experimental Farms on the Prairies was set up near Brandon, Manitoba in 1888, and in 1889 tried 17 varieties of wheat, 20 varieties of oats, 21 types of grasses and clovers, 12 types of corn, 8 types of millet, 93 of potatoes, 13 of turnips, and 3 types of mangel. They experimented with different soil preparations, methods of sowing, depth of sowing, weight of sowing, and manuring for some of these crops. They grew a wide variety of fruits, and tried out many different methods of animal husbandry. Not only did they develop good practices in many of these areas, but they also disseminated the information generated through the publication of pamphlets and newspaper articles, organisation of open days and exhibitions, and the sale of the seeds they recommended.

Additional Experimental Farms and Stations were established at Indian Head, Rosthern, Scott, Lethbridge, Lacombe, Fort Vermilion, Grand Prairie, Grouard, Fort Providence and Fort Resolution. The recorded crop yields extracted from the Annual Reports of these farms between

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[28] Strange, A Short History of Prairie Agriculture, Appendices I to V.

1889 and 1920 were far higher than the Census averages. The principal problem with the use of the Experimental Farms data is that they represents the best technical practise, which was by no means adhered to on the majority of farms. The Experimental Farms were not run to generate a profit, and generally used labour, equipment and other inputs far more lavishly than commercial farms did. To ensure that the yields from the various strains of each crop, or the various treatments given to the crops, were strictly comparable, it was necessary to plant all 17 varieties of wheat, or all 93 varieties of potatoes, on the same day. All other operations on that crop would then also occur at similar times, which resulted in a series of 'peaks' in labour demand, between periods of little activity. This care resulted in extremely high yields for many crops - far above the Provincial and District averages - and therefore these data were not useable for the analysis of this thesis.

Raw yield data from the decadal Census were unsuitable for use in the models due to their randomness. Yields in 1900 and 1910 were particularly non-representative, due to the extremely poor weather conditions. It was necessary therefore to use more representative information from which to construct settlers long-run expectations of yields. The annual yield data for wheat, oats and barley collected by Strange[29] were used to calculate long-run averages for these three crops, on the basis of five year moving averages[30]. This technique provided an average expected yield for each Prairie province for each of the four decadal years.

The yields at the five farm locations within each province were then calculated using the cross-sectional information in the Census data[31]. The long-run relationship between the average

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[29] Strange, A Short History of Prairie Agriculture. Appendices 1 to 5. Strange used information collected from Provincial records and also the records of the Searle Grain Co.

[30] Except for 1880, for which only one data point for each province was available.

[31] Census data for 1880, 1885, 1890, 1900, 1910 and 1920 was used. The yield for the smallest available Census area which contained the place in question was expressed as a proportion of the Census Provincial average yield,. (The 1920 data was used to improve the degree of accuracy, since in the 1890 and 1900 Censuses the level of aggregation of the reported data was very high - in 1900 only a single aggregate figure was given for each crop for the whole of Alberta, and one for

yield of each crop at each of the farm locations[32], and the Provincial average yield, was calculated from Census data. This relationship was then applied to the moving average yield calculated from the data in Strange[33]. Tables 3.1 to 3.6 list the various expected yields calculated.

Table 3.1

Basic Expected Gross Yields[34] of Spring Wheat[35]

	Proportion	1880	1890	1900	1910
Manitoba					
Moving Average (Province)		20.1	18.1	18.1	17.9
Brandon	1.05	21.1	19.1	19.1	18.8
Saskatchewan					
Moving Average		21.1	15.2	18.6	19.1
Indian Head	1.06	22.3	16.1	19.7	20.2
Scott	1.17	24.7	17.8	21.8	22.3
Alberta					
Moving Average		21.1	15.2	16.8	22.8
Lacombe	1.21	25.5	18.4	20.3	27.6
Lethbridge	1.00	21.1	15.2	16.8	22.8

Saskatchewan. The 1920 data was not used in calculations of the absolute levels of yields.) An average of these six proportions was calculated for each location.

[32] Appendix 4 lists the Census district for each of the five farms for each of the Censuses used.

[33] *Op.cit.*

[34] These figures are for the gross yields from the Census data, and deductions for seed had to be made to arrive at the net yield.

[35] These yields are calculated directly from the relevant Census data. Table 3.3 below lists the relative yields attributed to crops grown in rotations. By implication therefore, to maintain the true averages, crops not grown in rotations would have rendered yields lower than the figures listed in this table. For this reason, the yields assigned to crops grown repeatedly on the same plot of land (from 1900 onwards) are incorporated in the models as being 10% lower than these Census figures.

Table 3.2

Yields of Fall Wheat

Fall wheat is included only in the models for Southern Alberta, and there only for 1900 and 1910. Listed below are the actual proportions of fall wheat grown, taken from the Census data:-

1880	Total for Prairies - 0.4% of all wheat.
1885	No data
1890	Total for Prairies - 0.04% of all wheat.
1900	Total for Prairies - 0.09% of all wheat.
1910	Manitoba - 0.02% of all wheat.
	Saskatchewan - 0.3% of all wheat.
	Alberta - 26% of all wheat.
1920	Manitoba - 0.2% of all wheat.
	Saskatchewan - 0.3% of all wheat.
	Alberta - 0.6% of all wheat.

	1900	1910
Alberta		
Provincial Average	11.3	13.4
Lacombe	28.3	20.7
Lethbridge	28.3	9.6

Table 3.3

Yields of Crops Grown in Rotations[36]

Wheat one year after bare fallow - yield 12% greater than basic.
Wheat two years after bare fallow - yield 3% greater than basic.
Wheat one year after green manured fallow - yield 15% greater than basic.
Wheat two years after green manured fallow - yield 5% greater than basic.
Oats or barley after wheat, in rotation - yield 3% greater than basic.

[36] The only source of information for these relative yields were the Reports of the Experimental Farms. As stated elsewhere, the yield data in those Reports had to be treated with extreme care, since all yields were relatively high due to the excessive attention lavished on the crops on the Experimental Farms. Results of experimentation on crop rotation on the Brandon and Indian Head Experimental Farms are reported from 1893 onwards. The relative yields listed in the table were calculated by comparing a sample of these reported yields with the results form the control plots in the same experiments.

Table 3.4

Basic Expected Gross Yields of Oats

	Proportion	1880	1890	1900	1910
Manitoba					
Moving Average (Province)		36.3	33.7	34.0	39.3
Brandon	0.95	34.5	32.0	32.3	37.3
Saskatchewan					
Moving Average		25.0	22.9	29.3	38.1
Indian Head	0.94	23.5	21.5	27.5	35.8
Scott	1.15	28.8	26.3	33.7	43.8
Alberta					
Moving Average		25.0	20.4	29.3	39.8
Lacombe	1.08	27.0	22.0	31.6	43.0
Lethbridge	0.74	18.5	15.1	21.7	29.5

Table 3.5

Basic Expected Gross Yields of Barley

	Proportion	1880	1890	1900	1910
Manitoba					
Moving Average (Province)		20.0	25.0	27.7	30.2
Brandon	1.03	20.6	25.8	28.5	31.1
Saskatchewan					
Moving Average		20.0	17.6	22.8	25.2
Indian Head	0.90	18.0	15.8	20.5	22.7
Scott	1.05	21.0	18.5	23.9	26.5
Alberta					
Moving Average		20.0	17.6	22.8	27.8
Lacombe	1.10	22.0	19.4	25.1	30.6
Lethbridge	0.75	15.0	13.2	17.1	20.9

Table 3.6

Expected Gross Yields of Other Field Crops[37]

	Potatoes (bu/ac)	Hay(Cultivated) (tons/ac)	Flax (bu/ac)	Turnips (bu/ac)
Manitoba				
Brandon	119	1.5	8.4	229
Saskatchewan				
Indian Head	119	1.3	9.3	219
Scott	127	1.1	7.9	183
Alberta				
Lacombe	137	1.4	7.1	202
Lethbridge	121	1.5	5.0	141

[37] All figures in this table are calculated as simple arithmetic averages of all Census data available for that location from the Censuses for 1880, 1885, 1890, 1900, and 1910.

Seasonality

a) Introduction

The sequence and organisation of agricultural activities is largely predetermined by the passing of the seasons. The farmer has to solve a highly complex optimisation problem in which all the exogenous variables he faces - prices of all the multiple inputs and outputs and the weather, with its effect on work loads and yields - are stochastic. He has to form expectations of these factors, and organise his cropping and animal husbandry accordingly. Some of his decisions, such as the proportion of the available acreage to use for each of the various field crops, can be revised annually. Others, such as the number of animals of each type to keep, can be adjusted only more slowly. Such adjustments are slower partly from the need to erect more accommodation for additional livestock and to rearrange the availability of labour, and partly because there is likely to be correlation between farmers' perceptions of relative profitability of different activities. This correlation will create quasi-rents during the stock adjustment period in the ownership of animals whose profitability has risen, inhibiting changes in the level of that husbandry activity.

Two reasons are usually advanced for the farmer's decision to undertake multiple cropping. The first of these is risk aversion - particularly the desire to avoid catastrophic loss in the event of a single crop failing. Whilst this is undoubtedly of some importance, it is not clear how much income loss a farmer would be prepared to accept in order to avoid such situations. A more important reason for multiple cropping is the seasonality of agricultural operations. Each different crop has its own schedule of operations, requiring planting during one period, cultivation in another, cutting and binding in another, collecting and then threshing in others. Concentration in only one or two crops will usually not make optimal use of the available labour, with some seasons becoming very busy, and at other times the farmer having little to do. The models developed in this thesis show that even without incorporating the influence of uncertainty, farmers would have chosen a blend of different crops and animal husbandry activities, because

their different seasonal labour requirements enabled them to obtain a greater value of output. Even with both considerations, it is still possible that under some circumstances farmers would maximize expected profitability with a choice of only one crop. The decision to undertake multiple-cropping, and also some animal husbandry activities, is an empirical matter.

A realistic variety of crops and other activities are 'offered' to the settler in the linear programming models used in this thesis. Five field crops are included - wheat, oats, barley, flax and a mixture of peas and oats for pasture. Two haying options are offered, and potatoes and turnips. Cows may be kept for dairy operations; three different beef-raising activities and four pig rearing activities are available, as are the keeping of hens for eggs and for chicken raising, and also sheep rearing for wool and lambs. The inclusion of this variety of potential activities, with realistic seasonality of the workload for each one, led the linear programming models to predict some diversity of operation. The smallest selection was two grain crops, hay, one root crop and three animal husbandry activities[38].

It is not feasible with a linear model to capture the precise expected yield/planting date relationship with complete accuracy. There is some period for each activity which is optimal in the sense that the return from the activity is close to a maximum if it is undertaken at that time. For most activities, there are additional periods just before or after that optimal time, during which the activity may still be undertaken, even though it yields expected returns which are somewhat lower. These periods of lower expected returns could not easily be incorporated into the linear programming models, which were large enough to present computational problems without their inclusion.

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[38] Minimum numbers of cows, pigs and hens were specified in the linear programming models, to represent the self sufficiency in food for home consumption achieved by the majority of homesteads.

b) Data

From the Annual Reports of the Experimental Farms between 1889 and 1920 I extracted the dates of planting and ripening of all the major crops, which are summarised in Appendix 1. One problem with the use of unscreened data such as this is that the decision to begin each activity was made by the farmer, who was able to observe one very important variable - the weather - for which I do not possess detailed information. Since I could not use the crop yields from the Experimental Farm reports, for reasons discussed in this chapter, it is possible that some bias may arise. The Experimental Farm manager was trying to achieve the best yield possible, rather than the greatest farm total volume of crop possible. He may therefore have on occasion planted his crop later than a profit-maximizing farmer would.

The commercial farmer was likely to plant earlier - he could always re-seed if there was a late frost, though at the cost of a lower yield. He was planting a larger area per worker than the Experimental Farm manager, and the expected loss of delaying the sowing was damage to his grain from an early fall frost, since he would not have the manpower available to get his crop out quickly if the temperature began to fall unexpectedly in August. Whilst theoretically this could be a problem, in practice it is unlikely to be significant. It was possible to set up the linear programming models so that all crops were in the ground for the expected duration necessary for maturity, and were cut before the expected date of the first frost.

The information in the Experimental Farms Reports was used to calculate the mean date on which planting and harvesting of each crop was carried out at each location[39]. Given the length of time needed for the crop to reach maturity and the harvesting dates, the duration of the planting and harvesting periods for each crop were then calculated. The timing of other activities associated with each crop was found from the same information.

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[39] See Appendix 1.

Some of the Experimental Farm Reports contain details of all the inputs of labour, equipment, materials and power used in cropping operations. This information, if usable, would have been extremely helpful. On examination though these costs turned out to be very high. There was never the intention to run the Experimental Farms for profit, and the issue of the overstaffing necessitated by the exceptionally high peaks in labour demand would have ensured that costs were excessive. Overstaffing of labour was complemented by the use of far more equipment than the private farmer would have chosen to own.

There is also another problem - the purpose of the Experimental Farms was to find the crops and techniques which maximized yields, rather than maximized profits, and every operation was therefore carried out according to 'best practise'. The profit maximising farmer needed to minimize his costs and therefore used short cuts and cheaper alternatives. Experimental Farm costs, however carefully analyzed, were therefore significantly too high for profitable farming. Data from the Experimental Farms on animal husbandry activities were unusable due to the unprofitably high levels of inputs used to obtain the high levels of output achieved.

Whilst the Experimental Farms Reports provided good data on the dates of planting and harvesting of individual crops, they do not include consistent information about the overall length of the agricultural season. In the spring, ploughing and harrowing starts some days before the first seeds are sown. These activities could start once the frost was out of the ground, which was up to seven or eight weeks before the last frost. Most seeding could take place before the last expected frost, since the plants would not suffer damage until their shoots were above ground, which took five to eight days from seeding. Even then they would only be damaged if the frost was heavy.

Similarly, in the fall, the field crops had to be harvested and gathered in before the expected date of the first frost. However there was usually quite a long period after that first frost during which the ground was still soft enough to plough. Field operations could therefore continue for some time after that first frost.

Additional information therefore had to be collected to find out how much time was available in the spring and the fall to undertake these operations. Fortunately a good source for this data was found, although for a somewhat later time period. A statistical atlas of the Prairie Provinces was prepared from the information collected for the 1926 Census of the Prairie Provinces[40], which included maps showing the average date of the start of spring, and the average date of the start of winter for the area of the Prairies.

There was no standard definition of 'the start of spring' or of winter, so Hurd and Grindley established their own, based on the temperature needed for normal plant growth. They defined the start of spring as "the first day of the year when the temperatures may be expected to touch 43 degrees in the afternoon as the high point of the day"[41]. This criterion is based on the idea that "ordinary growth begins at an air temperature of 43 degrees"[42] . Using similar logic, Hurd and Grindley define the beginning of fall as "the last day when a maximum of 43 degrees may be expected"[43].

The information needed to construct the linear programming models includes both the date by which harvesting must be finished, which has been taken as the average date of the first killing frost of fall[44], and also the last date on which ploughing could be carried out in the fall. In practice ploughing continued until the ground was too frozen to be turned over, which was a more difficult point to determine accurately. For all the Experimental Farm locations, some observations of this date were available, and for the other locations used, information was obtained from contemporary sources, principally newspapers.

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[40] W.B.Hurd and T.W.Grindley, Agriculture, Climate and Population of the Prairie Provinces of Canada (Ottawa: F.A. Acland, 1931)

[41] *Ibid*, p. 9.

[42] *Op.cit.* p. 9.

[43] *Op.cit.*, p. 10

[44] Taken from Hurd and Grindley, *Op.cit.*, Figure 15, p. 18.

The information extracted from the Experimental Farms Reports and used in the analysis is summarised in Appendix 2. It consists of the average date of the start of sowing and the start of harvesting for the principal field and root crops grown in each area.

Peas (as a cash crop) and mangels were not included in the final versions of the models. Peas were never selected by the linear programming models, being similar in use and input requirements to, but less profitable than, oats, and mangels similarly were less profitable than turnips. Both of these predictions of the models appear to be realistic, since according to Census information these two crops were little used.

The dates for the start of activity in spring and the end of ploughing in early winter are also tabulated in Appendix 2, with the sources of the information used.

c) Weather and Other Delays

As Palliser noted, although the Prairies receive relatively little rain, the majority of what they do get comes during the summer[45]. I came across many stories in the contemporary newspapers and journals of the problems encountered because of the rain, particularly with reference to travel by (what were called) the 'roads'. Hauling either a wagon or a seeder through thick mud was very slow work, and it is clear that a lot of time was lost during the agricultural season due to rain and also, in the spring, due to late snowfalls[46]. Macoun[47]

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[45] The following rainfall data are given by Short and Doughty (Eds., Canada and Its Provinces, Vols 19,20 (Prairie Provinces) (Toronto: Glasgow, Brook & Co., 1914)), pp. 517, 547 and 585. (Expressed here as a percentage of the annual total):-

	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec
Brndn	5	5	5	5	10	20	14	14	8	5	5	4
Sask	4	4	6	5	13	21	15	13	8	3	4	5
Alta	4	3	5	5	18	22	14	14	6	4	3	3

[46] For example (Manitoba Free Press, 14 April 1877) "..complete breakup of roads has brought business to nearly a complete standstill". (Manitoba Free Press, 14 April 1887) ".. roads in a frightful condition". (Manitoba Free Press, 31 May 1887) " .. roads bad". (Saskatchewan Herald, Battleford, 11 August 1879) " rained 8 days in July".

[47] John Macoun, Manitoba and The Great North-West, (Guelph: The World Publishing Company, 1882); Chapter 10 "Practical Remarks on Climate".

recorded the weather for each day during the summers of 1879 and 1880, from June 19 to August 31. There was rain of some degree on 55 of the 152 days he lists, and also several days of "strong gales"[48]. There would also have been many days following the several thunderstorms he records on which the soil would be too soft to pull implements.

Another factor which affected the amount of time available for field work was the observance of Sunday as a day of rest. I found several references to the fact that many settlers did not work in the fields on Sundays. In one newspaper there was an item which noted the fact that the Mounted Police could order a farmer to stop if he was seen out working on a Sunday. These two factors, plus an allowance for the unavoidable delays due to trips into town for food, repairs to broken equipment, etc. necessitated a reduction in the total amount of time allowed for productive work. Table 3.7 below lists the proportions by which the total time for each activity was reduced to allow for these reasons.

TABLE 3.7
Allowance for Inclement Weather and Other Delaying Factors

	Inclement Weather	Sundays, etc	Total	Remaining
January	50%	14%		43%
February	40%	14%		51%
March	30%	14%		60%
April	20%	14%		69%
May	15%	14%		73%
June	20%	14%		69%
July	20%	14%		69%
August	10%	14%		77%
September	20%	14%		69%
October	30%	14%		60%
November	40%	14%		51%
December	40%	14%		51%

[48] *Op.cit.*, p. 172. - August 24, 1879 'Our tents blown away'.

CHAPTER 4

THE TECHNOLOGY OF FIELD CROPPING - 1880 TO 1920

Introduction

This chapter describes in detail the technology available to the farmer on the Prairies, and how this technology changed over the period between 1880 to 1910. The way in which the various components of that technology have been incorporated into the linear programming models used in this thesis is also discussed.

To grow any crops, the ground had first to be 'broken' - the initial turning over of the tough Prairie sod. Regular activities after that consisted of plowing (turning over the top few inches of soil - performed either in early spring or late fall); harrowing (breaking down the clods of plowed earth into fine particles); seeding; cultivation (breaking up the surface of the soil and pulling up weeds during the growing season); mowing and reaping (cutting the stalks of grain and collecting them up); threshing (separating the grain from the stalk; digging up roots and vegetables); transporting goods around the farm; and applying manure and fertilizers.

The labour and machine production rates in the following sections have been derived from data found in contemporary sources. In so far as possible figures pertinent to the typical farm of 160 to 320 acres gross area were selected[1]. Each of these processes will now be considered in detail.

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[1] The only way in which verification of this has been possible was by cross-checking between different sources, which has been done as far as possible, with multiple sources being cited in the text.

a) Breaking

The power required to cut through and turn over the untouched Prairie Sod was immense, given the crude technology available in the 1880s. Kranich[2] calculated that a 12 inch breaking plow cutting 5 inches deep required a steady draft[3] of 720 to 900 lb. There were frequently roots of up to 5 inches diameter to be cut through, which would require either a significant addition to this power, or for the plowman to stop, move the plow (which weighed about 125 lb[4]) and dig up and cut the root with an axe.

Breaking was initially carried out using a pair of oxen and a breaking plow. Oxen generated less power than horses because of their slower speed[5], but their immense weight (up to 2,650 lbs[6]) meant that they could readily provide the draft needed for breaking. A typical ox could provide a steady draft of about 350 to 400 lb at 1½ mph for up to 10 hours a day, which meant that the settler on clear land could do his breaking with two oxen. This however left no surplus power to cope with roots, stones or hard ground, and breaking with two oxen was a slow process. Some settlers bought a third or even fourth oxen, although hitching up two yoke (pairs) of oxen was time consuming and difficult, and the four oxen were then very hard to turn around at the end of each furrow.

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[2] F.N.G. Kranich, Farm Equipment for Mechanical Power. (New York: Macmillan,1927), p. 27.

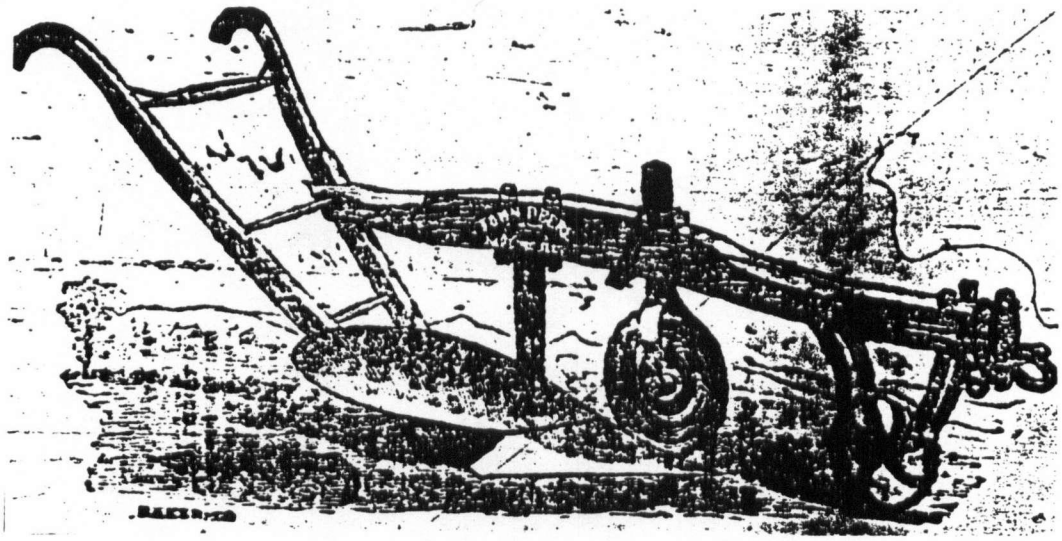
[3] The force of the horizontal pull.

[4] Hurt, Leslie J. The Victoria Settlement: 1862 - 1922. Edmonton: Alberta Culture, Historical Resources Division, 1979, No.7., p. 13.

[5] Davidson, J. Brownlee and Chase, Leon Wilson , Farm Machinery and Farm Motors. (New York: Orange Judd,1920), p. 28.

[6] Manitoba Agricultural Museum, Brochure, 1979, p. 181.

Figure 4.1



Prairie Queen Breaker Plow[7]

As discussed in the section on power, most early settlers apparently kept their oxen for just the first four or five years and then traded them in for horses, which moved at 2½ mph instead of 1½. Using ox power and a walking breaking plow, an output of 0.9 acres per man day is used for 1880[8].

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[7] Reproduced from The Winnipeg Daily Times, 12 April, 1879

[8] Derived from the following data:

W. de Gelder. A Dutch Homesteader on the Prairies. (Toronto: Toronto University Press, 1973), p. 70 - 'Four oxen, less than 1 acre/day'

Martin L. Primack. Farm Construction as a Use of Farm Labour. 1850 -1910. (Journal of Economic History XXV, March 1965) - 'Oxen 2/3 acre/day (1850)'

Manitoba Free Press (Weekly) July 5, 1887 - '24 teams, 20 acres in 1 day (= 0.83 acres/day)'

Breaking in of new land could only be carried out during the early part of the season, until about the second week of June[9], since the alternating heat and rain of summer was necessary to break up the hard sod. When first turned over, the soil was a hard slab, which needed the heat and rains of summer to break it up. Once it was softened, the broken sod had then to be 'backset' - turned back over, with about 2 in of additional soil lifted on top of it. This operation was carried out in late July or August, at a rate of about 2½ acres per man day, if oxen were used for motive power. With horse power the breaking plow moved more slowly, since two horses had insufficient draft - about 500 or 600 of the necessary 700 to 900 lbs. Output fell to 3/4 acre per man day with only two horses. The use of 3 horses could bring the plow back up to speed, but a 3-horse hitch was difficult to even up for a heavy, slow job. Using horses, however, 3 3/4 acres could be backset in a day. The need for the heavy draft of the ox for breaking was I believe the principal reason why settlers kept their oxen for the 5 years it took them to break in enough land, and then sold them.

If the land was wooded, preparation took a great deal longer. The felled timber could be sold, which was a profitable operation. There is much discussion in the newspapers in the early 1880s of land being homesteaded solely for its timber. Clearing an acre of trees could take 10 to 20 man days[10], but could yield more than enough timber to pay for the operation, since even in summer wood generally fetched $3 or $4 per cord[11]. However pulling an acre of stumps took at least a further 13 man days per acre[12], and the land still had to be plowed. Land covered with tree stumps was frequently left idle for some years after the trees were felled, before

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[9] Farmers' Advocate, Eastern Edition, March 1880, p. 33; John Bracken, Crop Production in Western Canada, (Winnipeg: Grain Growers' Guide, 1920), p. 108.

[10] Martin Primack, "Land Clearing Under Nineteenth Century Techniques: Some Preliminary Calculations". Journal of Economic History Vol.22, December 1962, p. 484.

[11] Manitoba Free Press, Market Reports 1877-1880.

[12] Primack, "Land Clearing Under Nineteenth Century Techniques: Some Preliminary Calculations", p. 491.

its rental value due to its location rose sufficiently to justify the expense of stump-pulling, the cost of which operation had meanwhile fallen as the timber rotted. None of the models of farms evaluated in this thesis is based on land which needed this degree of clearing.

If broken early enough in the year, a crop of flax or wheat could be grown that first year, but the yield would be low, and even for settlers who arrived early enough in that first year the models allow for only eight working days in that year to break ground on which flax was then planted. More breaking was of course carried out after the flax seed was planted, but if the land was broken after mid June its yield remained low for several years[13].

Hamilton[14] recorded that breaking could be carried out on a contract basis, at a cost of $5/acre. Relatively few settlers could afford to have their breaking done for them. To the extent that this work was performed on a contract basis, it was carried out by poor settlers during the first year or two on their homestead 'working out' to tide them over until they could become self sufficient on their own farm. Since labour availability in the models in this thesis is reconciled in the aggregate (see Chapter 5: Section B, Part d), such contract breaking would not have increased the overall labour supply, and would not have any effect on the total area of breaking. It is not therefore included in the models for 1880 and 1890.

During the 1890s the sulky breaking plow was developed. This consisted of a single plowshare mounted on two side wheels, with a seat for the plowman. The draft necessary for breaking was so heavy that the sulky breaker did not offer the advantages of the sulky plow (see 'Plowing' section). It made the work of breaking somewhat easier on the plowman, and he might possibly have managed to work a longer day if his draft animals could have managed it,

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[13] Seager Wheeler, "Profitable Grain Growing", Grain Growers Guide. (Winnipeg, 1919), p. 57.

[14] J.C. Hamilton, "The Prairie Province", 1875, quoted in Harold A. Innis, Problems of Staple Production in Canada, (Toronto 1933), p. 747.

although the effect was probably minimal. Output for 1890 has therefore been taken as the same as for 1880.

By 1900, there had been major changes in the operation of breaking. The most significant of these was the advent of the steam traction locomotive, the development of which is described in the section of this chapter on power, and had reached its peak by 1900. Prior to 1890, a few traction engines existed, although they could scarcely move their own weight, but by 1900 contract steam breaking was commonplace. Since the constraint on Prairie agriculture was that of labour shortage, the use of the traction engine had a fundamentally different effect to that of animal powered contract breaking. The same labour force could now achieve a vastly greater output. The traction engine could break approximately one acre per horsepower per day of ten hours, pulling from six to eighteen plowshares fixed to steel frames at 2½ - 3 mph.

The sulky gang plow was sufficiently developed by 1910 to be used for breaking. de Gelder[15] suggests that with four horses, about two acres a day could be broken. The development of this type of plow is described more fully in the next section, but the output coefficients for breaking done by the farmer are increased to 1.6 acres per day after 1900.

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[15] de Gelder, A Dutch Homesteader on the Prairies, 1973 p. 70.

Table 4.1

Breaking and Backsetting - Productivity and Costs Incorporated in Linear Programming Models

	1880	1890	1900	1910
Breaking - output (acres/day)	0.9[16]	0.9	0.9	1.6
Backsetting - output	2.5	2.5	4.8	4.8
Power Required	2 oxen/ 3 horses	2 oxen/ 3 horses	2 oxen/ 3 horses	2 oxen/ 3 horses
Cost of Plow	$28[17]	$28	$25	$25
Cost of Contract Breaking	Not Included	Not Included	$5.25[18]	$4.50[19]

b) Plowing

The ground was usually plowed up during the first couple of weeks after the spring thaw, before the weather was warm enough to plant the seed. Alternatively the plowing could be carried out in the fall, immediately after the grain had been brought in to the stack, or had been threshed, but the time of plowing did affect the yield. Initially little or no fall plowing was done because of the slightly lower yields, but after some experimentation during the 1880s fall plowing did become more popular.

The most effective plow in 1880 was the chilled steel plow, which had been first developed in about 1870. These plows, such as the one illustrated in Figure 4.2, were heavy and

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[16] See Footnote 7.

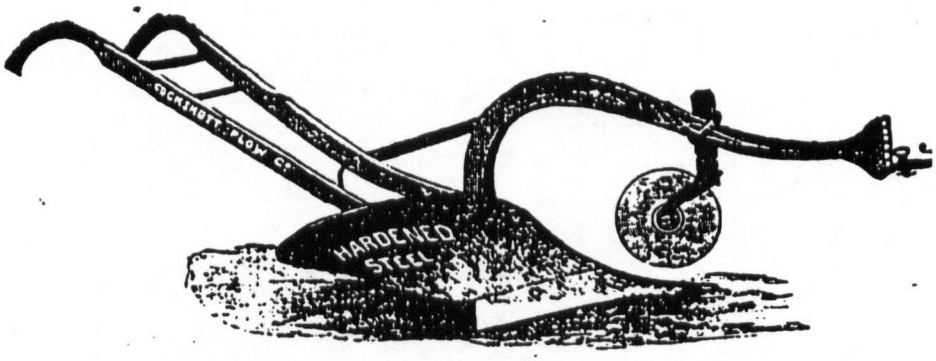
[17] John L. Tyman, By Section, Township and Range: Studies in Prairie Settlement. (Brandon: 1972), p. 44 - $25-30; Manitoba Free Press, March 10, 1877 'Report of the Minister for Agriculture and Immigration for 1876', $25-30; Trevor J.O. Dick, "Mechanization and North American Prairie Farm Costs 1896 - 1930" (Journal of Economic History. Vol.42 1982), p. 193: - $22.

[18] Edmonton Journal, May 10, 1897.

[19] NorWest Farmer, August 5, 1906, p. 819, $3.50/acre excluding backsetting and discing; Nor-West Farmer, March 20, 1909, $4.00/acre.

had a high draft, and they therefore needed two oxen or three horses to draw them through the soil[20]. The big advances in plowing technology in the 1880s and 1890s were the development of the sulky plow, the gang plow, and eventually the sulky gang plow. The early sulky plows consisted of a plowshare mounted on a pair of large wheels, one on either side of a carrying frame, with a seat for the driver to sit on. This reduced driver fatigue and increased the number of hours he could work, thereby increasing output by perhaps five to ten percent.

FIGURE 4.2



"STEEL" BEAM CROSS PLOW.
SHOWING ROLLING COULTER ATTACHED.
We have this Plow in three different sizes. 13 in., 14 in, and 16 in

Typical Beam Plow, 1887[21]

In 1882 the Farmers' Advocate[22] printed a letter commenting on the recent development of the sulky plow in the U.S.. Broehl[23] noted that the first Gilpin sulky appeared in 1875, but

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20 Marvin McKinley, Wheels of Farm Progress, (Michigan: American Society of Agricultural Engineers, 1980), p. 9.

21 Manitoba Free Press 15 September 1887.

22 Farmer's Advocate, November 1882, p. 298.

23 Wayne G. Broehl, John Deere's Company (New York: Doubleday, 1984), p. 201.

another letter in the Farmer's Advocate also in 1882[24] noted that no manufacturers were yet ready to sell such plows in Canada. The early sulky plows with two side wheels were transversally unstable since they could rock backwards or forwards about the cross axle, and were therefore not popular, with few comments on their use appearing in the literature. Since they offered few benefits, and do not appear to have been used very much, these early sulky plows are not incorporated in the linear programming models.

FIGURE 4.3

Typical Gang Plow, 1893[25]

The idea of the gang plow was to connect two or more plowshares together on a single frame, thereby enabling one man to plow more land at each pass. The draft of the early implements like this was very high - twice that of a single share. It therefore needed four to six

[24] Farmer's Advocate, December 1882, p. 32.

[25] Farmer's Advocate 20 May 1893.

oxen or six to eight horses to pull it. Managing a large team like that was difficult, particularly at the turns at the end of each furrow, and the gang plow therefore never became popular.

The concept of the sulky gang plow was obvious - mounting two or more plowshares on a wheeled frame. The Farmers' Advocate[26] showed an early example - with three small shares on a three wheel tricycle type frame, though without a seat for the driver. It was difficult to set the shares to the right depth, or to release a share if it caught on a rock or root. A plow also generates a sideward thrust, as it pushes the earth over to one side, and because of this wheeled plows tended to drift sideways. Hence for a variety of reasons the early sulky gang plows were ineffective and unpopular.

During the 1880s and 1890s several developments occurred to overcome these problems. In the mid 1880s plows were fitted with a frame of three wheels, ensuring transverse as well as lateral stability, and by the early 1890s the side wheels had been moved further back and angled over. These wheels would run along the edge of the previous furrow, counteracting the side thrust without creating any additional drag[27]. The advent in the 1920s of gasoline tractors eliminated the need for the canted frame, since the rigid tow enabled the tractor to absorb the side thrust from the plowshare.

Efficient mechanisms for setting the depth of each share accurately, and for allowing any one of the plowshares to be pushed up independently if it hit an obstruction were also developed in the late 1880s. With the development of angled wheels to counteract the side thrust, it became possible to remove the long 'landside' of the walking plow, which had previously contributed so much to the draft of the plow. Since the share was on a longitudinally stable frame, it could be tilted slightly 'nose-down', so that only the front edge touched the

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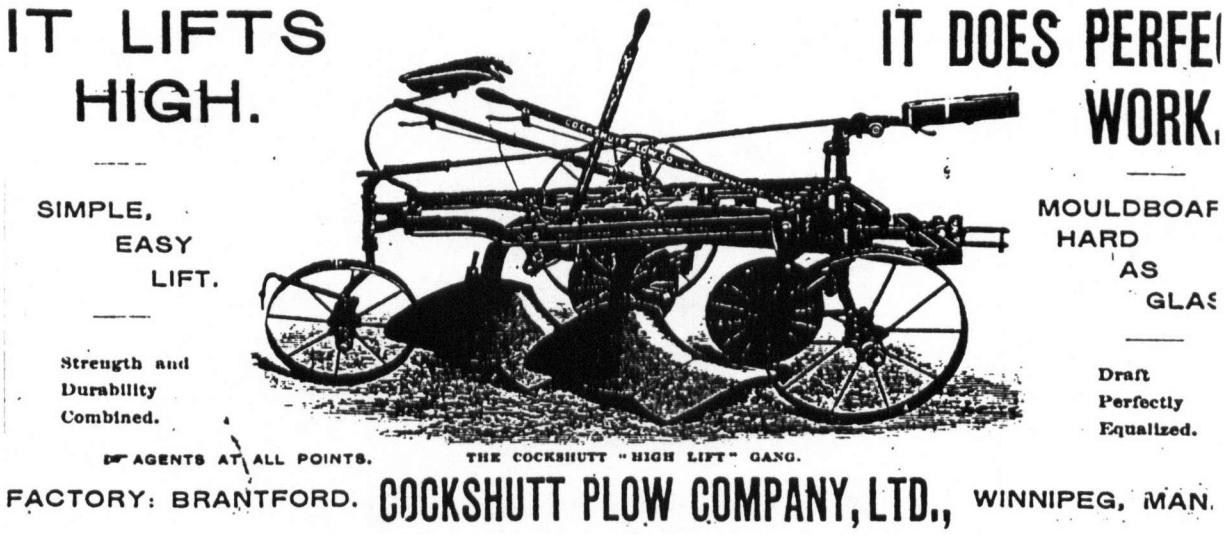
[26] Farmer's Advocate, March 1878, p. 72.

[27] For example see the advertisement by the Cockshutt Plough Co., Farmers' Advocate (Western Edition), June 1890.

bottom of the furrow, which reduced the draft significantly, making it quite feasible for two horses to pull two 14 in bottoms at about 2¼ mph. Figure 4.4 shows a plow with all these features.

The other development in plowing technology was that of the disc plow. With a fixed moldboard plow of any type, the main draft to be pulled was created by the friction of the soil against the plowshare and the landside. By using a circular saucer-shaped share, free to rotate, this friction was reduced significantly, since the disc turned as the soil was forced across it, and the soil only rubbed against the share for a short distance. Lateral thrust was resisted by setting the multiple discs of the disc plow in opposing directions.

FIGURE 4.4



Typical Sulky Gang Plow, 1899[28]

[28] Farmer's Advocate (Western Edition) 20 April 1899.

Table 4.2

Plowing - Productivities and Costs Incorporated in Linear Programming Models

Item	1880	1890	1900	1910
Plowing output (Acres/day)				
(2 oxen)	1.3[29]	1.3	3.0[30]	3.0
(2 horses)	2.1	2.1	4.8	4.8
Cost of Stubble Plow	$25[31]	$22[32]	$18[33]	$13[34]
Cost of Disc Plow	-	-	-	$75[35]
Cost of Sulky Gang Plow	-	-	$95[36]	$95

The first mention I found of the disc plow was a note in the Farmers' Advocate in 1878[37], which discussed the invention of a novel plow (which used large steel discs) by Thompson and Williams of Stratford, Ontario. However the disc plow was at first heavy to use, difficult in wet ground, and unable to turn a sufficiently wide furrow to be efficient. Advertisements for these plows do not appear until after 1900, even though the implement was discussed in the journals

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[29] 1880, 1890 - 14" plow at 1¼ mph for 10 hrs/day, less 20% of the time stopped for roots, etc., less 5% of the time lost turning, etc. = 1.3ac/day (oxen). Ditto at 2 mph = 2.1 ac//day (horses).

[30] 1900, 1910. Two 14" plowshares at 1¼ mph for 10 hrs/day less 10% of the time stopped for roots, etc., less 5% of the time turning, etc. = 3 ac/day (oxen). Ditto, at 2 mph = 4.8 ac/day (horses).

[31] W.H. Barneby, Life and Labour in the Far, Far West (Cassell, London, 1884); Winnipeg Daily Times, June 27, 1879, ('Writing Home').

[32] Manitoba Free Press Weekly, November 22, 1888.

[33] Dick, "Mechanization and North American Prairie Farm Costs", p. 193.

[34] Farmers' Advocate (Western Edition) July 5, 1905, p. 992.

[35] Nor-West Farmer, January 5, 1909 - Maw-Hancock.

[36] Edna T. Parson, Land I Can Own (Ottawa, 1981) p. 152; Nor-West Farmer, January 5, 1909.

[37] Farmer's Advocate (Eastern Edition), October 1878, p. 218.

in the late 1890s[38]. The first advertisement I found for an effective disc plow is for the Maw-Hancock disc plow in the Farmers' Advocate (Western Edition) May 20, 1902, page 407.

By 1910 a small amount of plowing was being done using steam traction engines. The only steam plowing incorporated in the models is breaking, since the steam traction engine was too large and cumbersome to plow small areas efficiently on a regular basis, and the spring plowing season was too short for the few engines available to accomplish much. In the fall the engines were all busy driving threshing machines.

c) Seeding

Prior to the late 19th Century this had always been performed by the 'broadcast' method - casting the seed over the ground by hand. Using this technique about four-fifths of an acre could be sown in an hour[39], increased in the 1870s by the use of hand rotary broadcast seeders to about five acres per hour[40]. Whilst the seed was dispersed rapidly, coverage was extremely uneven, with some areas being sown too thickly, and other parts receiving no seed. A large and erratic proportion of the seed also did not get covered by earth, and therefore did not germinate. During the 1870s the endgate seeder was developed. This was a broadcast seeder fixed to the back of a wagon, which could cover about 20 to 30 acres per day[41]. The work

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[38] Farmers' Advocate, August 21, 1907, p. 1300; Nor-West Farmer September 5, 1906, pp. 809, 812, September 20, 1901, "Farm Implements". Nor-West Farmer, July 1898, p. 305; J. Brownlee Davidson and Leon Wilson Chase, Farm Machinery and Farm Motors, (New York: Orange Judd, 1920), p. 67; Wayne G. Broehl, John Deere's Company (new York: Doubleday, 1984) p. 208; Farmer's Advocate (Western Edition), July 5, 1907, p. 490; Farmers' Advocate, (Western Edition) May 3, 1905, p. 659, November 22 1905, p. 1695; Nor-West Farmer, 20 August, 1901, p. 531.

[39] Leo Rogin, The Introduction of Farm Machinery (Berkley: University of California Press, 1931) p. 206.

[40] *Ibid.*, p. 206.

[41] *Ibid.*, p. 211; Hurt, The Victoria Settlement: 1862 - 1922, p. 28.

went quickly with this piece of equipment, but coverage was still uneven and much of the seed was wasted.

The big improvement in seeding technology was the development of the seed drill, which pushed the seeds into the ground at an even spacing, improving both coverage and the proportion of the seed germinating. The first drills appeared in the US in the late 1840s, but Rogin[42] noted that drilling did not supersede broadcast seeding until about 1885. As with many other items of equipment, seed drills did not appear on the Canadian Prairies in the early 1880s.

FIGURE 4.5

Typical Shoe Drill, 1902[43]

The early drills were also heavy and prone to jamming, but by the mid 1880s drills became more popular. An article in the Nor-West Farmer April 1886, page 441, says: "Seed drills ... now ...

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42 Rogin, The Introduction of Farm Machinery, p. 207.

43 Farmer's Advocate 20 April 1902, p. 102.

supplanting the broadcast seeder. It is expected the change will result in a marked advance in the early maturity of grain". The most important effect of burying the seed with a drill was that the seed then germinated almost immediately, because of the warmth and moisture under the surface. At the Experimental Farms it was found that wheat sown with a drill usually germinated two to four days earlier than if sown broadcast[44].

During the 1890s there were several improvements to these drills. The press drill - a seed drill with the addition of a free-running wheel behind each shoe to push the soil back over the small furrows created by the drill, and to press that soil down - was developed in the late 1880s[45]. The Experimental Farm for Manitoba tried out these press drills from 1890[46] onwards, and found that they both reduced growing time by about 4 days (over the broadcast seeder) and also increased the yield by about 7 percent[47]. Press drills which used wheels to push the soil down were heavy and cumbersome, and therefore slow to catch on. An alternative developed later in the 1890s instead of the press wheel was to attach a short length of chain behind each shoe, which was almost as effective, and far lighter to pull. Figure 4.5 shows a typical seed drill of that time. In the early 1890s, the seeds were placed into the soil through 'shoes' attached at the bottom of tubes through which the seed dropped. Pulling these through the earth resulted in a heavy draft. These early drills were typically 10 ft wide required two horses to pull them, and could cover about 15 acres per day. By 1910 most seed drills used discs to open the furrows,

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[44] Report of the Director of the Experimental Farms. Report of Experimental Farm for Manitoba, e.g., 1890, p. 249; 1892, p. 196; 1893, p. 236, etc.

[45] The Brandon Mail, December 26, 1869, p. 2.

[46] Experimental Farms Report, 1891, p. 249.

[47] The Report of The Experimental Farm for Manitoba, 1892, p. 196; 1893, p. 237; etc.

Table 4.3

Seeding - Productivities and Costs Incorporated in the Linear Programming Models

1880 Seedbox Seeder and Cultivator[48]
Power - First five years - 2 oxen - 6 acres/day
- After five years - 2 horses - 9 acres/day
Cost - $75[49]

1890 Eight foot wide shoe drill[50]
Power - First five years - 2 oxen - 6 acres/day
- After five years - 2 horses - 9 acres/day
Cost - $65[51]

1900 Twelve foot wide shoe press drill
Power - First four years - 2 oxen - 6 acres/day
- After four years - 2 horses - 10 acres/day
Cost - $90[52]

1910 Twelve foot wide disc drill
Power - First four years - 2 oxen - 11 acres/day
- After four years - 2 horses - 18 acres/day
Cost $110[53]

which reduced the draft significantly, enabling the size of the drill to be increased to between 12 and 14 ft, covering about 18 acres per day[54].

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[48] Rogin, The Introduction of Farm Machinery, p. 209.

[49] Manitoba Free Press, 9 February 1877. (Advertisement); Dick, "Mechanization and North American Prairie Farm Costs", p. 193; Manitoba Free Press Weekly, March 31, 1977.

[50] Rogin, The Introduction of Farm Machinery, p. 208.

[51] Manitoba Free Press, 22 November 1888, p. 7; Manitoba Free Press Weekly, November 22, 1888, p. 7; Dick, "Mechanization and North American Prairie Farm Costs", p. 193; Farmers' Advocate, March 1885, p. 87.

[52] Edmonton Journal May 10, 1897; Trevor O. Dick, "Mechanization and North American Prairie Farm Costs", Journal of Economic History, Volume 42, 1982, p. 193.

[53] Nor-West Farmer, January 5, 1909, p. 38 (prize); Dick, "Mechanization and North American Prairie Farm Costs", p. 193.

[54] Kranich, Farm Equipment for Mechanical Power, p. 90; Davidson and Chase, Farm Machinery and Farm Motors, p. 119, John. H. Gehrs, The Principles of Agriculture (New York, MacMillan, 1919) p. 85.

Root crops were sown by hand on the typical farm throughout the period. The linear programming models contain an allowance of 0.75 acres per day for sowing potatoes, and 1.00 acres per day for sowing turnips.

d) Harrowing and Cultivating

After the ground had been plowed, the clods of earth had to be broken up into a fine tilth, which made seeding easier, destroyed weeds, warmed the soil and enhanced water retention. In 1880, most harrows were of the simple 'peg tooth' type[55], and were used once or twice before sowing to break up the soil, and once again just as the plants came up, to weed the soil. During the 1880s and 1890s two new types of harrow became popular. The spring-tooth harrow, such as that shown in the Farmers' Advocate on December 20, 1901, page 819, was particularly efficient at pulling up weeds and coped well with any obstructions in the soil. For 1900 and 1910 the productivity of harrowing is increased in the models to 20 acres per day, and the second harrowing operation after spring plowing is no longer included, due to the greater efficiency of the new harrows.

Before 1900, the peg tooth harrow was dragged across the field once or twice after sowing, to reduce weeds. The disc harrow[56], which first appeared in the late 1870s, but was not at first practicable, and the duck-foot cultivator[57] became popular in the early 1890s[58]. These were generally more efficient at the job, rather than faster, and were particularly effective with root crops, which needed far more cultivating.

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[55] For example, see the illustration in the Farmers' Advocate (Eastern Edition) in May 1881, p. 126.

[56] A typical disc harrow of this period is illustrated in the Farmers' Advocate, Western Edition, February 20, 1899, p. 103.

[57] Farmers' Advocate, Western Edition, February 1890, p. 268.

[58] See for example the Cockshutt Diamond Point Cultivator in the Farmers' Advocate (Western Edition), April 1891.

Table 4.4

Harrowing and Cultivating - Productivities and Costs Incorporated in Linear Programming Models

Date	Technology		
1880	Peg Tooth Harrow - 8ft Wide,45 teeth.		
	Cost $24[59]		
	Output	First 5 years - (2 oxen)	- 8 acres/day
		After 5 years - (2 horses)	- 12 acres/day[60]
1890	As 1880		
1900	Spring Tooth Harrow [61]		
	Cost $25[62]		
	Output	First 4 years - (2 oxen)	- 10 acres/day
		After 4 years - (2 horses)	- 16 acres/day[63]
1910	Disc Harrow - 7 ft. cut		
	Cost $40[64]		
	Output	First 4 years - (2 oxen)	- 10 acres/day
		After 4 years - (2 horses)	- 14 acres/day[65]

With the development of dry-farming techniques in the late 1880s and 1890s, other implements became necessary, mainly to control the density of the topsoil. During the 1890s the implement used was the land roller, such as that advertised in the Farmers' Advocate, Western Edition on July 1891, page 270, which cost $10 to $40. By 1900 this had been developed into the subsurface packer, such as that advertised by the Brandon Machine Works in the Farmers'

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[59] Manitoba Free Press, November 23, 1878; Winnipeg Daily Times, June 27, 1887, 'Writing Home'; Manitoba Free Press Weekly, November 23, 1878, Advertisement of W.H. Disbrowe.

[60] F.N.G. Kranich, Farm Equipment for Mechanical Power, (MacMillan: 1923), p. 55.

[61] Farmers' Advocate (Western Edition) September, 1891, p. 351.

[62] Edmonton Journal, 10 May, 1897.

[63] L.C. Gray, Introduction to Agricultural Economics, (New York, Macmillan, 1924) p. 175.

[64] Nor-West Farmer, 5 January, 1909, p. 38.

[65] Kranich, Farm Equipment for Mechanical Power.

Advocate, Western Edition, on July 5, 1900, page 359. Use of a roller reduced the blowing of topsoil, induced more effective capillary action in the soil, and made reaping and plowing easier due to the more evenly compacted soil. The pulverizer and compressor[66] performed a similar function to the roller and subsurface packer, and has not therefore been incorporated in the models.

Table 4.5

Subsoil Consolidation - Productivities and Costs Incorporated in Linear Programming Models

Date	Technology
1900	Land Roller[67] Cost $30 Output (2 horses) - 10 acres/day (Attached to seeder, therefore no additional labour)
1910	Subsurface Packer Cost $60[68] Output (2 horses) - 18 acres/day (Attached to seeder, therefore no additional labour

e) Haymaking Technology

The collection of hay involves cutting the stalks near the ground with a mower, leaving the stalks on the ground for a few days, turning them once or twice, then collecting them up, taking them to a barn or stack and stacking them up. There were usually two harvests of hay in the summer, one in early July and the second in early August, immediately before the grain harvest.

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[66] Such as that advertised by the Watson Manufacturing Co. in the Farmers' Advocate or September 7, 1904, p. 1316.

[67] Farmers' Advocate (Western Edition), 5 July 1900, p. 359, and 5 January 1900, p. 20.

[68] NorWest Farmer, 20 January 1903, p. 56: Nor-West Farmer, January 20, 1903, p. 56; January 5, 1909, p. 38.

The first mowing machines were built in the 1830s and by 1880 were fairly well developed. At that time a typical mower[69] cutting a 5 ft swath at 2½ mph pulled by two horses could cut about 15 acres per day. The main changes introduced over the period from 1880 to 1910 were the addition of an easily operated lifting mechanism for the cutting bar, making it easier to turn the machine and move it from one field to another through narrow openings, improvements to the bearings and reciprocation mechanism, and reduction in weight. The principal effect of these improvements was that by 1900 two horses could pull a 7 ft mower, thereby increasing productivity by about twenty-five percent over the 1880 figure.

Improvements in other areas of hay handling were more important. From where it initially fell to the ground, the hay had first to be collected into a windrow, being turned over in the process. Self-dump horse drawn rakes existed prior to 1880[70], were pulled by one or two horses and could collect the hay from 10 acres in a day (For an 8 ft. rake). By 1900 the more efficient side delivery rake was in common use, enabling the rake to be collecting hay continuously, without the interruptions previously needed for dumping. With this implement output increased to about 13 acres per day.

From the windrow, the hay had to be loaded onto a wagon for transportation to the barn or haystack. Before about 1900, this was done by men using pitchforks to load loose hay onto a wagon, at a rate of about three tons per man day. The first hay loaders, machines attached to the back of the hay wagon which collected up the hay as the wagon moved along, became available soon after 1900[71], and increased output to about nine acres per man day.

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[69] Such as the 'New Model' advertised in the Farmers' Advocate, June 1879, by Larmouth & Sons.

[70] For example the advertisement for Sharpes self-dumping rake, Manitoba Free Press, May 19, 1877.

[71] For example the advertisement for the Dain Hay Loader in the Farmers' Advocate (Western Edition) May 15, 1903, p. 485.

At the barn or haystack, the hay had to be unloaded from the wagon and stacked. Before 1880, this was done by hand at a rate of about 10 tons per man day. By 1890[72] an apparatus had been developed to fit into a barn which could lift the hay off the wagons in very large bundles, pull it along beneath an overhead rail and drop it onto a stack, using the power of a horse. Costing less than $15[73] these machines increased output to about 40 tons per man day.

Table 4.6

Mowing Hay - Productivities and Costs Incorporated In Linear Programming Models

Date	Technology		
1880	5 foot Mower, costing $100[74]		
	Output	First 5 years - (2 oxen)	- 9 acres/day
		After 5 years - (2 horses)	- 15 acres/day
1890	6 foot mower, costing $75[75]		
	Output	First 5 years - (2 oxen)	- 10 acres/day
		After 5 years - (2 horses)	- 17 acres/day
1900	7 foot Mower, costing $70[76]		
1910	Output	First 4 years - (2 oxen)	- 12 acres/day
		After 4 years - (2 horses)	- 20 acres/day[77]

[72] See for example the advertisement for the Buchanan Pitching Machine in the Farmers' Advocate (Western Edition) May 1886, p. 156.

[73] Farmers' Advocate (Western Edition) June 20 1899, p. 339.

[74] Manitoba Free Press, 19 May, 1877.

[75] Manitoba Free Press, 22 November, 1887, p. 7.

[76] Farmer's Advocate (Western Edition) 5 September, 1893.

[77] McKinley, Wheels of Farm Progress, p. 19.

Table 4.7

Raking Hay - Productivities and Costs Incorporated In Linear Programming Models

Date	Technology		
1880	10 foot self dump rake		
	Cost - 1880 - $42.50[78]; 1890 - Cost $32[79]		
	Output	First 5 years - (1 ox) - 5 acres/day	
		After 5 years - (1 horse) - 10 acres/day	
1900, 1910	12 foot side delivery rake[80]		
	Cost $58[81]		
	Output	First 4 years - (1 ox) - 12 acres/day	
		After 4 years - (1 horse) - 20 acres/day	

Table 4.8

Turning Hay - Productivities and Costs Incorporated In Linear Programming Models

Date	Technology		
1880, 1890	10 foot self dump rake		
	Implement cost taken with raking		
	Output	First 5 years - (1 ox) - 8 acres/day	
		After 5 years - (1 horse) - 13 acres/day	
1900	7 foot hay tedder[82], costing $45[83]		
	Output	First 4 years - (2 oxen) - 8 acres/day	
		After 4 years - (2 horses) - 13 acres/day	
1910	9 foot hay tedder[84], costing $50		
	Output	First 4 years - (2 oxen) - 9 acres/day	
		After 4 years - (2 horses) - 15 acres/day	

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78 Manitoba Free Press, 19 May, 1877.

79 Manitoba Free Press, November 27, 1888.

80 Johnson, Johnson's Universal Cyclopaedia, (1895), p. 101.

81 Manitoba Free Press, 5 July, 1905. p. 992.

82 Farmers' Advocate (Western Edition), March 1891, p. 116.

83 Farmers' Advocate (Western Edition), 5 July, 1905, p. 992.

84 G.F. Warren, Farm Management, (New York, Macmillan, 1914), p. 359.

Table 4.9

Hay - Loading onto Wagon - Productivities and Costs Incorporated In Linear Programming Models

Date	Technology
1880, 1900.	Hand - with pitchfork Output - 2 acres/person/day
1910.	Hay Loader[85] Cost $58[86] Output - First 4 years - 2 oxen - 6 acres/day[87] - After 4 years - 2 horses - 10 acres/day

Table 4.10

Stacking Hay - Productivities and Costs Incorporated In Linear Programming Models

Date	Technology
1880, 1890	Hand - with pitchforks Output - 5 acres per man day
1900, 1910	Overhead horsefork and slings[88] Cost $12.50[89], (plus 2 days to install) Output - 15 acres per man day

f) Reaping and Binding of Grain

This operation involved cutting off the grain stalks close to the ground and tying the cut stalks into bundles, which were then dropped on the ground to be collected later for transportation to the threshing machine. The first machines for cutting and collecting the grain

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[85] Paul C. Johnson, Farm Inventions in the Making of America, (Des Moines, Wallace-Homestead Book Co., 1976) p. 101.

[86] Farmer's Advocate (Western Edition), 5 July, 1905, p. 992.

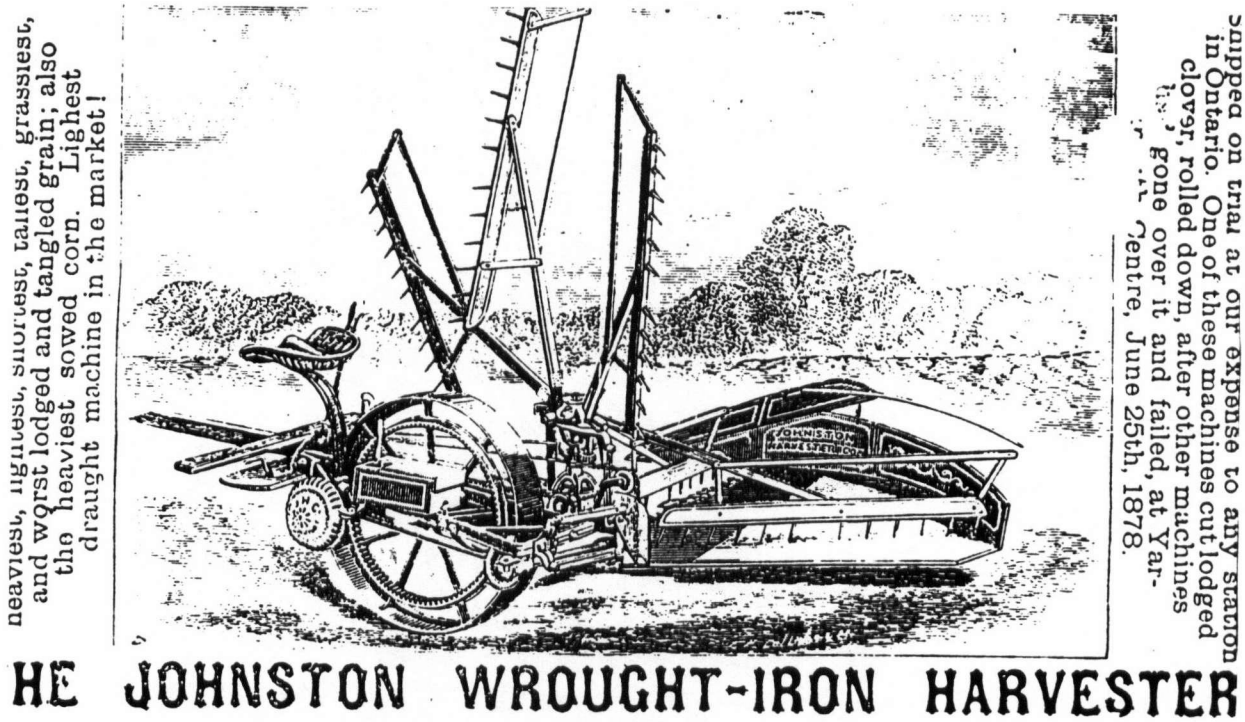
[87] (Estimated) - 2 horses, 8 foot swath, lifting half of the time.

[88] Farmer's Advocate (Western Edition), March 1891, p. 108.

[89] Farmer's Advocate (Western Edition), 20 June, 1899, p. 339.

were developed in the 1830s[90]. In the late 1870s the best technology available was the self raking reaper, of the type shown in Figure 4.6. Drawn by two horses and operated by one man, this type of machine could cut a 6 ft swath through the grain, clearing about nine acres per day, but leaving the loose stalks on the ground to be tied in bundles later. Another machine, the McCormick Harvester, carried three men, one driving and

FIGURE 4.6



Typical Self-Rake Harvester, 1879[91]

[90] As documented in Paul David "The Mechanization of Reaping in the Ante-Bellum Midwest", in Rosovsky, H. (Ed). Industrialization in Two Systems, (New York, John Wiley and Sons, 1966).

[91] Reproduced from the Farmers' Advocate (Eastern Ed.) May 1879, p. 118.

two tying the grain into bundles before it was dropped. Quick and Buchele[92] suggest that these two men on the machine could do the work of four or five men following behind on foot, who would have first to walk around collecting the stalks together before they could bind them into bundles. For 1880, typical productivity is taken as five men cutting and binding 10 acres of grain per day.

The first wire binders, which automatically tied the cut stalks into bundles, were sold in the U.S. in 1876, and a few were sold in Canada before 1880. These made subsequent handling of the grain stalks easier, and reduced damage to the grain due to rain or frost. These early machines had a variety of problems, and were superseded by the early 1880s by the superior twine binder, which cost about $290[93], needed three or four horses, one driver, and cut about 13 acres per day.

After the bundles were dropped from the binder, they were collected in groups of 8 to 10, and stood on end for about 10 days for the grain to dry out. The stooks were then pitched by hand into a wagon and either carried to a central point for threshing or, if threshing was delayed for some reason, were piled into a stack to avoid weather damage. The technology for this part of the work did not change between 1880 and 1910, although a greater output was achievable after 1890 when the binders were fitted with bundle carriers. These

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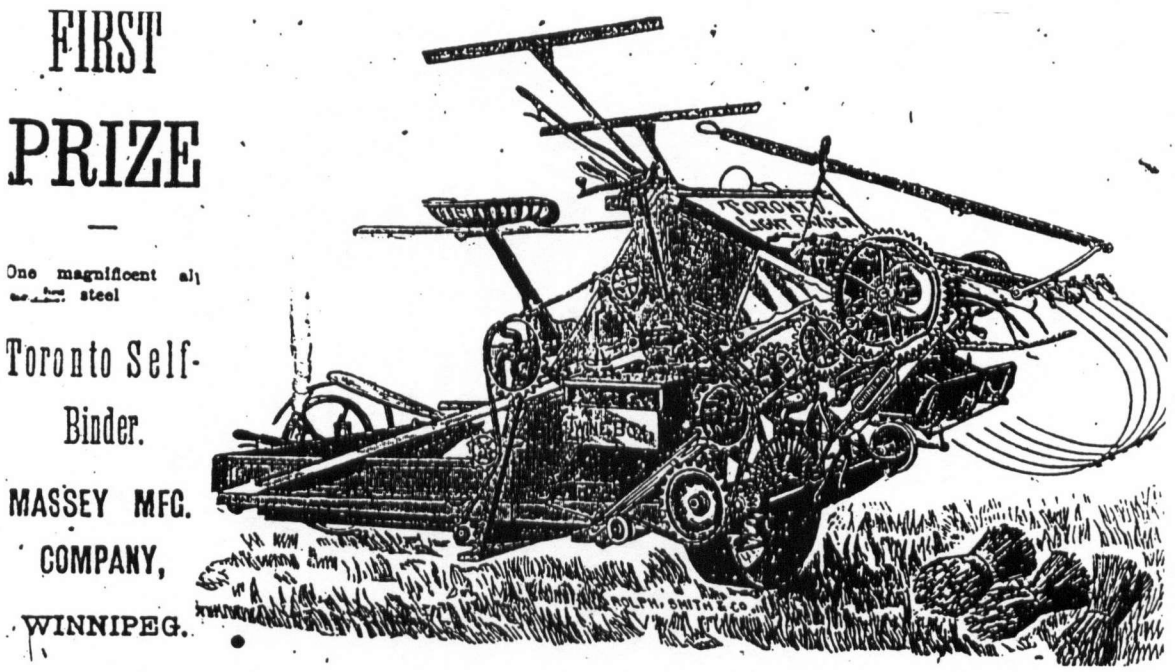
[92] Graeme Quick and Wesley Buchele, The Grain Harvesters, (Michigan: American Society of Agricultural Engineers, 1978), p. 74.

[93] William T. Hutchinson, Cyrus Hall McCormick, Vols. 1 and 2, (New York: D. Appleton-Century, 1935), p. 704.

FIGURE 4.7



Toronto 'Light' Binder, 1886[94]

held up to six stooks, releasing them in a single pile, thereby reducing the work of collection.

The early binders were heavy, cumbersome machines, as Figure 4.7 of the Toronto "Light Binder" shows. One of the main changes to occur in the 1880s and 1890s was to reduce the draft of the binder, which made it possible for the width of cut to be increased. By 1910 most binders were cutting an 8 ft swath, pulled by four horses.

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[94] Reproduced From The Manitoba Free Press, 25 November 1886, p. 3.

Table 4.11
Reaping and Binding of Grain - Productivities and Costs Incorporated In Linear Programming Models

Date	Technology
1880	6 foot self rake reaper (one operator) with four men gathering and binding, and two horses. Output - oxen - 6 acres/day; horses - 10 acres/day Reaper cost - $200[95] Twine cost - $1.20/acre
1890	6 foot twine binder One operator for binder plus one man stooking. Output - oxen - 8 acres/day; horses - 13 acres/day[96] Reaper cost - $260[97] Twine cost - $0.93/acre
1900	7 foot twine binder with bundle carrier with one operator. Output - oxen 9 acres/day ; horses - 15 acres/day Reaper cost - $155[98] Twine cost - $0.73/acre
1910	8 foot twine binder with bundle carrier with one operator Output - oxen - 10½ acres/day; horses - 17½ acres/day[99] Reaper cost - $155 Twine cost - $0.47/acre

[95] William T.Hutchinson, Cyrus Hall McCormick (Volumes 1 and 2), (New York, D. Appleton-Century, 1935) p. 475.

[96] Zintheo, in L.H. Bailey, The Cyclopaedia of American Agriculture, Volumes I-IV, (Toronto: Macmillan of Canada, 1917), p. 214.

[97] Hutchinson, Cyrus Hall McCormick, p. 704.

[98] Edmonton Journal, May 10, 1897.

[99] J.H. Gray, Men Against the Desert, (Saskatoon, Modern Press, 1967) p. 177; Nor-West Farmer, December 20, 1906, p. 1107.

Table 4.12

Stooking and Transporting Grain to Thresher - Productivities and Costs Incorporated in Linear Programming Models

Date	Technology
1880	Stooking - 10 acres/manday Transporting First 5 years - wagon and two oxen - 3 acres/manday Wagon cost $85[100] After 5 years - wagon and two horses - 3.5 acres/manday
1890	Stooking (bundles dropped in groups by binder) 15 acres/manday Transporting - As 1880
1900	Stooking - As 1890 Transporting - As 1880 Wagon Cost - $80[101]
1910	Stooking - As 1890 Transporting - As 1880 Wagon cost - $60[102]

Whether tied by machine or by hand, binding used a large amount of twine. Table 4.13 lists the amounts and costs of the twine used over the period.

Table 4.13

Consumption and Cost of Binding Twine

	Unit of Purchase	Amount Required	Cost/acre
1880	18¢/lb of 500 to 700 ft	4,000ft/acre	$1.20
1890	14¢/lb of 500 to 700 ft	4,000ft/acre	$0.93
1900	10¢/lb of 750 ft	4,000ft/acre	$0.53
1910	7¢/lb of 750 ft	4,000ft/acre	$0.37

[100] Manitoba Free Press, 10 March 1877.

[101] Edmonton Journal, 10 May, 1897.

[102] Farmer's Advocate (Western Edition), 5 July 1905, p. 992.

Before 1900 sacks for the grain had also to be bought, costing about 3c per 100 lb of grain, or about 30c per acre of wheat. By 1910 most of the grain was handled in bulk, eliminating the need for sacks.

g) Threshing

Threshing is the operation by which the ears of grain are separated from both the stalks, which become straw, and also from the husk surrounding the grain, which becomes the chaff. Until the 1850s this separation was carried out either by hand, using a flail, or by oxen trampling the grain. McKinley[103] calculated that in the 1840s, using flails, about eight bushels could be threshed per day, with the result that it could take all winter to thresh a crop from ten acres. Even at that a significant proportion of the grain was lost in the threshing process. Schlebecker[104] suggests that in 1880 only twenty percent of the wheat crop was being threshed by horsepower.

The first mechanical separators were developed in the 1850s, and by 1880 the principles of the cylinder separator were well developed. These separators made the threshing process itself quite quick, but did not help with the many ancillary operations. They tended to stall frequently, since the grain arrived at the machine in bundles which once cut open were frequently pushed into the cylinder all in one large mass. Feeding the grain to the cylinder was also a dangerous job, resulting in many amputated hands, and the cylinders and teeth were made of wood, and frequently broke. The straw poured out underneath the early threshers in an uncontrollable flow, resulting in the need for up to six men to pitch the straw from under the machine to prevent it clogging up, and the grain also poured continuously from the outlet spout,

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[103] McKinley, Wheels of Farm Progress, p. 25.

[104] John T. Schlebecker, Whereby We Thrive. A History of American Farming, 1607-1972, (Iowa: Iowa State University Press, 1975), p. 194.

resulting in a requirement for two workers to bag the grain. The overall labour saving from using the early mechanical threshers were worthwhile, but far greater savings were achieved later on.

Almost all threshing was done on a contract basis, since only the very largest farms grew enough grain to occupy a thresher for the whole season. The contractor would supply the separator, power, and enough men to operate them. Farmers would work on a co-operative basis, with from four to eight farmers pooling all their available labour and horses, working with the threshing contractor on each farm in turn. When the threshing was carried out as the grain was brought in from the fields, as was frequently the case, the labour provided by the farmer would consist of as many as 26 men - 8 to 10 teams bringing the grain in from the field, 4 men pitching the grain into the wagons, 2 unloading it at the other end and another 2 feeding it into the separator, with 6 men removing the straw and 2 more bagging and stacking the grain[105].

The timing of the threshing operation was less critical than that of most agricultural activities. In the extreme case, the grain crop could be stored right through the winter, and only be threshed the following year after seeding. The majority of settlers however suffered acute cash flow problems, and could not afford to delay the receipt of their income for so long. They had to 'meet their notes' for the equipment they had bought - usually in November. Threshing operations therefore usually started in late August or early September as soon as the first grain was cut, and went on until all the grain had been threshed. The Edmonton Bulletin, December 24, 1881 notes that threshing was still going on, though productivity must have been quite low because of the thick snow on the ground.

During the 1880s a few changes occurred to the operation of threshing. The most important of these was the introduction of steam power to drive the separator, instead of the various cumbersome and inefficient devices previously used to harness the power of horses. This

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[105] Harold E. Briggs, "Early Bonanza Farming in the Red River Valley of the North", Agricultural History, Volume 6 No 1, (1932), p. 31; Graeme Quick and Wesley Buchele, The Grain Harvesters, (Michigan: American Society of Agricultural Engineers, 1978), p. 107.

released more horses to pull the grain in from the field, and enabled a separator of a given size to operate at a greater speed, processing the grain more quickly. Better bearings had to be fitted to the cylinder to cope with the greater power, but by then these were available[106]. The other improvement was the addition of a belt elevator to remove the straw from underneath the machine. This greatly reduced the likelihood of clogging, and also lessened the straw handling crew from six to perhaps four or five. However this elevator only moved the grain about 10 ft, and such large quantities of straw were produced that almost all of it had to be moved again immediately so that the pile did not overwhelm the separator.

By 1890 most separators were fitted with metal cylinders and teeth, which greatly reduced the frequency of breakage and also reduced grain loss due to poor separation. The crew provided by the farmer fell from about twenty six men to about twenty four. This labour was only needed for one or two days on each farm, so in the aggregate there was enough labour available to cope with the requirements of all farms. The linear programming models account for this labour by reconciling the aggregate total labour supply with the aggregate demand from all farms[107]. Pooling arrangements for labour are well documented, justifying this method of working[108]. The models also allow for the farmer to hire additional labour if necessary, up to a limit determined by the aggregate labour supply[109].

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[106] Farmers' Advocate, Eastern Edition, July 1885, p. 205.

[107] See chapter 6 for a discussion of this issue.

[108] Quick and Buchele, The Grain Harvesters, p. 105; Harold E. Briggs, "Early Bonanza Farming in the Red River Valley of the North" Agricultural History, Volume 6, No 1, p. 31; Farmers' Advocate, Eastern Edition, August 1885, p. 231; Paul C. Johnson, Farm Inventions in the Making of America, (Des Moines: Wallace-Homestead Book Co., 1976),p. 70; Manitoba Agricultural Museum, (Brochure, 1979), pp. 173, 178; Edmonton Bulletin, September 22, 1898; de Gelder, A Dutch Homesteader on the Prairies, p. 10; Parson, Land I Can Own, p. 69; George Shepherd, West of Yesterday, (Toronto: McClelland and Stewart, 1965), p. 51).

[109] See chapter 6.

There were major advances in the technology of threshing machines during the 1890s. The steam traction engine became powerful enough to move the thresher from farm to farm (previously the engine had had to be pulled from one place to another by a large team of horses, who could not really be spared during the busy threshing season). New spark arresting devices were also developed for the steam engines - prior to that many threshers were destroyed by fire, along with the grain and straw piled around them.

An important innovation was the wind stacker, which superseded the straw elevator[110], and consisted of a large fan which blew across the straw outlet, and pushed all the straw up through a light steel tube which could be extended as much as 50 ft from the thresher. This tube swung back and forth, depositing the straw well away from the thresher, and produced with the help of only one person a neat stack of straw, thereby eliminating three or four men from the threshing team[111].

Of similar importance was the self feeder and band cutter[112], which consisted of a revolving belt which carried the bound sheaves into the thresher. Before reaching the cylinder, the twine was cut by a rotating cutter, and the flow of stalks was evened out by a set of reciprocating blades. This eliminated two men from the pitching and feeding team and greatly increased the rate at which grain could be fed to the cylinder, since it virtually eliminated the danger of stalling the separator by jamming too many stalks in at a time. This mechanism was so successful that it became necessary to fit a far larger agitator behind the cylinder, to cope with the greater throughput of straw. A typical threshing machine of this period is shown in Figure 4.8.

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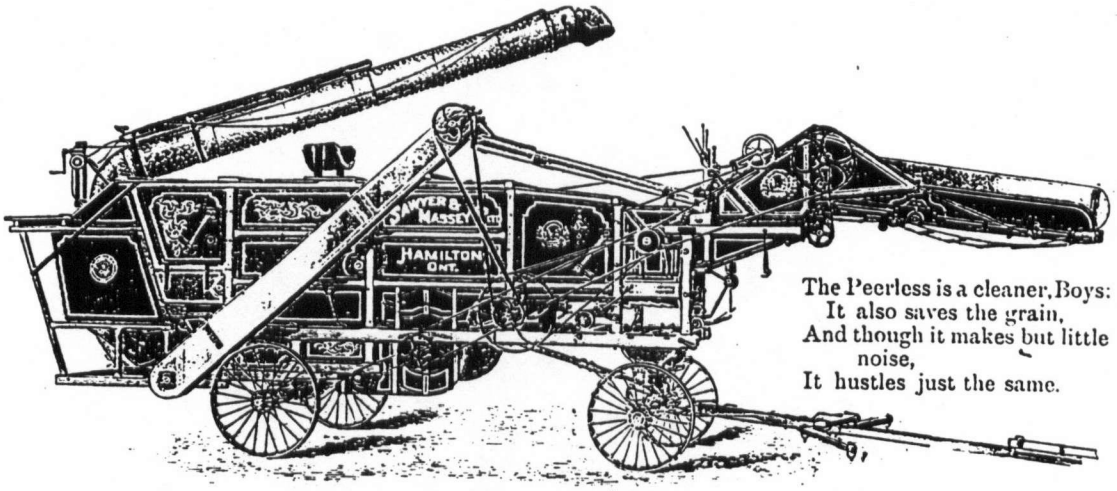
[110] In the Nor-West Farmer for April 1898 the J.I. Case Co. listed the wind stacker amongst other recent improvements.

[111] There is a clear picture of a wind stacker in the Farmers' Advocate for July 15, 1903, p. 635.

[112] A good cutaway view of this attachment is given in the Farmers' Advocate for July 1, 1904, p. 787.

FIGURE 4.8



S. & M. Improved "PEERLESS" with S. & M. Wind Stacker and Woods Bros.' Self-Feeder.

volution has made Labor-Saving Machines a matter of necessity to the Farmer and Thresherman. The S. & M. Peerless (improved) with al Feeder and Stacker, and with 17 to 25 H.-P. engine, leaves nothing to be desired. The best is always cheapest.

Typical Threshing Machine with Wind Stacker and Self-Feeder, 1904[113]

Another component of the thresher was the agitator - the arrangement of vibrating screens which sieved the grains, sorting out the usable grain from the weed seeds and chaff. The J.I. Case Threshing Machine Co. advertisement in the Nor-West Farmer for December 20, 1901, page 878, shows that a 36 in cylinder was by then matched with a 58 in rear agitator, due to the increased capability of the cylinder because of the addition of the self-feeder.

There were developments also in the area of grain bagging. The J.I. Case advertisement in the Nor-West Farmer on April, 1898, page 177, lists the new bagger as an important new improvement. Prior to this innovation, the grain ran out of a tube under the separator, and two baggers were needed, one worker holding a sack under the tube, the other sewing up the previous sack filled. The new bagging device lifted the grain about 10 ft off the ground, and let it run out of a two-nozzle pipe, under each nozzle of which was a weighing device on which a

[113] Reproduced from the Farmer's Advocate, 24 August, 1904, p. 1251.

sack was clipped around the outlet. As one bag became full, the flow was automatically switched to the other, giving the operator time to remove the one bag, sew it up, put it in a stack and fit a new bag before the other was full thereby eliminating the need for one worker. The device was cheap - in the Nor-West Farmer for December 20, 1901 the J.I. Case advertisement lists steel weighing baggers from $50 to $60 - approximately equivalent to the harvest wages and board for one month's work for a man.

A note in the Edmonton Bulletin on September 29, 1898, gave the output of a Sawyer Massey thresher with a 25 hp engine, self feeder, band cutter and cyclone (wind) stacker as 2,500 bushels of wheat per day. This was exceptional - a more realistic average was probably 1,800 bushels - which was still an enormous increase over the decade. Not all threshers had all the attachments, so for the linear programming models figures of 1,500 bushels of wheat, 2,000 bushels of oats or barley or 650 bushels of flax per day are used for the year 1900[114]. Flax was more difficult to thresh than the other grains due not only to its awkwardness because of the small, slippery seeds, but also because of the need to clean the separator out completely both before and after threshing the flax.

Between 1900 and 1910, usage of these devices became almost universal. Kranich[115] suggested that by 1920 over ninety-five percent of threshers were equipped with all three. Also by 1910 a large proportion of the grain was handled in bulk, instead of being bagged, which eliminated the need for a bagger entirely, and made the transportation of the grain easier (See next section).

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[114] Farmers' Advocate, (Western Edition) April 5, 1902, p. 253.

[115] Kranich, Farm Equipment for Mechanical Power, p. 221.

The first combine harvester appeared in Saskatchewan in 1909[116] but by 1923 there were still only four, indicating that they were not important before 1910.

One serious problem with the shared use of threshing machines was that occasionally some farms had not been threshed before the start of winter[117]. If the grain was still in stooks in the fields it would be seriously damaged by a heavy frost, reducing its worth to that of feed grain for animals, which sold for only about one half the price of No. 1 Northern quality.

Throughout the period there is discussion of the relative merits of threshing from the stook as opposed to stack threshing. The operation of collecting the bundles into stooks, pitching them into wagons and then carrying them to a central point was carried out in either case. The additional work of building a stack, which was later dismantled and fed into the thresher, cost quite a bit of labour time, but yielded several advantages. An article in the Farmers' Advocate, Western Edition on August 28, 1907, page 1337, examined this issue carefully, and suggested that typically, stacked grain graded one grade higher due to its better colour, plumper kernels and reduced damage. The farmer then was caught in a dilemma. If he agreed to join a threshing group, then his farm might end up last on the list to be threshed, and run a significant risk firstly

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[116] Ernest B. Ingles, Some Aspects of Dry-Land Agriculture in the Canadian Prairies to 1925, (Unpublished M.A. Thesis, University of Calgary, 1973), p. 29.

[117] See for example the Farmer's Advocate, (Eastern Edition), 16 August 1905, pp. 1233, 1234, or the Nor-West Farmer, 20 December 1901, p. 751.

Table 4.14

Threshing - Productivities and Costs Incorporated In Linear Programming Models

Date	Technology
1880	Mechanical thresher with 20 in separator, powered by a 2 horse tread, operating on a contract basis. Contract rates:- wheat 8c/bu.; oats, barley 7c/bu.; flax 18c/bu[118]. Labour provided by farmer: - 14 men[119] Outputs :- wheat 600 bu/day; oats, barley 800 bu/day; flax 250 bu/day[120].
1890	Mechanical thresher with 20 in separator, straw elevator, powered by a 6hp portable steam engine, operating on a contract basis. Contract rates :- wheat 5 c/bu; oats,barley 3½c/bu; flax 12c/bu[121]. Labour provided by farmer:- 12 men Outputs:- wheat 900 bu/day; oats, barley 1200 bu/day; flax 350 bu/day[122]
1900	Mechanical thresher with 30 inch separator, wind stacker, self feeder and grain bagger, powered by an 18hp locomotive steam engine, operated on a contract basis. Contract rates :- wheat 3½c/bu; oats, barley 2½ c/bu; flax 9c/bu[123]. Labour provided by farmer :- 6 men Outputs :- wheat 1500 bu/day; oats, barley 2000 bu/day; flax 650 bu/day.
1910	Mechanical thresher with 36 inch separator, wind stacker, self feeder and high grain outlet, powered by an 18hp locomotive steam engine operated on a contract basis. Contract rates :- wheat 4c/bu; oats,barley 3c/bu; flax 10 c/bu[124] Labour provided by farmer :- 5 men Outputs :- wheat 1650 bu/day; oats, barley 2200 bu/day; flax 700 bu/day.

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[118] Edmonton Bulletin, November 12, 1881.

[119] Labour figures exclude collection of grain from field, and contractors labour. Total labour for each year: 1880 - 21 men; 1890 - 25 men; 1900 - 24 men; 1910 - 22 men.

[120] McKinley, Wheels of Farm Progress, p. 29; Rogin, The Introduction of Farm Machinery, p. 172.

[121] Brandon Weekly Mail, October 27, 1887 'Farming Profits'.

[122] Brandon Weekly Mail, December 8, 1887; Nor-West Farmer, January 1886, p. 353.

[123] Edmonton Journal, 10 May, 1897; 30 September, 1897.

[124] Nor-West Farmer, 20 May 1907, p. 477.

that his grain might suffer frost damage, and also that it might not be threshed until very late in the year, delaying the farmer's cash receipts. His alternative wasto stack the grain himself and either buy or contract in a small thresher, which were less efficient in the use of labour, largely because they were too small to support the use of devices such as the wind stacker. However the additional labour of building the stack was also costly. The Farmers' Advocate for August 16, 1905, pages 1233 and 1234 discusses threshing. The author preferred to stack, "but with the enormous crops and small supply of labourers in this country, it is in many cases out of the question."

After 1900 small efficient small threshing machines[125] were developed, which cost about $1,400 to $2,000 and could thresh about 800 bushels per day. These have not been incorporated in the linear programming models since they do not appear to have been the predominant technology.

The productivities listed in Table 4.14 are for threshing in late September or early October, when the weather was not too cold, and there were about 10 hours of daylight. During winter, with daylight of 8 hours or less and temperatures well below zero, productivity was far lower. For the winter period, outputs inthe linear programming models have been cut to 60% of fall levels. The labour involved in hauling the grain from the stook to the thresher remained unchanged throughout the period. A big threshing outfit would need eight or ten stook teams, with four good pitchers. In a typical day such a team could handle about 1,200 bushels of wheat[126].

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[125] Farmers' Advocate, Western Edition, August 16, 1905; April 24, 1906, p. 728; Nor-West Farmer, October 21, 1901, p. 655; September 21, 1903.

[126] Farmers' Advocate, Western Edition, April 5, 1902, p. 253.

Table 4.15
Overall Summary of Labour in Threshing Teams
(Excluding labour provided by contractor)

a) Load sheaves onto wagon in field and transport to thresher:-

1880 4 wagons - 4 drivers plus 2 additional loaders - 6 men
1890 6 wagons - 6 drivers plus 3 additional loaders - 9 men
1900 10 wagons - 10 drivers plus 5 additional loaders - 15 men
1910 12 wagons - 12 drivers plus 6 additional loaders - 18 men

b) Feed sheaves directly from wagons into thresher:-

1880, 1890 - 3 men
1900, 1910 - 2 men

c) Organise work, runabout, etc.

All dates - Farmer plus 1 man.

d) Remove straw from machine and from stack:-

1800 Remove straw - 4 men. Stack - 2 men. Total 6 men.
1890 Remove straw - 3 men. Stack - 2 men. Total 5 men.
1900 Remove straw - 1 man. Stack - 0 men. Total 1 man.
1910 Remove straw - 1 man. Stack - 0 men. Total 1 man.

e) Bag grain:-

1880, 1890 2 men.
1900 1 man.
1910 0 men. (Grain spouted directly into tank).

f) Form temporary stack prior to threshing and later feed to thresher:-

All dates:-

1) If grain threshed immediately - no additional labour.
2) If grain threshed at a later date - 5 acres/manday

g) Move grain to storage:-

1880, 1890, 1900 (Bags moved to barn by wagon):-
1) If grain transported directly to market/station - no additional labour. (Labour counted with transport).
2) If grain taken to market/station during winter - 1 extra man during threshing.

h) Miscellaneous Field Cropping Activities

There were a few items of hand labour for which there was little or no technical progress during the period. The following productivities have been used in the linear programming models for these activities:-

- Hand cultivation of potatoes during summer -
  - weed (1½ days/acre) twice, harrow (½ day/acre) twice - 0.25 ac/day
- Hand cultivation of turnips during summer -
  - weed twice, harrow once - 0.286 ac/day
- Hand dig potatoes, collect and store - 0.5 ac/day
- Hand dig turnips, collect and store - - 0.3 ac/day

j) Local Transport

There was little or no change in the method of moving goods locally during the period. In the early 1880s many settlers still used the old two wheel high frame Red River carts. These required only one draft animal, but could carry a maximum of only about 1,000 lb about 12 miles per day[127]. However at such a slow speed one driver could look after up to three carts[128]. Such a cart cost from $10 to $20[129]. Prior to the coming of the railway, all long distance haulage had also used Red River carts, often in 'trains' of several hundred carts - the last of these cart brigades was in 1879[130]. By 1880 the four wheeled farm cart was rapidly superseding the

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[127] Edmund H. Oliver, "The Settlement of Saskatchewan to 1914", (Royal Society of Canada. Transactions, Volume XX, Section 11, 1926), p. 158; Grant MacEwan, Power for Prairie Plows, (Saskatoon: Prairie Books, 1971), p. 6; J.M. Careless, The Pioneer, A Picture History of Canadian Settlement, 1973, p. 88.

[128] Grant MacEwan, Power for Prairie Plows, (Saskatoon: Prairie Books, 1971), p. 6.

[129] Manitoba Free Press Weekly, March 10, 1877, Report of Minister of Agriculture and Immigration for 1876.

[130] Morton, Manitoba. A History, p. 199.

Red River cart. These carts cost about $80 to $90[131] and could travel a distance of about 25 miles per day[132] carrying a load of about 5,000 lb[133].

A large proportion of farm output was delivered to the market or railway station during winter. In the early winter, before the snow started, the roads were firm due to being frozen, and the trip to the station was quicker than in the rainy seasons. Once the snow had begun, sleigh runners, costing about $25 to $35 per set[134] were fitted to the wagon, instead of wheels. This made haulage particularly easy.

Most of the rain that falls on the Prairies comes during the summer. When it did rain, wagon haulage on the dirt roads of the Prairies became extremely difficult, as Figure 4.9 shows.

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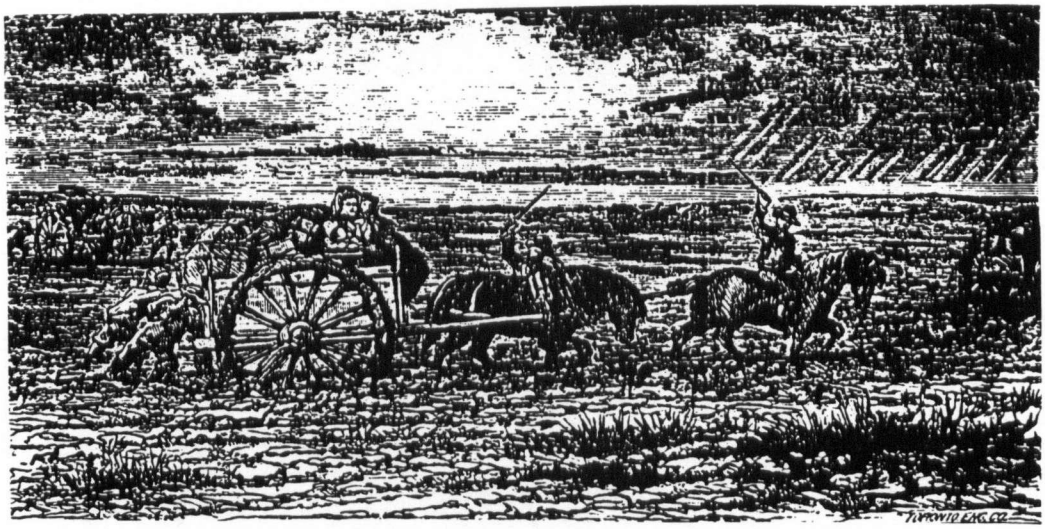
[131] Manitoba Free Press Weekly, March 10, 1877, Report of the Minister of Agriculture and Immigration for 1876; Tyman, By Section, Township and Range: Studies in Prairie Settlement, p. 44; Barneby, Life and Labour in the Far, Far West p. 257; Winnipeg Daily Times, June 27, 1879.

[132] Careless, The Pioneer, A Picture History of Canadian Settlement, p. 88; L.H. Thomas, "History of Agriculture on the Prairies", in Development of Agriculture on the Prairies, (1975), p. 13.

[133] McKinley, Wheels of Farm Progress, p. 98; Brandon Weekly Mail (October 27, 1887).

[134] Manitoba Free Press, November 22, 1888, p. 7; Edmonton Journal, May 10, 1887.

FIGURE 4.9



"Travelling Near Winnipeg, Manitoba" (1879)[135]

There were endless comments in the newspapers about the problem of the bad roads. To cite only a few, in the Manitoba Free Press: April 14, 1877 - "Complete break up of the roads has brought business to nearly a complete standstill"; April 12, 1887 - "Roads in a frightful condition"; October 6, 1898 "Heavy rain - no travel"; Regina Leader Post, April 10, 1888 - "Settlers in from the Qu'Appelle Valley report the trails dry for a distance of (only) five miles from the south bank". Saskatchewan Herald, Battleford, April 14, 1888 - "Snow gone - roads in usual bad condition". Road maintenance was the responsibility of the local municipalities, who attempted to discharge this obligation in two ways. All municipalities imposed a range of taxes on their residents, including taxes for road building and maintenance. One option for the Municipality was to hire labourers to do the work, but few were available. As an alternative most municipalities offered residents the option of working off at least a portion of the tax by working

[135] Reproduced from the Farmers' Advocate, (Eastern Ed.), August 1879, p. 177.

on the road directly, but the quality of this unsupervised work was generally very poor[136]. All that could usually be done under the circumstances was to pull a log along behind a couple of horses, which would level the soil out somewhat but achieve little else.

Settlement was so spread out that there was simply too much road for each farm to maintain. Even if each farm was only a one-quarter section, and all farms were occupied, every farmer would have to maintain half a mile of road, for which less that one day's work per year was allowed (and no money for gravel or other materials).

Care of roads was at best a classic common property problem, and was usually worse even than that, since if any individual did improve a section of road at his own expense, the superior quality of that road would attract additional users, increasing its rate of deterioration. Farmers near a railway station would see their roadwork destroyed within a day or two of doing it - a poor incentive for doing a good job.

There was little improvement in the roads until the 1920s, when the gasoline powered truck became more popular. One of the main reasons for the switch to a gas truck was the saving in time to the farmer. This time saving could only be achieved if the roads were good enough to drive quickly, which meant that they had to be properly surfaced. Some gravelling of roads used mostly for wagon haulage was done, but the laying of Macadam or Concrete paving was essentially a joint good with the motor truck, since neither was economically viable without the other. An inquiry by the Dominion Bureau of Statistics in 1924[137] showed a very high correlation between the paving of roads (or lack of it) and the proportion of farm produce being carried by motor truck.

The problem of bad roads was not solved during the period before 1910, and this component of the work is therefore constant in the linear programming models. This may shed

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[136] Farmers' Advocate (Western Edition), November 1892, p. 424.

[137] Canada. Monthly Bulletin of Agricultural Statistics, (Ottawa: June 1925), p. 165.

some light on another interesting question in Canadian Prairie development. By 1907, most occupied areas of Manitoba and Eastern Saskatchewan were served by railways, which at that date were spaced about forty miles apart. This meant that almost all farmers could journey to a station and back within one (long) day. However pulling a full wagon of grain along the bad roads would involve an overnight stop in town for those more than about twelve miles from the railway.

Table 4.16a

Local Transportation - Productivities and Costs Incorporated In Linear Programming Models

Date	Technology
All dates	First four/five years[138] - all haulage by four-wheeled wagon pulled by two oxen - hauled up to 5000lbs (maximum capacity of typical wagon[139] up to 12 miles per day[140]. After four/five years - wagon hauled by two horses - up to 20 miles per day[141].
Cost of Wagon	
1880, 1890	$85[142]
1900	$75[143]
1910	$65[144]

[138] L.H. Neatby, Chronicle of a Pioneer Prairie Family, (Saskatoon: Western Producer Prairie Books, 1979) p. 24; Morton Manitoba. A History, p. 164.

[139] McKinley, Wheels of Farm Progress, p. 98.

[140] Grant MacEwan, Power for Prairie Plows, (Saskatoon: Prairie Books, The Western Producer, 1971) p. 6; Careless, The Pioneer, A Picture History of Canadian Settlement, p. 88.

[141] *Ibid.*

[142] Manitoba Free Press 10 March 1877; Winnipeg Daily Times 27 June 1879.

[143] Harry Piniuata, (Translator), Land of Pain, Land of Promise, (Saskatoon: Western Producer Prairie Books, 1978) p. 45.

[144] Farmer's Advocate (Western) 5 July 1905, p. 992; Grain Growers' Guide 15 May 1909.

Table 4.16b

Local Transportation - Productivities and Costs Incorporated In Linear Programming Models

Cost of Sleigh Runners (For pulling wagon in winter)

1880, 1890	$35[145]
1900, 1910	$25[146]

Cost of Grain Tank (Put on wagon frame for bulk handling of grain).

1910	$45[147]

Improving the roads would have reduced this problem, but the common property problem precluded this solution. Between 1907 and 1916, a large number of short 'infill' railway lines were built, many running parallel to existing lines, bisecting the gap between the existing lines to give a maximum of about a ten mile journey, which a farmer could then do in a day with a full load of grain. These infill lines didn't bring much additional land into cultivation, and were entirely captive economically to the major railroads on to whose tracks all the grain had to be passed.

It is difficult to see any other reasons why many of these branch lines were built, since they can have had little effect on total rail traffic. Their main effect was to reduce the distance to a railway station for some farmers, which would have yielded some value which a railway could capture in its freight rates. No simple scheme for taxation for roads could achieve this. It was only when the incentives increased, with the development of the motor truck, that road paving became viable. Once that had happened, it was no longer worthwhile to operate these

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[145] Manitoba Free Press 22 November 1888 p. 7.

[146] Edmonton Journal 10 May 1897.

[147] NorWest Farmer 20 June 1902 p. 492. (Held 325 bushels - filled direct from thresher grain spout).

additional branch lines, since the time saving had largely disappeared. Many of these lines were closed, particularly during the 1930s, due to insufficient traffic. By that time, of course, most of the roads had been surfaced, and the extra infill lines were no longer needed.

To summarize, there was a significant amount of technical change in almost all aspects of field cropping technology towards the end of the 19th Century, induced presumably by the agricultural potential of the large areas of land which comprised the next stage of expansion on the North American continent.

CHAPTER 5

POWER ON THE FARM

By its nature, agriculture is an extensive activity. The farm implements described in Chapter 4 had to be pulled back and forth across the fields over large distances. For example, plowing the typical 1890 Brandon field crop area of 52 acres with a 14 inch plowshare involved slowly pulling a heavy load a distance of almost 370 miles, plus turns. Many of the implements were heavy and imposed a considerable draft on the motive power used to propel them.

There is a clear sequence of the sources of that power: oxen, horses, steam, and finally gasoline power. Each of these had its own strengths and weaknesses, which will be discussed in the following sections. Incorporating choices of motive power in the linear programming models was not feasible, due to the complexity of the way in which the decision affected almost all labour productivities. It was therefore necessary therefore to specify in the programs the type of power used .

Oxen

From the earliest days of the Red River settlement, the primary source of power had been the ox. These huge beasts could pull great loads, although only at a slow speed - about 1½ miles per hour. They had the great advantage of not needing any prepared feed during the summer. They could forage enough from any green plants and grasses, which meant that they were very suitable for the first few years on a farm when any feedstuffs would have had to be bought[1].

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[1] Morton, A.S. "History of Prairie Settlement." In Canadian Frontiers of Settlement 2. Toronto: MacMillan, 1938, p. 164.

Another advantage of using oxen was that their depreciation was low. The animal had a long working life, and at the end of it could be sold to a butcher for meat[2]. The ox was well suited to pulling a plow or a wagon, but less so for more complicated equipment such as seeders or binders. If a horse felt that an obstruction was stopping the equipment, it stopped pulling, whereas an ox would lean its weight against the obstacle. This was useful for pulling a plow through roots, but could result in a lot of damage to a binder or mower caught on a rock. The ox was therefore almost indispensable during the Prairie farm's initial period of breaking in, due to its great power for pulling the breaker plow through the heavy sod. An ox could pull a similar weight to a horse over the field, but at about 2/3 of the speed, therefore generating only 2/3 of the horsepower[3]. On the very bad roads of the early Prairie days an ox-drawn wagon could cover only about twelve miles per day[4].

The typical pattern of ownership was for a new settler to buy a yoke (pair) of oxen when he arrived, and to keep them for three to five years[5]. Another pair of oxen was sometimes added, but four oxen were very difficult to harness and handle for field operations since they are not prepared to 'back up'. Towards the end of the first four or five years a pair of horses were usually bought, and a second pair added after a couple more years, at which time the oxen were sold. This pattern of ownership appears repeatedly in the literature throughout the period, and has therefore been utilized in the models. For 1880 and 1890 the oxen are assumed to be

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[2] Manitoba Agricultural Museum. Manitoba Agricultural Museum. 1979., p. 181.

[3] Davidson, J.B. and Chase, L.W. Farm Machinery and Farm Motors. New York: Orange Judd, 1920, p. 287.

[4] Careless, J.M. The Pioneer, A Picture History of Canadian Settlement, 1973, p. 88; De Gelder, W. A Dutch Homesteader on the Prairies. Translated by H. Ganzevoort. University of Toronto Press, 1973

[5] Morton, A.S. "History of Prairie Settlement." In Canadian Frontiers of Settlement 2. Toronto: MacMillan, 1938., p. 164; Neatby, L.H. Chronicle of a Pioneer Prairie Family. Saskatoon: Western Producer Prairie Books, 1979, p. 24.

kept for five years. From 1900 on the opportunity cost of the lost production due to the slower speed of oxen was greater, and the settler is assumed to change to horses after four years.

During the working season the oxen were fed some hay and concentrated grain, since there was not sufficient time at the end of the day for them to graze. An allowance of 1000 lbs of oats or barley, 4000 lbs of hay and 2 acres of pasture has been made in the linear programming models. A pair of oxen cost about $150 in 1880[6], and their yoke an additional $18[7]. In 1890 this cost had fallen to about $120[8], plus the yoke, and by 1900, the price was about $100[9]. This rose again to about $180 by 1910[10], presumably due to a scarcity of the animals, resulting from an increase in their marginal revenue product. Oxen required relatively little care - not more than ten minutes per pair per day, including yoking them up.

Horses

The principal source of farm power between 1880 and 1910 was the horse. As discussed in the preceding section, most homesteaders kept one or more yoke of oxen for the first few years, and then gradually replaced them with horses once the farm had generated enough cash and could produce enough oats to feed them. Horses could work a ten hour day, similar to oxen, but could keep up a steady speed of about 2½ mph, compared with about 1½ mph for the ox. Their feed and care however were more involved and expensive than thoae of the oxen. A horse needed to eat about 1 lb of concentrated feed (grains, etc.) for each 100 lb of body

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[6] Manitoba Free Press, March 18, 1877, Minister of Agriculture and Immigration Report for 1876; July 14, 1877; April 19, 1879; Winnipeg Daily Times, June 27, 1879, 'Writing Home'.

[7] Manitoba Agricultural Museum. Manitoba Agricultural Museum. 1979, p. 175.

[8] Manitoba Free Press, April 21 and 28, 1887.

[9] Edmonton Journal, May 10, 1879.

[10] de Gelder A Dutch Homesteader on the Prairies., p. 58; West, E. Homesteading: Two Prairie Seasons. London: T. Fisher Unwin, 1920, p. 44.

weight, plus hay etc., if it were to be able to work hard all day[11]. The amount of food allowed in the model is derived from Census data, and tabulated in Chapter 6. To feed, groom, harness and otherwise care for a horse took about twenty minutes per horse per day[12]. Typical farm horses weighed from 1,000 to 1,600 lb with the average increasing over the period, from about 1,100 lb in 1880 to 1,400 lb by 1910. The horse could pull about 1/10 to 1/7 of its own body weight continuously, and up to 1/2 its weight for very short periods.

Generally speaking, the power of the horse was taken through a harness to pull a moving load directly behind the animal. However where stationary power was needed, particularly for threshing or chopping grain, two pieces of equipment - the tread and the sweep - were developed to turn a rotating wheel. The tread was like a short escalator, with one or two horses continually walking uphill, pushing the treads down. A typical horse tread made by Sawyer and Massey is illustrated in the Farmers' Advocate, June 1, 1902,. A one horse tread was an efficient means of capturing the power of a horse, since it used the horse's weight rather than its pull, to turn the wheel. A 1,100 lb horse in a tread could generate almost 1-1/2 horsepower, compared with about 3/4 of a horsepower pulling an item of equipment[13]. It was not however possible to make a tread for more than three horses, and even that was rather less efficient. Treads were often used for small threshing machines, but were not suitable for larger threshers.

The sweep consisted of an arrangement of from four to twelve long arms projecting at equal spacings around a central capstan, to each of which was attached a horse which walked in circles around the capstan, from which power was taken by a rotating shaft running along the

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[11] Spector, D. Field Agriculture in the Canadian Prairie West, 1870 to 1920, With Emphasis on the Period 1870 to 1920. Ottawa: Parks Canada, Department of Indian and Northern Affairs, National Historical Sites and Parks Branch, Manuscript Report No.205, 1983., p. 143; Brumfield, K. This Was Wheat Farming. Seattle: Superior Publishing, 1968., p. 56.

[12] McKinley, M. Wheels of Farm Progress. Michigan: American Society of Agricultural Engineers, 1980., p. 71; Haro, p. 211;

[13] Davidson and Chase Farm Machinery and Farm Motors, pp. 293, 296.

ground. Whilst more horses could be harnessed to a sweep than to a tread, a large proportion of their energy was wasted, due to the incorrect line of draft[14]. Sweeps were used less frequently than treads, since there were never enough spare horses.

Since they were working most of the time, horses had to be fed prepared feed, and obtained only a minor portion of their sustenance from pasture. The linear programming models allow for one acre of pasture per horse, 2500 lbs of oats and 2000 lbs of hay. In 1880 a pair of horses cost about $300[15]. Harness for the pair was an additional $15[16]. For 1890 that figure is unchanged[17]. The cost then fell to about $150 in 1900[18], at which date the harness cost about $27 per pair[19]. By 1910 the cost of horses had risen significantly, probably because of a shortage created by the rapid rate of settlement, to about $500 per pair[20], although the weight and therefore also the output of the team had also risen.

The average number of horses per farm on the Prairies increased from 2.34 in 1880 to 3.18 in 1890 and to 4.77 in 1900 before falling slightly to 4.45 in 1910. However the number of horses per 1,000 cropped acres fell significantly, reflecting both the increasing use of inanimate power both on and off the farm, and the increasing efficiency of the implements used. In 1880 there were 93.8 horses per thousand cropped acres, which then fell to 71.2 in 1890, 67.9 in 1900 and 51.3 in 1910.

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[14] *Ibid*, p. 296.

[15] Manitoba Free Press Weekly, March 10, 1877 (Report of Minister of Agriculture and Immigration 1876), and December 1, 1877; Hamilton (1875), pp. 254, 255.

[16] Ankli, R.E. and Litt, R.M. "The Growth of Prairie Agriculture." In Canadian Papers in Rural History 1, pp. 35-64. Edited by D.H. Akenson. Gananoque: Langdale Press, 1978, p. 51.

[17] Nor-West Farmer, January 1886, p. 353, April 28, 1887; July 16, 1887.

[18] *Ibid.*, February 6, 1899, p. 102; October 20, 1899.

[19] *Ibid.*, April 5, 1899, p. 211.

[20] Manitoba Free Press Weekly, May 15, 1907; de Gelder A Dutch Homesteader on the Prairies, p. 72.

Steam Power

The introduction of steam power had a considerable impact on Prairie agricultural operations. Its principal use was for threshing and plowing, but it also powered sawmills and flour mills, chopped grain, and pulled wagons. Though too cumbersome to replace the horse in all operations, the enormous power of the large traction engines ensured their dominance for many applications.

In 1880, there were very few steam engines on the Prairies. The Manitoba Free Press Weekly for July 17, 1880 noted that up to 1879 only 252 engines had been built by one of the largest Canadian manufacturers, the Waterous Steam Engine Works Co. of Brantford, Ontario. None of these were traction engines (i.e. engines which could move from one place to another under their own power, and pull other pieces of equipment), and few would have found their way to the Prairies. No usage of steam power is reflected in the models for 1880. A typical early portable steam engine is reproduced in Figure 5.1. It consisted basically of a firebox made of corrugated steel, a vertically mounted pressure vessel, and a small engine. It would have produced about four to eight horsepower, was mounted on wheels, and needed two to four horses to move it from one place to another.

By 1890 there had been significant progress. Barger and Landsberg[21] suggest that by that date the use of steam engines for threshing was standard in the U.S., although almost no plowing was done by steam because of the rudimentary nature of the steam traction engine. A typical engine of that date would be that advertised by Geo. White and Sons of London, Ontario, in the Farmers' Advocate of August 5, 1893, page 296.

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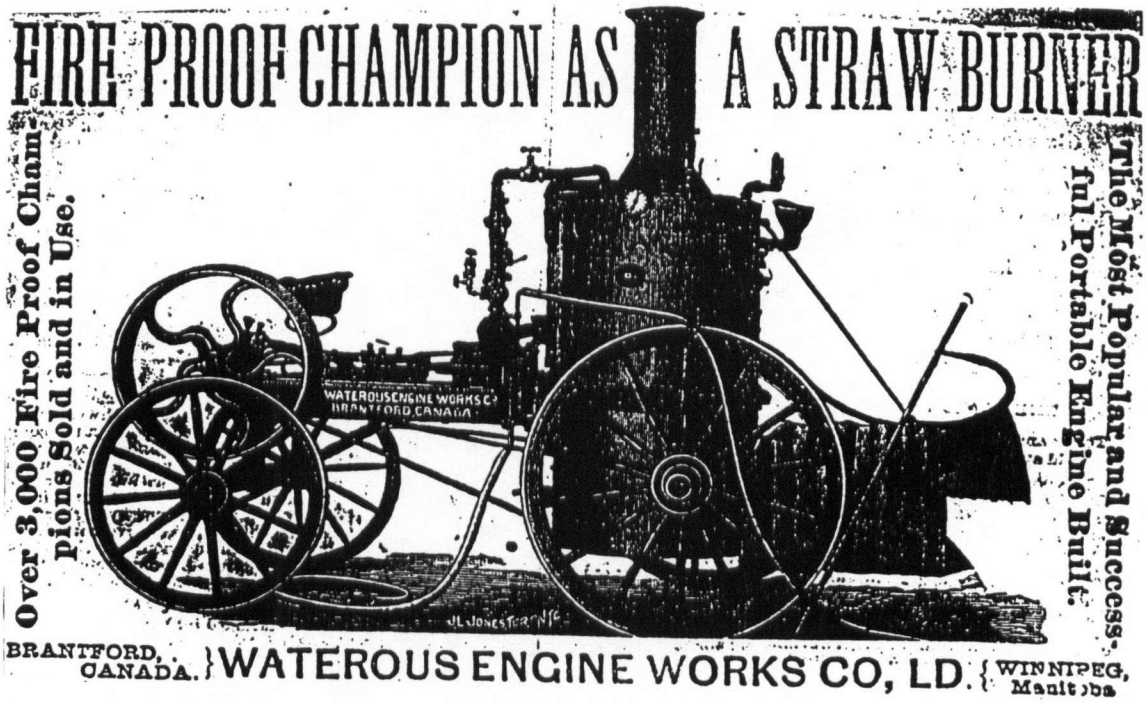
[21] Barger H. and Landsberg, H.M. American Agriculture 1899-1939. A Study of Output, Employment and Productivity. New York: National Bureau of Economic Research, 1942, p. 199.

FIGURE 5.1



Typical Portable Steam Engine of the 1880s[22]

An advertisement in the Farmers' Advocate in June 1886, page 189 by the Waterous Engine Works Co., demonstrates that some of these engines were self-propelled by that date. Brumfield[23] suggests that the first experimental use of steam power in the field came in the late 1880s, and by 1890, McKinley[24] counted a total of 3,000 steam tractors throughout the U.S.A., producing from 8 to 12 hp each. According to McKinley a typical steam engine, the Rumely portable, cost about $1,200[25]. The use of steam power is incorporated in the linear

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22 Reproduced from the Manitoba Free Press of 11 August, 1887, p. 5.

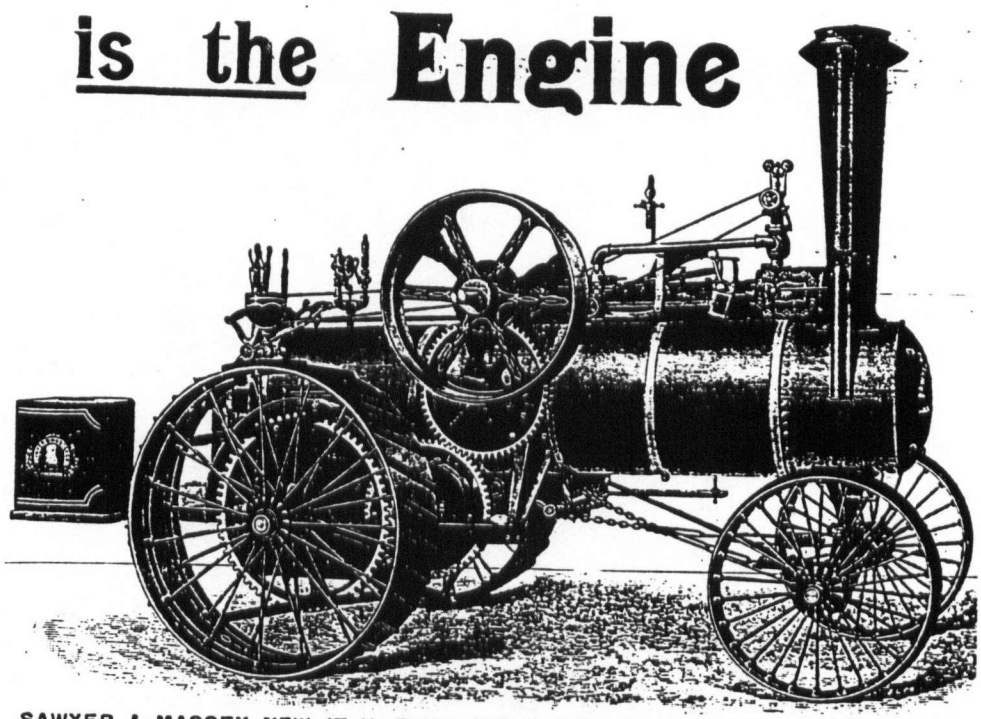
23 Brumfield This Was Wheat Farming, p. 88.

24 McKinley Wheels of Farm Progress, p. 27.

25 *Ibid.*, p. 27.

programming model for 1890, but only for powering threshing machines, not for breaking operations.

FIGURE 5.2



Typical Steam Traction Engine, 1904[26]

Steam engines developed very rapidly during the 1890s, and by 1900 large, powerful, reliable traction engines of up to 110 hp were available, powering threshers in the fall, sawmills and flourmills in winter, and breaking new land during the summer. These engines were very powerful and efficient, although they never became agile enough to carry out all field operations. Another advertisement by the J.I. Case Co. in the Nor-West Farmer for December

[26] Reproduced from the Farmer's Advocate of 29 June, 1904, p. 931. (Advertisement by Massey-Harris Co.)

20, 1901, gave the price of a 25 hp simple traction engine as $1,850 in Winnipeg. The smallest 9 hp traction engine cost $1,100.

Very few farmers owned a large steam engine themselves, since for all operations the output of a steam engine was far greater than could be used on a single farm. Most engines were owned by contractors, who undertook breaking and threshing on a contract basis, and often either ran their own sawmills or rented the engine to a sawmill owner during the winter. The steam engine is therefore not incorporated directly in the model, but only through its effect on contract prices for breaking and threshing. The steam engine required a significant amount of attendance to keep it operating. A stationary engine operating a thresher would need one engineer in full time attendance and also a fireman and a waterman with a team of horses and water tank - typical water consumption of a large steam engine was 300 to 450 gallons of clean water per day[27]. The waterman's time was taken up not so much by moving the water as by pumping it up from the well or pond and then into the engine.

The major technological improvements to the steam engine had been made by 1900. From then until 1910, improvements consisted primarily of refinements which made the engines more efficient and reliable. Early steam engines needed a team of horses to move them from place to place, since they were 'portable' rather than 'locomotive'[28] engines. Even in the early 1890s, many traction engines still needed two horses harnessed in front for additional traction and for steering.

The operation of plowing exhibited increasing returns to scale for the operator of a steam engine, leading to enormous machines of up to 110 hp. However even the largest threshing machine could be operated by a 16 hp engine. As discussed in the section on threshing, one of the important advances over the period 1900-1910 was the development of small reliable

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[27] Brumfield, K. This Was Wheat Farming. Seattle: Superior Publishing, 1968, p. 88.

[28] McKinley, Wheels of Farm Progress, p. 27, notes that the Rumely portable steam threshing engine needed eight horses to move it.

steam engines. By 1910 these had become cheap enough to be owned by individual farmers, and therefore enabled those farmers to become independent of the delays which frequently occurred at threshing time to contractors due to mechanical breakdowns, bad weather, etc.. Another problem with early traction engines was their enormous weight - thirty tons or more. This led to frequent accidents on the insubstantial Prairie bridges, which were built to cope with a typical load of a team of horses and a wagon - a far lighter and less concentrated load than a steam engine.

Gasoline Engines

Towards the end of the period in question the gasoline engine began to be adapted for agricultural use. The Nor-West Farmer[29] in 1899 noted that there were no gas engines known of in use in Manitoba at that time, but that they could be bought in Winnipeg, costing from $100 for a one hp engine to $250 for three hp. The Farmers' Advocate[30] discussed the use of gasoline engines for threshing, and concluded that they were not yet sufficiently powerful or large, and did not perform well outdoors. They had however the promising advantage of not needing an engineer or a fireman.

In 1902 the Farmers' Advocate[31] had a picture of threshing operations on the Experimental Farm at Indian Head, which shows a gas engine being used at that early date. The Nor-West Farmer[32] discussed the use of gasoline engines for threshing, and was generally approving. The author of that article had an 18 hp Waterous portable engine, which cost $1,650,

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[29] Nor-West Farmer, June 5, 1899, p. 367.

[30] The Farmers' Advocate Weekly, November 20, 1901, p. 692.

[31] The Farmers' Advocate Weekly, September 1, 1902, p. 800.

[32] The Nor-West Farmer, August 5, 1901, p. 695.

and used about 25 gallons of gas per day to drive a 36 in separator. However, Ingles[33] noted that in 1905 there were still only thirty four gas tractors on the Prairies. The use of gasoline engines is therefore not reflected in the linear programming models.

MISCELLANEOUS ITEMS OF FARM TECHNOLOGY AND COSTS

Buildings

The typical building pattern on a Prairie farm was for a small wood hut or sod house to be constructed in the first year, the materials for which cost $50 to $100 for a ten by twelve foot shack. A most important purchase before the first winter was a cast iron wood burning stove, which cost about $38[34]. A crude animal shelter also built for the first winter cost only about $25.

At some later stage, if the cattle rearing operations were successful, a large barn would be built to house the horses, oxen, cattle and some of the implements, the materials for which would cost about $500. Some time during the sixth to the tenth year, a larger farmhouse costing about $1000 would usually be built, to accommodate the growing family. The pattern of housebuilding changed little over the period; variation was due more to ethnic and wealth differences. The cost of the first shack is included in the linear programming models as it formed an unavoidable part of the initial capital requirement of the settler. The more elaborate houses built later are considered as part of consumption expenditure and are not included in the models.

The cost of buildings to house animals is included in the models as a part of the cost of keeping those animals. For 1880, 1890 and 1900 $15 per animal plus three days labour is allowed

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[33] Ernest B. Ingles. "Some Aspects of Dry-Land Agriculture in the Canadian Prairies to 1925", Unpublished M.A. Thesis, (University of Calgary, 1973), p. 57.

[34] Manitoba Free Press, 18 March 1877.

for housing cattle, horses or oxen[35]. By 1910 standards had improved. Floors were concreted and better ventilation and sanitation arrangements were incorporated. The cost of the materials to build a barn is increased for 1910 to $40 per animal[36], plus five days labour. The cost of accommodating pigs is included as $10 per pig plus one day of labour, and the cost of building a hen coop and run is put at $2 per hen, plus 1/4 days labour. For sheep, an allowance of $15 per animal for materials plus two days labour is built in to the models for all dates.

Water

Provision of water on the farm was of great importance for both human and livestock requirements. The first settlers in each area would take homesteads on which water was readily accessible, but subsequent settlers would need to have some means of raising their water mechanically. In the 1880s this was achieved with a well dug by hand and a hand water pump[37], but by 1890 windmills were common on the Prairies[38]. Left to run whenever the wind blew, these windmills on tall steel masts could keep a large tank filled continuously, providing as much water as the ground would yield up.

Until about 1890 wells were dug by hand. This was slow, expensive in time, and dangerous for the digger, who might have to go 50 feet or more below ground[39,40]. By 1900, well boring

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[35] Barneby, W.H. Life and Labour in the Far, Far West. London: Cassill 1884, p. 198, suggests that a barn cost about $250.

[36] The Farmers' Advocate (Western) 11 September 1908 puts the cost of a large 'up-to-date' barn for 41 animals at $81 per animal, including all labour.

[37] Although available before 1878 (See for example the Farmers' Advocate, Eastern Edition, January 1878, p. 47, advertisement by Fred Hills.), an article in 1884 (Farmers' Advocate, Eastern Edition, April 1884, p. 105, 'Wind Power on the Farm'.) noted that 'although popular in the U.S.A., windmills were comparatively unknown in Canada'.

[38] See, for example, the Nor-West Farmer, May 1886, p. 489; June 5, 1899, p. 367; July 5, 1899, p. 444; Regina Leader Post, April 26, 1887; Farmers' Advocate (Western Edition), June 1890; July 1891.

[39] Parson, E. Land I Can Own. Ottawa, 1981, p. 42.

machines consisting of a small tripod from which an auger was driven, powered usually by a horse sweep, were in use. Whilst the cost per foot drilled scarcely changed, the well was completed quickly, and could be drilled far deeper[41]. For 1880 and 1890, the only cost incorporated in the models for water is an allowance of five days in the second year to dig a well, plus $20 to buy a hand pump[42] to extract the water. For 1900 an allowance of $60 plus two days labour is incorporated, to allow for the installation of a shallow bored well and a hand pump. By 1910, most farms were installing deep bored wells with wind vane pumps. To cover the cost of this, $150 is included in the 1910 models[43].

Fencing

An important cost of keeping livestock was that of enclosing the areas in which they were pastured. Traditionally this had been carried out with post and rail wood fencing, but wood fencing took a lot of time to erect, and in areas where there were few trees was quite expensive. Barbed wire was developed in the 1870s, costing about 1¢/foot in 1880[44], which fell to about ¼¢/foot by 1910[45]. On the basis of 1.5 acres of pasture per animal and an average of 5 cows, the cost of fencing materials for cattle, oxen and horses is put at $15 per animal in 1880, $12 in 1890, $8 in 1900 and $5 in 1910. One day of time per animal is allowed to erect the fencing.

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[40] Well boring machines were first developed in the 1870s, but there is no mention of them in the Prairie newspapers before 1890. (See for example de Gelder, A Dutch Homesteader on the Prairies, p. 62; West, Homesteading: Two Prairie Seasons, p. 105.

[41] For example Parson, (*Op.cit.*), p. 92, gives an example of a well 593 ft deep.

[42] Manitoba Free Press, 1 December 1877, $20; Edmonton Journal, 2 August 1897, $10 + 10¢/foot for piping.

[43] NorWest Farmer, 5 June 1899, p. 367, windmill $125; 5 January 1909, p. 38, $90 for windmill. West, Homesteading: Two Prairie Seasons, gives a cost of $1.00 per foot for boring a well - allowing for 50 feet gives $50.

[44] Farmers' Advocate (Eastern), September 1890, p. 120.

[45] de Gelder A Dutch Homesteader on the Prairies.

The only subsequent technical change which occurred was the development of woven wire fencing, which was better than barbed wire at keeping in pigs and poultry, and came into use after 1900[46].

Labour

A common theme running through the contemporary literature, and one very much relied on in this analysis, is that hired labour was scarce at the extensive frontier. The existence of free land was bound to reduce the supply of available agricultural labour, in that a competent worker would work for another farmer only in order to gain local experience or to build up capital to enable him to start his own farm. Either of these conditions would last only for a short while, when the worker would set up on his own land. At the frontier there was therefore no significant pool of permanent agricultural labourers to assist in the working of farms, as there was in communities which had been in existence longer. The Census data outlined in Chapter 3 and analysed below support this.

The labour constraint is incorporated in the models by limiting the total number of work hours available on the farm to those provided by the settler and his family. Additional labour was sometimes available at harvest time, partly in the form of workers supplied by a threshing contractor, and partly as short term hired hands. The numbers of additional workers available though was limited, and is reconciled in the linear programming models at the aggregate level, primarily by the use of Census data.

In essence, Census data has been used to estimate the extra labour available, at the level of aggregation of the Province, and these totals have then been divided equally among all farms in the Province. The type of information available in the Census is different for each decade, and different calculations are therefore used for each date.

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[46] See, for example, the Farmers' Advocate, Western Edition, July 5, 1902; April 27, 1904; July 5, 1905.

One way of alleviating the shortage of labour at the most critical season - harvest time - was the introduction by the CPR in 1890 of harvest excursion trains. These brought large numbers of seasonal workers to the Prairies, principally from Eastern Canada, although some came from B.C., the U.S.A. and as far away as Britain. Table 5.1 lists the numbers of excursionists for the years from 1890 to 1910.

TABLE 5.1

Numbers of Harvest Excursionists, 1890-1929[47]

1890	292	1897	6,000	1904	14,000
1891	3,000	1898	4,250	1905	16,858
1892	2,000	1899	11,004	1906	23,657
1893	1,489	1900[48]	2,175	1907	21,000
1894	1,555	1901	18,375	1908	27,500
1895	5,000	1902	13,000	1909	23,000
1896	2,350	1903	18,000	1910	14,387

One source of labour was farmers' sons, who have not been included in the aggregate calculations below but are represented in the linear programming models. Given that the models are intended to represent a newly arrived young settler, it would not be realistic to attribute to that new homestead a son of working age. The models are set up on the basis that the typical settler got married within three years of settlement, and within three years of that had a male child who survived and chose to work on the farm from the age of 15. Each farm

[47] Derived from information in:- J.H. Thompson. "Bringing In The Sheaves: The Harvest Excursionists, 1890 - 1929". In Canadian Historical Review Vol.LIX, (December 1978), pp. 467-489.

[48] 1900 was an exceptionally bad crop year and few additional workers were called for. An interpolated figure of 13,000 has been used in the calculations for the expected number of harvest workers for that year. For similar reasons, in 1910 an expected figure of 25,000 migrants has been used. These figures were divided evenly over the total number of farms for Manitoba and the Territories.

therefore has one additional worker from the 21st year of operation to the 40th, which is the final year included in the analysis, with the settler having reached the age of about 65.

As the following analysis shows, the numbers of full time labourers available were never large, varying from 1 between every 3.1 farms to none at all, with most periods falling in the range of 1 labourer to every 4 or 6 farms. This is too small a proportion to justify the inclusion of any full time hired labour in the models, in that the typical settler could not realistically expect to hire a permanent full time worker. Accordingly no full time hired labour is incorporated in the models. The effect of including these additional amounts of labour would be to increase farm values, but the later values of the farms in Saskatchewan and Alberta would be expanded by more than the earlier values, thus emphasising the results calculated in this thesis.

Table 5.2 lists data on the wage rates paid to short term harvest labourers over the period.

TABLE 5.2

Harvest Wages

	Daily Wage	Board and Lodging	Total Daily Wage
1880	$1.25	$0.25	$1.50
1890	$1.75[49]	$0.25	$2.00
1900	$1.35[50]	$0.25	$1.60
1910	$2.00	$0.35	$2.35

[49] Farmers' Advocate, Eastern Edition, January 1885, p. 12; May 1885, p. 133; Manitoba Free Press Weekly, October 2, 1890; Brandon Weekly Mail, July 15, 1885.

[50] Farmers' Advocate, Western Edition, January 1892, p. 5; October 5, 1900, p. 543; Manitoba Free Press Weekly, September 15, 1898; Edmonton Journal, September 27, 1897.

TABLE 5.3

Hired Labour for 1880

A) Manitoba

Data:-

'Occupiers of Land' - Assumed to yield the total number of farms and ranches - 9077
Farmers - 10889
Labourers - 2537 (No information as to sphere of work - assumed that 33% worked on farms, and an additional 25% were available for the harvest period) (2537 x 33% =) 846 fulltime + (2537 x 25% =) 634 for harvest.

Therefore - year-round workers - (10889 farmers - 9077 farms =) 1812 landless farmers + 846 labourers = 2658
Divide this total by 9077 farms = 29.3% - i.e. 1 per 3.4 farms
Additional workers at harvest time - 634
Assume that harvest workers were available for a total of 40 days, of which they worked 80%. (The losses being due to inclement weather, Sundays, lack of work, etc.) Total available mandays = 634 x 32 = 20288.
Deduct from this the labour used by threshing contractors, implicitly included in the models:-

Labour used by threshing contractors -

Wheat	1,033,673 bu/600 bu.day =	1722 days
Oats, barley, rye	1,525,067 bu/800 bu.day =	1906 days
		3628 days

for a crew of 5 men = 18,140 mandays.

Therefore harvest labour per farm = 20288 - 18140 = 2148/9077 = 0.3 days/farm - use zero

B) The Territories

Data :-

'Occupiers of land" - 1014
Farmers - 831
Labourers - 314 - fulltime on farms - allow 50% = 157 - harvest 25% = 79
Therefore - year-round workers - (831 + 157) - 1014 = (26). (i.e. zero)
Additional harvest workers - 79

Labour used by threshing contractors -

Wheat	119,655 bu / 600 bu.day =	199 days
Oats, barley, rye	108,637 bu / 800 bu.day =	136 days
		335 days

for a crew of 5 men = 1,675 mandays

Therefore harvest labour per farm (including full and part time workers)
= 831 + 157 + 79 - 1014 = 53 people x 32 days = 1696 persondays less
1675 for threshing, = 21, between 1014 farms = 0.02 persondays per farm. i.e. zero

TABLE 5.4

Hired Labour for 1890

A) Manitoba

Data:-

'Occupiers of land' - 22,571
Farmers - 20,575
Farm labourers - 5,033 - It is not clear that all these people worked full time on farms. Allow for 90% to be full time (4,530), and the remaining 10% (503) to available only in the harvest season.
Therefore - year-round workers - (20,575 + 4,530) - 22,571 = 2,534
i.e. 1 worker per 8.9 farms
Additional harvest workers - (20,575 + 5,033) - 22,571 = 3,037
Labour used by threshing contractors -

Wheat	16,092,220 bu / 900 bu.day =	17,880 days
Oats, barley, rye	9,835,597 bu / 900 bu.day =	8,196 days
		26,076 days

for a crew of five men = 130380 person days
Therefore additional harvest labour 3,037 people for 32 days = 97,184 less 26,076 persondays = 71,108 between 22,571 farms = 3.2 days per farm.

B) The Territories

Data:-

'Occupiers of land' - 9244
Farmers - 7798
Farm labourers - 1379 x 90% = 1241 full time - 138 for harvest only

Therefore year-round workers - (7798 + 1241) - 9244 = (205)
Additional harvest workers - (205) + 374 = 169
Labour used by threshing contractors -

Wheat -	1,792,409 bu / 900 bu.day =	1992 days
Oats, barley, rye -	1,845,323 bu / 1200 bu.day =	1538 days
	Total	3530 days

for a crew of five men = 17650 days
Therefore total harvest labour per farm 169 people for 32 days = 5408 persondays -17650 = 0

TABLE 5.5

Hired Labour for 1900

A) Manitoba

Data:-

'Occupiers of land' - 31812
No information on numbers of farmers
Weeks of hired labour - 419,180
Value of hired labour - $2,614,752 - (Average $6.24 per week)
- no information on the occupations of the population, or breakdown of hired labour between full time / harvest.
Assume 2/3 of farm labourers were full time - 1/3 for harvest only
Therefore # workers = 2/3.52.# + 1/3.6.# = 419,180
= 11,433 - 7,621 full time - 3,812 harvest only.
Therefore full time workers - 7,621 - ie one farm in 4.2 had a full time worker
Labour used by threshing contractors -

Wheat -	18,352,929 bu / 1500 bu.day =	12,235 days
Oats, barley, rye	13,266,107 bu / 2000 bu.day =	6,633 days
	Total	18,868 days

for a crew of four men = 75,472 person days
Additional harvest workers - 11433 x 32 days = 365,856 days
- 75,472 = 531,824 days between 31812 farms = 16.7 days per farm

B) The Territories

Data:-

'Occupiers of land' - 22,813
Weeks of hired labour - 229,532
Value of hired labour - $1,567,228 - (Average $6.83 per week)
Assume 2/3 of labourers worked full time -
Therefore # workers (2/3).52.# + (1/3).6.# = 229,532
= 6,266 of whom 4,177 were full time
Therefore full time workers - 4177 - i.e. one farm in 5.5 had a full time worker.
Labour used by threshing contractors -

Wheat	5,103,930 bu / 1500 bu.day =	3,403 days
Oats, barley, rye	6,566,002 bu / 2000 bu.day =	3,283 days
	Total	6,686 days

for a crew of 3 people = 20,058 person days
Additional harvest workers - 6266 x 32 days = 200,512 person days - 20058 = 180,454 between 22,813 farms = 7.9 days per farm

TABLE 5.6

Hired Labour for 1910

A) Alberta

Data:-

'Occupiers of land' - 61,496. Deduct # ranchers = 59,729 farms
Farmers - 62,761
Farm labourers - 8,161 - assume 90 % full time = 7,345 - 816 harvest only
Harvest excursionists (Thompson) - 14387 - allow expected figure of 25,000 due to unusually bad harvest
Allocation of harvest excursionists - assume proportional to harvest

Threshing days -	Alberta -	14,347
	Manitoba -	37,452
	Saskatchewan -	68,773
	Total	120,572

25,000/120,572 = 0.207

Therefore -	Alberta -	2,975
	Manitoba -	7,765
	Saskatchewan -	14,260

Labour used by threshing contractors -

Wheat -	9,060,210 bu / 1,650 bu.day =	4,491 days
Oats, barley, rye -	19,483,011 bu / 2,200 bu.day =	8,856 days
	Total	14,347 days

for a crew of 3 people = 43,041 person days
Therefore full time labour - 62,761 + 7,345 - 59,729 = 10,377 - ie 1 worker per 5.8 farms
Additional harvest labour - 62,761 + 8,161 + 2,975 - 59,729 = 14,168 people x 32 = 453,376 person days - 43,041 = 410,335/61496 farms = 6.7 days per farm

B) Manitoba

Data:-

'Occupiers of land - 45,606. Deduct # ranchers (437) = 45,169 farms.
Farmers - 44,143
Farm labourers - 17,149 x 90% = 15,434 full time + 1,715 harvest only.
Hired labour - weeks - 600,891 - value - $5,411,916 - (Average $9.01/week)
Proportion of harvest excursionists (above) - 4,469
Labour used by threshing contractors -

Wheat	- 34,127,498 bu / 1,650 bu.day =	20,683 days
Oats, barley, rye -	36,892,558 bu / 2,200 bu.day =	16,769 days
	Total	37,452 days

for a crew of 3 = 112,357 days
Therefore full time labour = 44,143 + 15,434 - 45,169
= 14,408 people between 45,169 farms = 1 per 3.1 farms
Additional harvest labour - 44,143 + 17,149 + 7,765 - 45,169
= 23,888 people for 32 days = 764,416 person days - 112,357
= 652,059 between 45,169 farms = 14.4 days per farm

C) Saskatchewan

Data :-

'Occupiers of land' - 96,372. Deduct # ranchers (803) = 95,569 farms.
Farmers - 101,101
Farm labourers - 20,420 x 90% = 18,378 full time - 2,042 harvest only
Hired labour - weeks - 564,417 - value - $5,909,663 (Average $10.47 week)
Proportion of harvest excursionists (Above) - 8,206
Labour used by threshing contractors -

Wheat	- 66,978,996 bu / 1,650 bu.day =	40,593 days
Oats, barley, rye	- 61,995,347 bu / 2,200 bu.day =	28,180 days
	Total	68,773 days

for a crew of 3 people = 206,319 person days
Therefore full time labour - 101,101 + 18,378 - 95,569 = 23,910
- between 96,372 farms = 1 per 4 farms
Additional harvest labour - 101,101 + 20,420 + 14,260 - 95,569
= 40,212 x 32 days = 1,286,784 - 206,319 = 1,080,465 person days
between 95,569 farms = 11.3 days per farm

CHAPTER 6

ANIMAL HUSBANDRY ACTIVITIES

Introduction

The purpose of this thesis is to examine the rate and pattern of human settlement on the Prairies over the period from 1880 to 1910. The animal husbandry activities studied are therefore those undertaken on the typical 'mixed farm', rather than the quite different scale of activity engaged in by ranchers in southern Saskatchewan and Alberta. Those enterprises had started at an earlier stage of Prairie development, primarily as extensions of ranching activity in the northern states of the US. They did not contribute to, but in fact resisted, the advances of grain and mixed farming during the period from 1880 to 1910.

The activities studied in this chapter include dairying and the rearing of beef cattle, pigs, sheep and hens. In all of these spheres there were improvements in the technology during the period in which I am interested.

a) Dairy Cattle

In the 1870s and early 1880s dairy activity on the typical farm was confined to a couple of cows (the 1881 Census gives an average of 2.4 milch cows per farm). Initially these provided butter, beef and some milk for the local market. Dairying did not become commercially profitable until after the occurrence of a series of technological developments, the most important of which was a large increase in the total milk supply brought about by increasing the lactation period[1]. This income was achieved mostly through improvements in feeding standards,

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[1] David Spector 'Field Agriculture in the Canadian Prairie West, 1870 to 1940, With Emphasis on the Period 1870 -1920', Manuscript Report N° 205. (Ottawa: Parks Canada, Department of Indian and Northern Affairs. National Historical Sites and Parks Branch, 1977) p. 37.

particularly for the winter period. Experiments in the United States and England showed that feeding cattle root crops such as turnips and mangels increased the lactation period of dairy cattle. This gave a slightly sharp taste to the milk which it was later found could be overcome by the use of ensilage. The technique of ensilage - the preservation of green fodder in a silo - was developed more rapidly in the U.S. due to the greater suitability of the climate and soil for growing corn, but became popular in Canada by about 1915.

The Canadian Census does not record milk production, so the only Census data accessible are those of the amount of butter produced per cow. Taking the province of Manitoba, the weight of home-made butter produced on the farm from each cow was 47 lb in 1880, 58 in 1890, 63 in 1900 and 70 in 1910. There is probably a significant downward bias in the later figures, since an increasing proportion of the butter was manufactured at Creameries, and was not therefore included in these figures.

The second important improvement in dairying was the development of the butterfat tester. Prior to the mid 1880s there was no method of testing how much butterfat was contained in any particular batch of milk, which led to a typical common property problem as there was no incentive for the individual farmer to try to improve the quality of the milk he sold. Indeed, the farmer usually could only guess which of his cows produced well and which poorly, even for butter making on his own farm. Little butter was made commercially in the 1880s, since there was no feasible way for the buyer of milk from different sources to know the value of any one farmer's milk. Any commercial butter maker would therefore pay for milk at a rate equivalent at best to the average butterfat content. With no price differentiation, the farmer, if he did have any idea of the relative quality of the milk from his various cows, would keep back the best for butter-making on the farm, sending the poorer quality to the creamery. The converse of this is of course that there was no incentive for the farmer to try to improve the quality of his stock or of the milk, since he would continue to receive payment only for the average quality of milk received by the dairy.

It is difficult to date precisely the introduction of an efficient, cheap butterfat tester[2]. The first advertisement which I found for the efficient Babcock milk tester appeared in the Farmers' Advocate in 1890[3], which is also the date which Schlebecker[4] suggests for the development of the butterfat tester. The linear programming models include only one dairying activity - that of keeping a cow for its milk, butter, calves and manure. Table 6.1 lists the productivity of dairy cattle over the period from 1880 to 1910.

TABLE 6.1

Dairy Cattle Outputs - per Cow

	1880	1890	1900	1910
Skim Milk	2,800 lb	3,200 lb	3,400 lb	3,924 lb
Butter	47 lb	58 lb	63 lb	70 lb
Manure-Weight of feed less 1/8 of weight of milk less weight of beef	13.8 tons	14.4 tons	15.6 tons	15.6 tons
Beef (after 8 years)	1,000 lb	1,100 lb	1,200 lb	1,250 lb
Calves-proportion alive after 3 months	0.67	0.7	0.72	0.75

The amount of milk which could be sold commercially was insignificant in 1880, since it was not feasible to transport fresh milk far due to the lack of refrigerated transportation facilities, and the market for milk within the small feasible transportation radius was small. By 1900, with the growth of the transportation network and improvement in refrigeration techniques, selling milk

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[2] In 1885 the Farmers' Advocate carried an article entitled "New Method of Testing the Quality of Milk for Butter and Cheese", but the instrument discussed is an early version called a 'lacto scope', which apparently failed to achieve much success.

[3] Farmers' Advocate (Western Edition), December 1890, p. 418.

[4] John T. Schlebecker. Whereby We Thrive. A History of American Farming; 1607 - 1972. (Iowa: Iowa State University Press, 1975) p. 184.

was more feasible[5]. For 1880, the quantity of milk sold by the farm at the extensive frontier is limited in the models to that from a single cow. This restriction is removed after 1900, but the high time cost of delivery still deterred these farmers from selling any milk.

The improvements induced by the butterfat tester took some time to come into effect, as farmers culled out their poorer producing cows and learned how to improve winter feeding, and while commercial (and provincial government) creameries came into existence. Since the amount of milk produced increased over the period, the feed consumed on average by each cow is also changed in the models, for consistency. Feed data can be corroborated from Census figures for crop production - i.e. a lot of the oats, barley, peas, turnips and hay grown on the Prairies are taken as having been consumed by livestock. Several references to the large-scale importation of oats were found in the literature[6]. The purchase of these oats, as well as other feeds such as bran, oil cake and shorts are therefore added, to give the feed and labour inputs listed in Tables 6.2 and 6.3.

TABLE 6.2

Labour Inputs to Dairying, per Cow. (Hours per Month)[7]

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1880	9	9	9	8	8	8	7	7	8	9	9	9	100
1890	10	10	10	10	9	9	8	7	8	9	10	10	110
1900	11	11	11	11	10	10	9	9	9	10	11	11	123
1910	13	12	13	13	11	11	10	10	11	12	13	13	142

[5] The Nor-West Farmer discussed the profitability of delivering milk to Winnipeg, from places over 150 miles away.

[6] For example, Manitoba Free Press Weekly, January 20, May 3, 1887; Saskatchewan Herald, Battleford, August 11, 1888, April 23, 1890; Brandon Weekly Mail, December 19, 1888.

[7] Derived from information in: Farmer's Advocate (Western) 20 August 1894, p. 235, 31 August, 1909, p. 1272.

TABLE 6.3

Dairy Cattle Inputs

	1880	1890	1900	1910
Feed:				
Small grains	15 bu	20	22	25
Roots	2	2	2	2
Pasture	1.5	1.5	2	2
Hay	3.5tons	3.5tons	3.5tons	3.5tons
Bought feeds[8], vet	$4.00	$4.00	$6.00	$7.00
Capital:				
Cow:- initial cost	$30[9]	$30[10]	$35[11]	$40[12]
- rental (8%for8 yrs = 0.169)	$5.07	$5.07	$5.07	$5.91
- mortality (5% of cost)	$1.50	$1.50	$1.75	$2.00
Cowshed (from 'buildings')	$15.00 +3 days	$15.00 +3 days	$20.00 +3 days	$40.00 +5 days
Fencing				
- materials	$20	$15	$10	$5
- labour (days)	1	1	1	1
Feed cutter ($30 x 10 yrs, 8% - 10 animals)	$0.43	$0.43	$0.43	$0.43
Dairy equipment[13]	$0.75	$1.00	$1.02	$1.02

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[8] Farmers' Advocate (Western) 20 August 1894, p. 235, 31 August 1909, p. 1272.

[9] Manitoba Free Press, 10 March 1877; 14 July 1877; 1 December 1877.

[10] Winnipeg Daily Times, 27 June 1887; Manitoba Free Press, 9 June 1887; 16 June 1887; Brandon Weekly Mail, 21 March 1888.

[11] Calgary Herald, 9 August 1899; Edmonton Journal, 10 May 1897.

[12] W. de Gelder, A Dutch Homesteader on the Prairies, (Toronto: University of Toronto Press, 1973).

[13] The equipment needed for a small farm dairy producing its own butter is listed in the Farmers' Advocate, June 14, 1905, p. 882. The cost of that equipment totalled $105.80, and it was sufficient for up to perhaps fifteen cows. The capital charge, assuming a life of ten years and eight percent interest, would be $1.02 per cow per year.

b) Beef Cattle

Prior to the 1890s cattle farming was carried out on a somewhat hit-or-miss basis, and animals were allowed to feed at will on whatever pasture was available. The period 1890 to 1910 saw three important changes in the technology of beef raising - the introduction of pure bred stock[14], the development of refrigeration in the transportation of meat[15], and the optimization of feeding methods. The first of these is reflected in the models through the gradual improvements in animal weights, and the second through the increases in Winnipeg beef prices. The optimization of feeding methods needs more careful examination, to evaluate its importance and effects.

Farmers who raised beef cattle would sell them either at birth, or at 1, 2 or 3 years old, and Table 6.4 shows the estimated weights of cattle at these ages. Between 1880 and 1910 two offsetting changes occurred in the area of optimization of feeding. Improvements in feeding methods, following from the research results at the Experimental Farms in Canada and the US, enabled cattle to gain more weight more quickly. Farmer education however encouraged farmers to maximize net, rather than gross, returns and therefore to market their cattle earlier. I have assumed that market weight increased slightly over time.

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[14] Theodore C. Byerley. Livestock and Livestock Products. (New Jersey; Prentice Hall, 1964), p. 6.

[15] Farmers' Advocate (Western) November 1882, p. 286.

TABLE 6.4

Weight of Beef Cattle at Date of Sale, by Decade

Weight at:	1 Year	2 Years	3 Years
1880	500	800	1,100
1890	530	870	1,300
1900	560	940	1,300
1910	600	1,000	1,400

Table 6.5 lists the prices of beef cattle livestock over the period.

TABLE 6.5

Initial Purchase Price of Beef Cattle

1880	1890	1900	1910
$25	$29[16]	$27.50[17]	$30.00[18]

The principal inputs to beef raising were fertile cows, feed and labour. It is assumed that the calf crop was 0.75 per cow in 1880, increasing to 0.8 by 1910[19]. Feed requirements are shown in Table 6.6, and reflect the changes in feeding methods described above.

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[16] NorWest Farmer, January 1892, p. 1.

[17] Edmonton Journal, 8 December 1898.

[18] Manitoba Free Press, 22 May 1907, "Steer Feeding".

[19] W.J.Spillman. Farm Management. (New York: Orange Judd, 1923), p. 204; Newton Ashby, "Equipment and Other Capital Required for a Grain Farm, With Special Reference to Corn and Wheat", in L.H.Bailey, The Cyclopaedia of American Agriculture. Volumes I to IV. (Toronto: Macmillan of Canada, 1917), Volume 1, p. 169.

TABLE 6.6

Feed for Beef Cattle - Per Year

	1880	1890	1900	1910
Calf 0-1 year				
Grain	6 bu	8 bu	9 bu	12 bu
Hay	1.5 ton	1 ton	1 ton	1 ton
Pasture	1.5 ac	1.5 ac	1.5 ac	1.5 ac
Milk	600 lb	600 lb	600 lb	600 lb
Chop/Bran/ Shorts	$1.00	$1.00	$1.50	$1.50
Vet	$0.10	$0.10	$0.15	$0.25
Turnips	1.5 bu	1 bu	0.8 bu	0.7 bu
Calf 0-2 years				
Grain	9 bu	10.5 bu	11.5 bu	15 bu
Hay	2 tons	1.5 tons	1.5 tons	1.25 tons
Pasture	1.75 ac	1.75 ac	1.75 ac	1.75 ac
Milk	300 lb	300 lb	300 lb	300 lb
Chop/Bran/ Shorts	$1.00	$1.00	$1.25	$1.25
Vet	$0.08	$0.08	$0.10	$0.15
Turnips	1.5 bu	1.25 bu	1.25 bu	0.6 bu
Calf 0-3 years				
Grain	11.7 bu	13.3 bu	14 bu	16.7 bu
Hay	2.3 tons	1.67 tons	1.5 tons	1.3 tons
Pasture	2 ac	2 ac	2 ac	2 ac
Milk	200 lb	200 lb	200 lb	200 lb
Chop/Bran/ Shorts	$1.00	$1.00	$1.33	$1.33
Turnips	1.67 bu	1.33 bu	0.83 bu	0.67 bu
Vet	$0.08	$0.08	$0.10	$0.12

The other principal input to beef cattle production was labour. Hare[20] states that beef cattle need 3½ work days per year, other cattle 2½, and ranch cattle 1. Given the lower feeding standards in 1880, it would be reasonable to attribute a lesser amount of time to care of the animals. The amount of time allowed in the linear programming models for each animal per month, in hours, is shown in Table 6.7.

[20] H.R. Hare, *p.cit.* p. 118.

TABLE 6.7

Labour inputs to Beef Cattle Activities, by Decade

Age of Calf	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1880												
0-1	3.25	3.25	3.25	2.75	2.75	2.25	2.25	2.25	2.75	2.75	2.75	3.25
1-2	3.00	3.00	3.00	2.50	2.50	2.00	2.00	2.00	2.50	2.50	2.50	3.00
2-3	2.50	2.50	2.50	2.00	2.00	1.75	1.75	1.75	2.00	2.00	2.00	2.50
1890												
0-1	3.50	3.50	3.50	3.00	3.00	2.50	2.50	2.50	3.00	3.00	3.00	3.50
1-2	3.25	3.25	3.25	2.75	2.75	2.25	2.25	2.25	2.75	2.75	2.75	3.25
2-3	2.75	2.75	2.75	2.25	2.25	2.00	2.00	2.00	2.25	2.25	2.25	2.75
1900												
0-1	3.75	3.75	3.75	3.25	3.25	2.75	2.75	2.75	3.25	3.25	3.25	3.75
1-2	3.50	3.50	3.50	3.00	3.00	2.50	2.50	2.50	3.00	3.00	3.00	3.50
2-3	3.00	3.00	3.00	2.50	2.50	2.00	2.00	2.00	2.50	2.50	2.50	3.00
1910												
0-1	3.75	3.75	3.75	3.25	3.25	2.75	2.75	2.75	3.25	3.25	3.25	3.75
1-2	3.50	3.50	3.50	3.00	3.00	2.50	2.50	2.50	3.00	3.00	3.00	3.50
2-3	3.00	3.00	3.00	2.50	2.50	2.00	2.00	2.00	2.50	2.50	2.50	3.00

TABLE 6.8

Other Inputs to Beef Cattle Operations

Buildings - 1880, 1890, 1900 - $25/animal + 3 days labour

- 1910 - $40/animal + 5 days labour

Fencing for Pasture - 1880 - $15/animal + 1 days labour

- 1890 - $12/animal + 1 days labour

- 1900 - $8/animal + 1 days labour

- 1910 - $5/animal + 1 days labour

c) Pigs

Pig raising has for centuries been a common method of supplementing farm income and providing fresh meat. Pigs were usually fed on the garbage and slops from the farm, therefore costing almost nothing to feed. This was the type of pig farming operation undertaken on Prairie farms in the 1880s and 1890s. A grown sow cost about $15[21], and was bred once or twice a year, producing five to nine piglets each time. These were either sold at six weeks old for about $1 each; if fed until six months old[22], they fetched $7.50 each. By 1900, pig raising like other animal husbandry activities had been put on a more scientific footing. There were innumerable articles in the Farmers' Advocate, the Nor-West Farmer and various local newspapers discussing improved breeding through the use of pure bred stock, alternative ways of feeding pigs, and the optimal age for sale.

A 50% increase in the use of concentrates such as feed grains is included in the linear programming models over the period from 1880 to 1910. The quantities of oats and barley grown on the Prairies were sufficient to facilitate such an increase, whereas there were not enough turnips produced to enable the newer feeding plans for roots to be implemented. There was some increase in the selling weight of pigs over the period, but it was slight in comparison to the gains made in cattle raising.

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[21] Manitoba Free Press Weekly, December 1, 1877; J.L. Tyman, By Section Township, and Range: Studies in Prairie Settlement. (Brandon: 1972), p. 44.

[22] Clarence Bundy, Ronald Diggins, and V. Christensen. Livestock and Poultry Production. (4th. Edition)(New Jersey: Prentice Hall, 1975) p. 37; Saskatchewan Herald, Battleford, May 8 1889.

TABLE 6.9

Pigs - Output Weights in lb[23]

	1880	1890	1900	1910
Sow	250	250	250	250
Piglet - 6 weeks	20	20	20	20
- 8 months	140	150	150	150
- 2 years	300	350	350	350

TABLE 6.10

Pigs - Labour Input - Hours/Month

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Sow	0.90	0.65	0.50	0.50	0.50	0.45	0.50	0.70	0.90	1.05	1.00	0.95
Piglet 0-6 weeks	0.90	0.00	0.00	0.50	0.50	0.20	0.00	0.00	0.50	0.20	0.00	0.00
0-8 months	0.90	0.70	0.60	1.40	1.20	0.50	0.60	0.70	2.50	1.35	1.00	0.90
0-2 years	2.00	1.40	1.20	1.20	1.20	1.10	1.20	1.50	2.00	2.20	2.10	2.00

TABLE 6.11

Other Inputs to Pork Rearing

Pig Sty - $10.00 per animal for materials plus 1 day of labour

[23] Data for the pig breeding operations included in the models are taken from articles in the Farmers' Advocate, Western Edition (August 1891, p. 292, March 6, 1893, p. 84, June 20, 1899, p. 326, November 20, 1901, p. 701, December 25, 1907, p. 712); the Nor-West Farmer (June 5, 1899, p. 357); H.R. Hare, 1946 (pp. 111, 118, 211); J.H. Gehrs, 1919 (pp. 118, 124); and the Manitoba Free Press Weekly (March 31, 1909, p. 12).

TABLE 6.12

Pig Feed

	1880	1890	1900	1910
Initial purchase price of stock sow	$14[24]	$16	$16[25]	$12[26]
Sow				
- oats	8 bu	8 bu	10 bu	12 bu
- turnips	2 bu	1 bu	1/4 bu	1/4 bu
- pasture (ac)	0.20	0.20	0.25	0.25
- bought feed	$2.00	$2.00	$2.00	$2.00
- vet	$0.10	$0.10	$0.20	$0.20
- boar service	$0.25	$0.25	$0.25	$0.25
Piglets - 0-6 weeks				
- skim milk	50 lb	100 lb	100 lb	125 lb
- oats	1/4 bu	1/4 bu	1/4 bu	1/4 bu
- bought feed	$0.25	$0.25	$0.25	$0.25
- vet	$0.05	$0.10	$0.10	$0.10
Piglets - 0-8 months				
- skim milk	300 lb	350 lb	350 lb	375 lb
- oats	4	4	5	6
- turnips	1	1/2	1/4	1/4
- pasture	0.05	0.05	0.10	0.10
- vet	$0.05	$0.10	$0.10	$0.10
- bought feed	$0.25	$0.25	$0.25	$0.25
Piglets - 0-2 years				
- skim milk	300 lb	350 lb	350 lb	375 lb
- oats	8 bu/yr	9 bu/yr	10 bu/yr	12 bu/yr
- turnips	2 bu/yr	1 bu/yr	1/4 bu/yr	1/4 bu/yr
- pasture (ac)	0.40	0.40	0.50	0.50
- vet	$0.10	$0.10	$0.20	$0.20
- bought feed	$0.40	$0.40	$0.40	$0.40

[24] Manitoba Free Press, 1 December 1877; J.L.Tyman, By Section, Township and Range, (Brandon: Assiniboine Historical Society, 1972), p. 44.

[25] Farmers' Advocate (Western Ed.), August 1891, p. 292; Edmonton Journal, 10 May 1897.

[26] Farmers' Advocate, 20 March 1906, p. 416; Edmonton Bulletin, 23 November 1909.

d) Sheep

Sheep farming was not a major source of income for Prairie farms. On average a Manitoba farm owned 0.67 sheep in 1880, 1.59 in 1890, 0.93 in 1900 and 0.85 in 1910. These sheep produced 2.7 lb of wool each in 1880, 4.5 lb in 1890 and 1900 and 2.4 lb in 1910[27]. There were some changes in the methodology of sheep farming over the period - the introduction of pure-bred stock, and improvements in feeding. The available data are however insufficient to substantiate changing the parameters of the models, which are therefore constant from 1880 to 1910.

There is enough discussion in contemporary newspapers to be able to calculate the relevant inputs and outputs to sheep farming[28], and one sheep rearing activity is allowed in the model. This consists of the keeping of a ewe, which yields 4 lb of wool each year, and 0.75 lambs per year, which are fed for 8 months and then sold.

The inputs to this composite operation are:

Feed - oats	- sheep	2 bu	
	- lamb	2 bu	4 bu
- pasture - sheep		1-1/4 acres	
- lamb		3/4 acre	2 acres
- bought feeds, vet, ram, etc.		$1.00	
- labour - sheep		- total 1 day/year	
- lambs - 8 months		- total 1 day/year	
- barn	- materials $15		- labour 3 days
- fencing	- materials $10		- labour 4 days

[27] Canada. Census of Canada. (Ottawa: 1880, 1890, 1900 and 1910).

[28] Theodore C. Byerly, Livestock and Livestock Products. (New Jersey: Prentice Hall, 1964), p. 169; Saskatchewan Herald, Battleford, September 24, 1887 ('Sheep Rearing in the North'); Nor-West Farmer, May 1886, p. 113; July 1898; H.R. Hare, Farm Business Management. (Toronto: Ryerson Press, 1946), pp. 111, 118, 211, 222.

TABLE 6.13

Labour Inputs to Sheep and Lamb Rearing, by Decade

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Hours per month Lamb(full)	0	0	0	1.50	1.50	0.67	0.50	0.67	0.67	0.75	0.75	1.00
(x0.75)	0	0	0	1.13	1.13	0.50	0.38	0.50	0.50	0.56	0.56	0.75
Sheep	1.00	1.00	0.75	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.75	1.00
TOTAL	1.00	1.00	0.75	1.63	1.63	1.00	0.88	1.00	1.00	1.06	1.31	1.75

TABLE 6.14
Initial Purchase Price of Stock Sheep

1880	1890	1900	1910
$6.00[29]	$4.50[30]	$4.00[31]	$4.00

e) Poultry

Poultry raising, like pig rearing, was an easy way for a farm to generate cash flow and to have fresh food for farm consumption. Outputs from poultry raising consist of eggs, chicken and manure. Data on the number of eggs produced show no trend over the period - an average of 115 eggs per hen per year has been used in the models[32]. Several technological innovations contributed to making poultry farming more profitable. The incubator was developed in the early

[29] J.C. Hamilton, 'The Prairie Province', p. 254; J.L.Tyman, By Section, Township and Range, (Brandon: Brandon Historical Society, 1972), p. 44.

[30] Saskatchewan Herald, 4 August 1888, ($3.50); NorWest Farmer, May 1886, p. 113, ($5.50).

[31] Edmonton Journal, 10 May 1897.

[32] See Manitoba Free Press Weekly, June 6, 1887 (130-140); Regina Standard, July 22, 1897 (156); Nor-West Farmer, November 1898, page 499 (215); January 21, 1904 (93); February 5, 1904, page 131 (117); April 20, 1904, page 450 (74).

1880s[33] and the colony type heated breeder for baby chicks appeared after 1900[34], making it possible to raise large numbers of chicks at the same time. The development of mechanical refrigeration also helped, enabling meat to be kept far longer than it could previously have been using ice. The increase in the number of chickens raised per hen was small - from about 1½ to 2½ per year[35]. More important for profitability was the increase in the number of poultry kept per farm, which Census data show as increasing from 24 in 1890 to 57 in 1910.

This thesis considers one composite poultry rearing operation - the keeping of a flock of 20 hens and 2 roosters, with all labour input by the farmer's wife. The inputs and outputs for this operation change somewhat over the period for the same reasons as for other animals - improvements in feeding and organization, and the introduction of pure-bred stock. Table 6.15 shows the cost of poultry stock, and Table 6.19 the feed consumed by the composite poultry raising operation included in the linear programming models, which consisted of a flock of 20 hens, 2 roosters, and the chickens born

TABLE 6.15
Initial Purchase Price of Stock Hens

1880	1890	1900	1910
$0.11[36]	$0.20	$0.35[37]	$1.00[38]

[33] See, for example, the Nor-West Farmer, January 1887, p. 845.

[34] John T. Schlebecker, Whereby We Thrive. A History of American Farming 1607 - 1972. (Iowa: Iowa State University Press, 1975), p. 185.

[35] Farmers' Advocate, October 20, 1900, p. 581; Regina Standard, July 22, 1897; Nor-West Farmer, January 21, 1904, February 5, 1904, p. 131, April 20, 1904, p. 450; H.R. Hare, *Op.cit.*, p. 222.

[36] J.L.Tyman, By Section, Township and Range, (Brandon: Brandon Historical Society, 1972) p. 44.

[37] Edmonton Journal, 10 May 1897, ($0.20 - $0.50).

[38] W.de Gelder, A Dutch Homesteader on the Prairies, (Toronto: University of Toronto Press, 1973) p. 6.

TABLE 6.16
Poultry Feed, by Decade

1880			
Oats	20 hens + 2 roosters	22 x 50 lb	1,100
(etc)	20 x 1-1/2 = 33 chickens for 4 months	33 x 40 lb	1,320
		=	2,420
		/20 hens =	121 lb/hen
1890			
	20 hens, 2 roosters,	22 x 50 lb	1,100
	+ 40 chickens for 4 months	40 x 40 lb	1,600
			2,700
		/20 hens =	135 lb/hen
1900			
	20 hens, 2 roosters,	22 x 50 lb	1,100
	+ 48 chickens for 4 months	48 x 40 lb	1,920
			3,020
		/20 hens =	151 lb/hen
1910			
	20 hens, 2 roosters	22 x 50 lb	1,100
	+ 48 chickens for 4 months	55 x 40 lb	2,200
			3,300
		/20 hens =	165 lb/hen

Table 6.17 shows the amount of labour needed to care for the poultry.

TABLE 6.17

Labour Hours per Hen per Month[39]

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1880	0.33	0.31	0.35	0.79	0.75	0.75	0.72	0.65	0.68	0.81	0.88	0.95
1890	0.34	0.32	0.36	0.79	0.75	0.75	0.72	0.65	0.68	0.82	0.89	0.96
1900	0.36	0.32	0.36	0.79	0.75	0.75	0.72	0.65	0.68	0.83	0.89	0.97
1910	0.35	0.33	0.36	0.79	0.75	0.75	0.73	0.65	0.68	0.83	0.90	0.98

TABLE 6.18

Other Input to Hen Rearing

Hen Coop and Run - Materials $2.00 per hen plus ¼ day of labour.

[39] All labour caring for the poultry is represented in the linear programs as being carried out by the farmer's wife.

CHAPTER 7

AGRICULTURAL PRICES AT THE EXTENSIVE MARGIN

Introduction

This chapter develops estimates of the prices at which potential settlers could have expected to sell their agricultural output. Contemporary newspapers and journals were searched for market reports containing raw price data, from which annual commodity price series were calculated. The spatial patterns of these prices were analyzed, and the patterns found were then used to generate commodity price series for the places at which the farm models were located. Expected future prices were then calculated on the basis of static expectations formed from a weighted average of past prices.

Calculation of Annual Prices

a) Data

The methodology used to calculate the annual prices was to collect weekly market prices on the relevant commodities; to estimate the cross sectional and time series patterns of that raw data; and then to combine the raw prices into weighted annual averages using the patterns found. Since there is little or no information available in secondary sources about local market prices for the Prairies for the late nineteenth Century, all commodity price information was obtained from primary sources. The principal data base used for the comparison of prices consists of weekly price observations on each of a total of 56 commodities for 13 locations during the period 1871 to 1889[1]. The length of the various series obtained ranges from a minimum 14

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[1] Commodities:- Wheat, Oats, Barley, Flax, Peas, Potatoes (Wholesale and Retail), Turnips (Wholesale and Retail), Shorts, Chop, Native Hay, Timothy Hay, Flour, Carrots (Wholesale and Retail), Onions (Farmers', Wholesale and Retail), Beets (Farmers' and Retail), Tomatoes (Retail), Beans (Wholesale and Retail), Wood, Beef (Live, Wholesale and Retail), Pork (Live, Wholesale and Retail), Mutton (Live, Wholesale and Retail), Calves (Live and Retail), Veal (Wholesale and Retail), Lambs (Live and Retail), Ham (Wholesale and Retail), Bacon (Farmers', Wholesale and Retail), Chicken (Wholesale

months for some locations such as Portage, Rapid City, Minnedosa, and Morris, to 19 years for Winnipeg, the principal market. Prices were also collected for Winnipeg and Edmonton for the years 1897, 1898 and 1899 and also 1907, 1908 and 1909. These last data were used in the preparation of the expected prices for 1900 and 1910, but not in the analysis of the spatial variation of prices.

In many communities newspapers were founded surprisingly early on, often when there were only a couple of hundred settlers in the community, and many early Prairie newspapers carried reports on local market prices. A large number of these contemporary newspapers and journals were searched for price information, primarily for the period 1871 to 1889, since that period saw the establishment of the majority of the markets studied. Markets in most commodities sprang up quite quickly after settlement began, and reported prices seem to be representative of actual trading prices. Most goods appear to have been traded for cash through the local market system, although there was a fair amount of trade on credit, with implicit interest charges incorporated in differential prices. There were also occasional comments in the newspapers about barter trade, but the majority of transactions apparently went through the markets. A list of the sources used is given in Appendix 6.

There are several problems with price data collected from newspapers. Some of the prices found had to be disregarded because they were quoted as being "nominal", presumably when there was no trade in that commodity. The basis of such price quotations appears to have been either the last price at which the commodity was traded, or the price at which people expected that it would trade if it were available, and the figures may therefore not have been very meaningful. A likely explanation for the lack of market transactions is that the supply curve

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and Retail), Whitefish (Wholesale and Retail), Butter (Wholesale and Retail), Cheese (Wholesale and Retail), Eggs (Wholesale and Retail) and Wool.

Locations:- Battleford, Brandon, Edmonton, Emerson, Gladstone, Minnedosa, Morris, Prince Albert, Portage-la-Prairie, Rapid City, Stonewall, West Lynne and Winnipeg.

There was an extremely high rate of missing observations in the data set, where no transactions occurred, or they were not reported, or I did not find the report.

had shifted up so far that it no longer intersected the demand curve and therefore none of the commodity was being traded. Such nominal prices were thus either the choke price of the demand curve or possibly some sort of 'traditional price', and did not reflect an authentic exchange value. Any price reports noted as being nominal were omitted from the data set. Nominal prices arose during periods such as August and March, when for most commodities little was marketed. The weighting schemes used give very low weights to prices at these times of the year, and any nominal prices remaining in the weekly times series data will have had little influence on the annual average price.

Another problem is selection bias in the reporting of prices. Figures were occasionally recorded when they were interesting either because of a large change, or because they were unusually high or low. Newspapers also sometimes did not update their market reports for extended periods, evidenced by the lack of any variation in any of the prices. Whilst this may not have been a source of significant bias, it made some of the data unusable for estimation purposes because of collinearity with seasonal dummy variables. Another issue that arose was that some of the price changes over a year would have been due to systematic quality changes. Fresh produce or meat may have been expensive either because it was out of season and scarce, or because the quality was high during that particular season (for example new potatoes). There may also have been systematic quality differentials between locations, due for example to soil conditions. This again is not likely to lead to significant bias in the calculation of the average prices.

There was also a problem due to thin markets. For example the Regina Standard on April 7, 1898 answered a query as to why there was no regular market report with the observation that the market was too small. It noted that the preceding week hay had sold for $12 per ton because of a shortage, so in response "every farmer brought in a load" and the price fell to $6.

Whilst these problems exist in the data, the only one of them which might have led to any systematic bias in the results was the issue of reporting selection bias, which may have affected

individual isolated price observations. In most cases it was not possible to tell whether such bias existed. Any prices which were noted in the newspaper as being unusually high or low were not used in the calculations, which hopefully alleviated the problem. The issue does not arise in the context of a long series of observations, and overall the large numbers of data points should outweigh any problems which this issue might create.

b) Weighting of Observations

The raw price observations were used to generate average annual prices for each commodity for each year and for each location for which data were available. Three different types of weights were used in the calculation of these average prices, as discussed below. The annual prices are intended to be 'producer prices' - the prices which the typical farmer could have expected to receive for his produce in the local market, and the weights used therefore had to take into account firstly the fact that farmers' sales tend to be more seasonal than overall sales, and also the fact that the average quality of produce was not necessarily the highest grade for all commodities.

i) Blending of multiple prices.

The first type of weighting was necessary because many market reports contained more than one price for a particular commodity. These multiple price reports occurred for two different reasons. In the majority of cases the range over which prices for the commodity had varied during the period was being reported, with no implication about the quality of what was being sold. In such cases a simple arithmetic average of the two prices was taken.

In other cases different prices were reported for different qualities of the commodity in

question. For example in the case of wheat, prices for eleven different grades were collected[2]. In such instances, generating a single representative price was more complicated. The systematic relationship between the prices for the different qualities was found by regressing the different price series on each other, wherever there were overlaps. All the different prices for the commodity were then converted to a standard price using the relationships found. In the cases where there were overlapping series, the final price used was a simple arithmetic average of these standardised prices, otherwise the one available (converted) price was used. Details of the methodology used are given in Appendix 7.

ii) Seasonal Quantity Weights.

The second type of weighting adjusted the annual average for the relative quantity sold in each month of the year. Without such a correction, the average price would have implicitly incorporated an equal weighting for each observation, although for example the quantity of grain sold in June was small in comparison to that sold in November. Again the method of constructing the weights is discussed in Appendix 7.

iii) Seasonal Price Weights.

The third weighting adjustment corrected for the seasonal effects of missing data. For example, if for one year there were only July prices for wheat, then failure to adjust those seasonally high prices would bias the annual average upwards. The seasonal pattern of prices appears from the data to differ from one location to another, and different seasonal price weights were therefore used for each location. The details of the methods of estimation and calculation of these seasonal weights are also given in Appendix 7. For several locations it was

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[2] C.B.Piper Principles of The Grain Trade of Western Canada (Winnipeg: The Empire Elevator Company, 1915), pp. 42-43, lists a total of 165 gradings for wheat, 28 for oats, 20 for barley and 13 for flax.

not possible to estimate this seasonality, in which case constant weights had to be used.

The overall effect of this component of the weighting was very small. It was not possible to estimate the seasonality of prices unless I had a sufficiently large number of observations and if I had plenty of observations the adjustment was not necessary. However from a logical standpoint it is a necessary part of the calculation of the annual prices, and was therefore retained in the computer algorithm which calculated the average prices.

Spatial Analysis of Prices

a) The Effect of Connection to the 'National Market'.

In order to be able to calculate representative commodity prices for each of the different farm model locations it was necessary to understand the effects on prices of spatial influences. The most important effect examined was that of connection of a local market to other markets by the construction of a railway. Interestingly, this proved to have an effect quite different to that which one might *a priori* have expected. Prices in four markets (Battleford, Edmonton, Prince Albert and Winnipeg) were traced through the period before and after construction of a railway line. In all four cases the pattern which emerged was that of initially high prices which then fell during the years immediately preceding the construction of the railway.

The effect of access to the national market system was examined statistically by pooling all the original weekly price observations for all locations together, one commodity at a time. The price of each commodity was regressed on a vector of 'semi-structural' independent dummy variables[3]. Four types of dummy variables were used. Eleven monthly dummies were included

[3] More sophisticated analysis was not feasible due to the different pattern of time series observations obtained for different locations. Techniques such as the Generalized Least Squares model or the Cross-sectionally Heteroskedastic and Time-wise Autogressive models described in Kmenta (J.Kmenta, Elements of Econometrics, Second Edition, Macmillan, 1986, pp. 616 to 615) require matched sets of observations for each different cross-sectional unit, and therefore could not be used.

to pick up the seasonal component of prices (with a base month of December). Annual dummies based on the agricultural year (from 1 August to 31 July) were incorporated to allow for shifts in the level of prices from one year to the next. The base period was taken as the 1882/1883 season.

One common dummy was included for all locations which at the date of that observation were not connected to the market system, and an individual dummy was included for each location other than those 'remote' locations, with the base location being Winnipeg. For other Prairie locations, connection to the market was taken to be the existence of a railway station within 25 miles. The principal locations for which observations were found prior to connection to the market were Edmonton, Battleford, and Prince Albert.

Because of less frequent market reports, many of the observations found for the three remote locations were for individual commodities for isolated weeks. Since isolated observations could not be used in the estimation[4], all such observations had to be dropped, which reduced the data set significantly.

[4] The Cochrane-Orcutt method of estimation had to be used because of the presence of significant first order correlation. (Using OLS estimation, Durbin-Watson statistics were of the order of 0.5 to 0.7).

The form of the pooled cross-section time series regressions run for each commodity was :

$$P_{imt} = \alpha_0 + \alpha_1 D(MONTH)_m + \alpha_2 D(YEAR)_t + \alpha_3 D(LOCATION)_i + \alpha_4 DREMOTE + \varepsilon$$

Where:-

P_{imt} is the price of the commodity in month m of year t at location i.

$D(MONTH)_m$ are 11 monthly dummies intended to capture seasonality.

$D(YEAR)_t$ are 13 annual dummies intended to capture shifts in the price level over time.

$D(LOCATION)_i$ are dummies for each location, excluding those which were at that date classified as remote.

DREMOTE is a dummy which takes the value 1 if the price is for a location which at that time was not connected to the national market, and 0 otherwise.

Econometric results for some of the commodities are tabulated in Appendix 8. The coefficient on DREMOTE indicates the extent to which the price of the commodity differed in the remote location from the level in 'connected' locations. The best fit was obtained using a logarithmic specification for the dependent variable, price. Table 7.1 summarizes these effects, and indicates that while the overall average price for wheat in the sample was 67.2c, the average for the remote locations was 145c. The result of this analysis is striking. All commodities except firewood, hay and retail beef were more expensive in locations which were not connected to the market, some by significant amounts.

TABLE 7.1

Effect of Connection to Market System

	Mean of all Observations	DREMOTE Coefficient	(T-Ratio)	Degr.Freedom
Wheat	4.2082	0.7685	(9.8348)*	770
Oats	3.5462	1.2032	(8.9243)*	806
Barley	3.6778	0.6630	(7.3454)*	675
Potatoes	3.8483	0.2749	(1.0893)	621
Flour	5.2685	1.0133	(9.0692)*	581
Hay	6.4368	-0.0235	(-0.1347)	615
Wood	6.0977	-0.5778	(-6.8915)*	554
Beef(retail)	2.5914	0.0412	(0.7471)	251
Pork (retail)	2.7959	0.4813	(10.055)*	177
Butter (wholesale)	3.0100	1.0079	(6.0258)*	758
Eggs (wholesale)	2.9117	0.4080	(3.1670)*	599

(* t-ratio significant at the 99% confidence level)

The annual price data for wheat is graphed in Figures 7.1 to 7.3[5]. These graphs clearly show the extent of the fall in prices, and the way in which the fall occurred before the construction of a railway line. For example, between May and July of 1876 the Winnipeg prices of wheat and barley switched from being the price of an importable commodity (i.e. Toronto price plus freight), to those of an exportable commodity (Toronto price minus freight). The price of oats declined in a similar fashion, but from 1877 remained approximately at the Toronto

[5] Appendix 9 contains similar graphs for oats and barley, which display similar movements.

FIGURE 7.1

Comparison of wheat prices in Toronto and Winnipeg. The Winnipeg price changed from being an 'importable' price to an exportable price in 1876

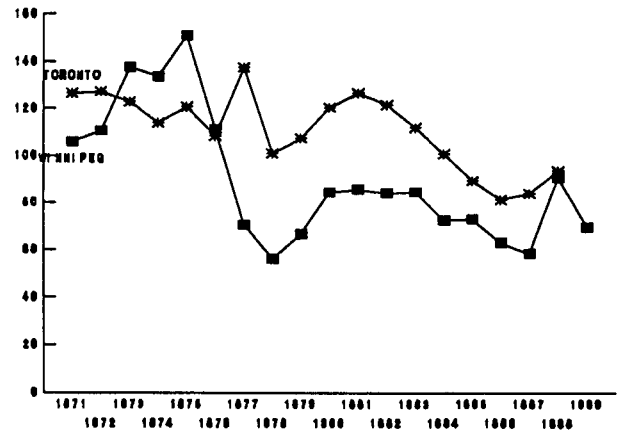


FIGURE 7.2

Comparison of wheat prices in Winnipeg and "Isolated" places. Prices in isolated locations were initially higher than in Winnipeg, but fell *before* the railway connecting that location to the National Market was built, as for Winnipeg in the 1870s.

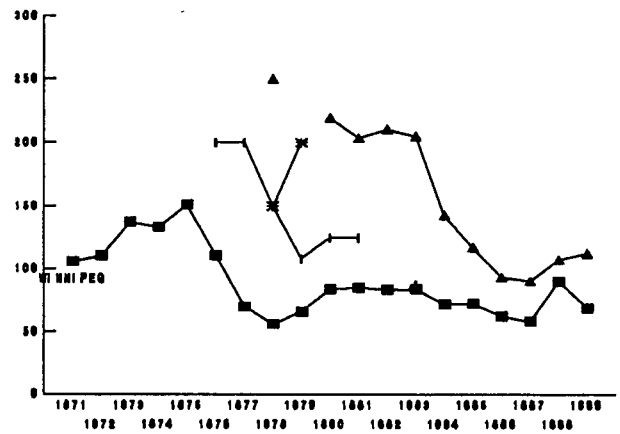
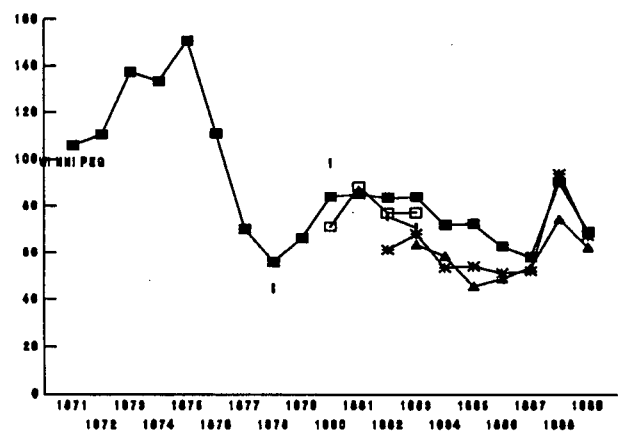


FIGURE 7.3

Comparison of wheat prices in Winnipeg with those in 'nearby' markets, which were already at this time connected by rail with Winnipeg. Nearby prices were highly correlated with those in Winnipeg, and the difference was closely related to transportation costs.



level rather than below it.

It is not clear why the relative structure of Toronto and Winnipeg prices for the three major grain crops changed in 1876. One would *a priori* expect such a change to occur when some new transportation facility was completed, and goods began to move to and fro more cheaply. Once any location was connected to the market, the price range of commodities would have been limited to lie approximately between the export and import prices (i.e. distant market plus or minus freight costs). Prior to that time, the price would have been determined by local market conditions. No such changes in transportation facilities occurred between 1875 and 1877. Winnipeg had been receiving goods via flat bottomed sternwheelers coming down river from towns in the US since 1859, and that continued to be the principal route for imports until 1878[6].

Interestingly, one important change came after the fall in Winnipeg prices, in 1878, when the first external rail link from St.Boniface to the U.S. was completed. In 1875, the Government began construction of the railway from Winnipeg to Fort William, although this proceeded very slowly, so that by 1878 only 76 miles of track had been completed.

The principal reasons for the high prices which prevailed in the remote locations appear to have been high production costs and high demand. In its Market Report for September 17, 1884, the Edmonton Bulletin commented: "Every year (since five or six years ago) the acreage has increased, but in no single year has there been sufficient wheat or barley raised to supply the demand". Demand was high because the markets which did exist in remote locations were in larger towns such as Edmonton and Battleford from which the Government drew supplies both for the Mounties and for treaty payments to the native Indian bands. The most important commodities purchased by Government contract were flour and oats, but some hay and wood were also bought. The demand for flour was met only by importing significant amounts - initially from Eastern Canada and the U.S., and later, once agriculture was well established, from

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[6] John Macoun, Manitoba and The Great North-West, (Guelph: The World Publishing Co., 1882), Chapter 25.

Manitoba.

Persistently high demand cannot explain these high prices without some constraint on supply also. From the 1880 Census we know that the average area of crops per farm in the Territories, including hay, was 21 acres. On average, each farm produced only 228 bushels of all grains, of which only 118 bushels were wheat. This amount would only have yielded about 64 sacks of flour if the wheat were all of sufficient quality, which is unlikely. These quantities would have been sufficient to feed the immigrant population, but were not enough to cope also with the Government contracts as well, many of which were filled with imported flour[7].

One possibility is that the change in the structure of Winnipeg prices between 1875 and 1878 may have reflected anticipation of impending changes in the flow of goods rather than actual changes. The same phenomenon may have occurred in the Edmonton market between 1883 and 1886[8], when the data also show a significant reduction in commodity prices in the remote location. In that case again there was no change in transportation facilities, although much anticipation of impending improvements. Another possible reason for the fall in Winnipeg prices in 1876 is the introduction of improved technology. In favour of this explanation is the fact that all three grain crops show similar declines in price at approximately the same time, suggesting that some factor common to all grain growing might have contributed to the fall. However although this appears feasible, there is no distinct change in technology at that point in time to which one could attribute the drop in prices.

The effect on prices of connection to a railway was therefore treated as a 'switch', which

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[7] See the editorial in the Edmonton Bulletin, March 21, 1885, entitled "Flour", which suggests that whilst there might have been enough flour available to fill a particular 1,400 sack tender for the Indian Department, the quality of the locally ground flour was inadequate, and the order was filled by being "..thrown...into the hands of parties outside the district".

[8] But see the editorial in the Edmonton Bulletin, December 31, 1887, which suggests that the price of flour had fallen because of the "comparative nearness" of the railway (in Calgary, about 175 miles away by cart trail). The prices of beef, pork and dairy produce however had not fallen. A fall in the price of flour due to lower transportation costs would suggest that flour was still basically an 'importable' commodity.

reduced market prices. Once a railway was built physical arbitrage became relatively straightforward, and commodity prices at different locations became integrated into a Prairie market.

There were some commodities for which the Prairies produced an insufficient total quantity, in which case the direction of flow for the commodity would have been be reversed, as would be the price gradient. This was certainly the case for oats, of which there was frequently a deficit on the Prairies. Several references to the importation of oats from Eastern Canada were encountered.

The relationships between the prices at different locations were therefore different for each commodity. The only commodities for which a simple uni-directional export price gradient was relevant throughout the period were wheat, flax and cattle. Even then local demand for wheat and beef sometimes temporarily reversed the flow of those commodities. Towards the end of the period oats and barley also developed export price gradients as output per farm increased. At earlier dates local demand for these exceeded local supply, and the difference had to be made up by imports, or the use of substitutes (such as the use of pasture instead of oats to feed horses).

Other commodities such as potatoes, turnips and hay, were not exported from the Prairies, and there was therefore no systematic price gradient throughout the area. Where there were areas of concentrated demand, such as Winnipeg and Edmonton, the prices of these commodities were higher due to the costs of transportation. The resulting pattern of such prices was therefore a relatively constant price in agricultural areas, determined primarily by costs, with higher prices in the two largest market towns.

b) Effect on Prices of Transportation Costs.

Two types of information were derived from the comparison of annual prices for locations which were connected by a railway. The direction of flow of physical arbitrage was inferred from

TABLE 7.2

Correlation Between Annual Commodity Prices at Different Locations

Commodity	Dates	#Obs	Location 1	Mean	Location 2	Mean	Correlation
Wheat							
-Isolated	1876-81	6	Winnipeg	78.79	Prince Albert	151.39	0.3692
	1880-89	10	Winnipeg	76.18	Edmonton	150.3	0.6889
-Connected	1883-89	7	Winnipeg	72.72	Brandon	63.00	0.8336
	1883-89	7	Winnipeg	72.72	Gladstone	58.03	0.7452
	1883-89	7	Brandon	63.00	Gladstone	58.03	0.9181
	1880-83	4	Winnipeg	84.18	West Lynne	78.50	0.8095
	1899-09	4	Winnipeg	88.46	Edmonton	73.78	0.9536
Oats							
-Isolated	1883-89	7	Winnipeg	33.47	Edmonton	94.87	-0.0544
	1883-89	7	Brandon	26.48	Edmonton	94.87	-0.1848
	1883-89	7	Gladstone	30.97	Edmonton	94.87	0.6155
	1878-81	4	Winnipeg	48.25	Battleford	125.14	-0.4535
-Connected	1883-89	7	Winnipeg	33.47	Brandon	26.48	0.5596
	1883-89	7	Winnipeg	33.47	Gladstone	30.97	0.5102
	1883-89	7	Brandon	26.48	Gladstone	30.97	0.2953
Barley							
-Isolated	1883-89	7	Winnipeg	38.10	Edmonton	66.83	0.1627
	1883-89	7	Brandon	33.16	Edmonton	66.83	0.2884
	1883-89	7	Gladstone	32.76	Edmonton	66.83	0.4810
-Connected	1883-89	7	Winnipeg	38.10	Brandon	33.16	0.2859
	1883-89	7	Winnipeg	38.10	Gladstone	32.76	0.3317
	1883-89	7	Brandon	33.16	Gladstone	32.76	0.3763
Hay							
-Isolated	1882-89	8	Winnipeg	776.44	Edmonton	920.19	0.3764
	1882-89	8	Brandon	751.74	Edmonton	920.19	-0.3756
-Connected	1882-89	8	Winnipeg	776.44	Brandon	751.74	0.1981
Potatoes							
-Isolated	1878-85	8	Winnipeg	67.03	Edmonton	92.24	0.6732
-Connected	1884-88	5	Winnipeg	45.45	Brandon	36.15	0.4663
	1884-88	5	Winnipeg	45.45	Gladstone	30.36	0.7200
	1884-88	5	Brandon	36.15	Gladstone	30.36	0.9088
Flour							
-Isolated	1883-86	4	Winnipeg	176.19	Edmonton	639.34	0.7690
	1883-86	4	Brandon	241.25	Edmonton	639.34	0.8343
	1883-86	4	Gladstone	212.54	Edmonton	639.34	0.9148
-Connected	1883-86	4	Winnipeg	176.19	Brandon	241.25	0.8864
	1883-86	4	Winnipeg	176.19	Gladstone	212.54	0.6016
	1883-86	4	Brandon	241.25	Gladstone	212.54	0.8569

TABLE 7.2 (Contd.)

Correlation Between Annual Commodity Prices at Different Locations

Commodity	Dates	#Obs	Location 1	Mean	Location 2	Mean	Correlation
Wood							
-Isolated	1882-89	5	Winnipeg	535.52	Edmonton	270.18	0.0957
	1882-89	3	Brandon	692.45	Edmonton	283.60	-0.6879
-Connected	1882-89	4	Winnipeg	586.40	Brandon	655.32	0.8991
Live Beef							
-Isolated	1899-09	4	Winnipeg	3.34	Edmonton	3.15	0.4024
-Connected	1883-89	5	Winnipeg	4.08	Brandon	3.86	0.5298
Wholesale Beef							
-Connected	1882-89	7	Winnipeg	7.62	Brandon	6.75	0.9303
	1882-89	3	Winnipeg	7.52	Gladstone	6.99	0.9105
	1882-89	3	Brandon	6.33	Gladstone	6.99	0.9474
Live Pork							
-Isolated	1899-09	4	Winnipeg	5.65	Edmonton	5.20	0.9790
-Connected	1882-89	3	Winnipeg	7.52	Brandon	6.33	0.9949
	1882-89	3	Winnipeg	7.52	Gladstone	6.99	0.9105
	1882-89	3	Brandon	6.33	Gladstone	6.99	0.9474
Wholesale Pork							
-Connected	1882-89	6	Winnipeg	7.41	Gladstone	8.99	0.8684
Wholesale Mutton							
-Connected	1882-89	5	Winnipeg	10.84	Brandon	9.84	0.5503
Wholesale Butter							
-Connected	1882-89	5	Winnipeg	21.78	Brandon	21.24	0.6744
-Isolated	1882-89	7	Winnipeg	21.66	Edmonton	45.84	0.8178
	1882-89	7	Brandon	22.21	Edmonton	43.19	0.8192
Wholesale Eggs							
-Connected	1884-89	6	Winnipeg	20.09	Gladstone	16.75	0.8234
-Isolated	1884-89	6	Winnipeg	20.09	Edmonton	40.59	0.8777
	1884-89	6	Gladstone	16.75	Edmonton	40.59	0.8036

a comparison of the means of the prices,on the assumption that the price differential between connected markets was due to transportation costs. The extent of physical arbitrage was also inferred from the degree of correlation between the pairs of prices.

The correlation between prices at different locations is shown in Table 7.2. Correlations reflect both arbitrage through direct transportation between the two markets (and through the switching of deliveries from intermediate production areas) and common production conditions created by similar weather patterns in different areas.

For wheat, as one would expect, the mean price in Winnipeg was always higher than prices in connected outlying areas, and the correlation coefficients for prices in connected markets were high. This result confirms that any movement of wheat would have been into Winnipeg, and that there was sufficient movement to result in a high correlation of prices. The majority of the wheat grown on the Prairies was exported from the area via the Lakes, which induced a fairly predictable price gradient determined within the Prairies by railway transportation costs. This physical arbitrage is the source of the correlation coefficient of 0.95 between Winnipeg and Edmonton wheat prices in the period 1899 to 1909, with the price difference of 15c being attributable to transportation costs.

Between 1876 and 1881 the correlation between Winnipeg and Prince Albert wheat prices was 0.37, although Prince Albert prices were approximately double those at Winnipeg. It is unlikely that any wheat other than a small amount of seed grain was moved from Winnipeg to Prince Albert at that time, and almost certainly none travelled in the opposite direction. The correlation of 0.37 is therefore presumably induced by the similarity of weather conditions.

Oat prices also demonstrate that the commodity flowed into the city market in Winnipeg, but the correlation coefficients are lower, suggesting that the proportion of the oat crop being moved was probably far lower. Oat prices in Edmonton between 1883 and 1889 were almost three times the level prevailing in Winnipeg, and were negatively correlated with Winnipeg prices. Small amounts of oats were moved from Winnipeg to Edmonton, which did not produce enough for local animal feedstuff needs. However the cost of transportation 822 miles by railway and 200 miles by wagon, and the erratic pattern of deliveries, would have prevented any systematic physical arbitrage.

Similarly barley, which was used primarily as an animal feedstuff, moved into Winnipeg, but in that case the correlation coefficients are even lower, at around 0.3, indicating that an even smaller proportion of the crop was moved. At these low levels, a substantial proportion of the correlation may again have been due to the similarity of the weather patterns in the different

places.

Hay prices show only a 0.20 correlation between Winnipeg and Brandon, although the levels are similar. Again any correlation of Winnipeg and Edmonton would have been due to corresponding weather patterns rather than physical arbitrage. All available flour prices in the period 1883 to 1886 show correlations of 0.6 or more. However in this instance there is a clear price gradient with prices rising with distance from Winnipeg. The only flour mills on the Prairies at that time were in Winnipeg, which therefore enjoyed the lowest prices. Meats generally show a price gradient into Winnipeg due to physical arbitrage. Eggs and butter show a high degree of price correlation, even between Manitoba and Edmonton in the 1880s when there cannot have been any physical arbitrage.

Calculation of Prices for Models

a) Prices

The spatial analysis of prices demonstrates that whilst some local commodity prices were determined by arbitrage with the Winnipeg market, other prices were independent. The local market prices used in the linear programming models were calculated on the basis of the spatial relationships found. Only wheat was treated as being an export commodity throughout the period from 1880 to 1910, with local market prices being calculated by taking the Winnipeg price and deducting rail transportation costs. The Winnipeg price would have reflected the cost of handling each commodity between the market and the station, and therefore it was realistic to deduct only net rail transportation costs from the Winnipeg price to arrive at local market prices. The freight charge deducted was not the cost of local freight to Winnipeg, but the difference between the cost of carrying wheat from that point to Port Arthur and the cost of moving wheat from Winnipeg to Port Arthur.

Costs of transporting other commodities were higher. Local freight charges, which were

proportionately higher than the long distance rates, had to be paid on these goods, and also the extra costs of moving the goods from the station at Winnipeg to the market. The difference between the city price for such a commodity and that prevailing in the agricultural areas therefore had to be greater than that for wheat.

Prices in both the Edmonton and Battleford markets were high for most commodities in the period prior to the construction of railway lines. However one of the principal reasons for the growth of both of these places in the 1870s was the fact that they lay on the originally planned route of the Canadian Pacific Railway main line. It was only the still inadequately explained decision by the CPR in 1882 to run the line through Calgary which left Edmonton without a line for another decade, and Battleford isolated until 1905. Long run expected commodity prices for those two places were calculated for 1880 on the basis of the (subsequently invalidated) expectation that the CPR main line would follow the originally intended route. Markets in such places as Calgary, Moose Jaw, Medicine Hat and Swift Current, which did end up on the revised route, had not developed prior to the construction of the main line. Prices in those locations, and in other places for dates at which no development had taken place, are incorporated in the models as the prices in the nearest functioning market. However the potential settler considering such a location had to allow for the large amount of time needed to transport the produce to that distant market.

b) Formation of Expectations

Potential settlers, in deciding whether to take a Prairie homestead, would have had, either implicitly or explicitly, to form expectations of the prices at which they would buy their inputs and sell their output. The precise mechanism by which such expectations were formed is of course not observable, and would have varied across individuals. Most econometric analysis in this area has been concerned with the formation of short run forecasts, rather than long run expectations. A settler making the decision to move to the Prairies was making a long run commitment based

on a projection which must have been at least implicitly extended many years into the future. It is likely that expectations were formed carefully, given the information available, even if the eventual move was a gamble.

Nerlove[9] points out an important distinction to be made in the analysis of the formation of expectations. He observes that there are really two distinct types of changes in prices :-

"(1) a change expected to be only temporary ... which has no effect on entrepreneurs' notions concerning the *level* of future prices; and

(2) a change which affects entrepreneurs subjective notions of the level of future prices."

Hicks[10] defines "the elasticity of a particular person's expectations of the price of a commodity *x*" as "the ratio of the proportional rise in expected future prices of *x* to the proportional rise in its current price." It is not possible to explicitly estimate this elasticity, and it may well be different for the case in point from the instance which Hicks or Nerlove envisaged. A decision to adjust acreage between crops on an existing farm can be reversed relatively costlessly. In contrast, a move to a Prairie homestead, whether from the Eastern seaboard or from Europe, was far more difficult to reverse. Almost inevitably most or all of the capital expended in moving to and establishing the farm would be lost, as would be several years of earnings.

The formation of price expectations is different to that of yield expectations, which is discussed in Chapter 4. In the case of yields, there would have been little *a priori* reason to anticipate significant long-run trends other than those due to factors under the control of the farmer, such as the introduction of new seeds. A moving average was therefore appropriate for the formation of yield expectations, giving equal subjective weights to each of the preceding observations. However for the formation of price expectations, it is logical to put greater

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[9] M. Nerlove, The Dynamics of Supply: Estimation of Farmers' Response to Price, (Baltimore: The Johns Hopkins Press, 1958), p. 45.

[10] J.R. Hicks, Value and Capital, (Oxford: 1946), p. 205, cited by Nerlove, (*op. cit.*), p. 52.

emphasis on more recent information, because of the possibility of market changes outside the control of the farmer, which could lead to permanent changes of price levels, or to continuing trends.

Even with the nineteen years of continuous grain prices for Winnipeg, no consistent time series pattern useable for predictive purposes could be found in the data other than that captured by the previous years' price[11]. A one year projection formed in this manner is however clearly not realistic for use over a twenty year period.

With no useful econometric methodology for the estimation of the unobservable formation of long run expectations, expected prices have been calculated using a simple ad-hoc three period distributed-lag formulation, according to the equation :-

Expected Price at time t = $0.5P_{t-1} + 0.3P_{t-2} + 0.2P_{t-3}$

This formulation is intended to represent the concept of putting the greatest emphasis on more recent price information when forming expectations. Only three lags are used since there is relatively little additional information about future prices in the prices prevailing more than three years previously. Using this equation, expected prices for all commodities were calculated for the Winnipeg market. The expected price of wheat at each Prairie location was then calculated from the base of the calculated expected price of wheat at Winnipeg.

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[11] Generally a good econometric 'fit' of the data could be obtained for the Winnipeg price series for the principal commodities for the period 1871 to 1889 from an ARIMA model with no more than a one period lag. This type of model however can represent only a very short run forecast, and would not reflect the concept of the 'normal' price to which Nerlove refers. The results of these ARIMA models are therefore not reported.

TABLE 7.3

Expected Prices of Wheat (cents per bushel) at Farm Locations

Location	1880	1890	1900	1910
Brandon	61(RE)[12]	72	61	99
Indian Head	56(RE)	69	59	96
Scott	52(I)	64(I)	56(I)	90
Lacombe	51(I)	63(RE)	54	91
Lethbridge	52(I)	66	56	93

TABLE 7.4

Expected Prices of Oats (cents per bushel) at Farm Locations

Location	1880	1890	1900	1910[13]
Brandon	36(RE)	32(RE)	27	41
Indian Head	36(I)	32(RE)	27	39
Scott	36(I)	32(I)	27(I)	35
Lacombe	36(I)	32(RE)	27	36
Lethbridge	36(I)	32	27	37

TABLE 7.5

Expected Prices of Barley (cents per bushel) at Farm Locations

Location	1880	1890	1900	1910[14]
Brandon	44(RE)	32	29	49
Indian Head	44(I)	32	29	47
Scott	44(I)	32(I)	29(I)	42
Lacombe	44(I)	32(RE)	29	43
Lethbridge	44(I)	32	29	44

[12] (RE) - Railway Expected. If a railway was constructed to a location within one year (three years in the case of the initial Canadian Pacific main line), I assumed that potential settlers knew in advance, and formed their expectations of future prices accordingly, on the same basis as for towns which were already served by a railway.

[13] Systematic export market based off the Winnipeg price, as for wheat.

[14] Systematic export market based off the Winnipeg price, as for wheat and oats.

TABLE 7.6

Expected Prices of Flax (cents per bushel) at Farm Locations

Location	1880[15]	1890	1900	1910
Brandon	90(RE)	75	73	112
Indian Head	86(I)	72	70	110
Scott	80(I)	69(I)	67(I)	105
Lacombe	78(I)	67(RE)	66	105
Lethbridge	80(I)	70	68	107

TABLE 7.7

Expected Prices of Potatoes (cents per bushel) at Farm Locations

Location	1880	1890	1900	1910
Brandon	38(RE)	32	28	46
Indian Head	38(I)	32	28	46
Scott	38(I)	32(I)	28(I)	46
Lacombe	38(I)	32(RE)	28	46
Lethbridge	38(I)	32	28	46

TABLE 7.8

Expected Prices of Turnips (cents per bushel) at Farm Locations

Location	1880	1890	1900	1910
Brandon	20	25	15	33
Indian Head	20(I)	25	15	33
Scott	20(I)	25(I)	15(I)	33
Lacombe	20(I)	25(RE)	15	33
Lethbridge	20(I)	25	15	33

[15] All flax prices are calculated on the basis of a systematic export price gradient. Transportation costs for flax were significantly higher than for other grains. Small amounts were carried in lined sacks, and had to pay higher rail freight rates because of the small quantities. When a larger amount, sufficient for a railway car load was to be transported, the car had to be completely cleaned out and all cracks stopped up to prevent the slippery grains from leaking out.

TABLE 7.9

Expected Prices of Native Hay (cents per ton) at Farm Locations

Location	1880	1890	1900	1910
Brandon	700(I)	700	550	850
Indian Head	700(I)	700	550	850
Scott	700(I)	700(I)	550(I)	850
Lacombe	700(I)	700(I)	550	850
Lethbridge	700(I)	700(I)	550	850

TABLE 7.10

Expected Prices of Cultivated Hay (cents per ton) at Farm Locations[16]

Location	1880	1890	1900	1910
Brandon	0	950	710	1190
Indian Head	0	950	710	1190
Scott	0	950(I)	710(I)	1190
Lacombe	0	950	710	1240
Lethbridge	0	950	710	1240

TABLE 7.11

Expected Prices of Live Beef (cents per pound) at Farm Locations[17]

Location	1880	1890	1900	1910
Brandon	4.33(RE)	3.07	2.88	2.94
Indian Head	4.25(I)	3.02	2.84	2.90
Scott	4.18(I)	2.95(I)	2.78(I)	2.80
Lacombe	4.17(I)	2.93	2.76	2.81
Lethbridge	4.18(I)	2.98(RE)	2.79	2.84

[16] Cultivated hay was not marketed on the Prairies in 1880.

[17] Live beef is treated as being an export commodity throughout the period. Once a town was connected via a railway line to Winnipeg, livestock prices acquired a price gradient to Winnipeg, which was the principal market on the Prairies at that stage. The gradient reflects gross transportation costs, rather than net. Prior to the construction of a nearby railway, animals had to be driven on the hoof to the nearest railway, for which a 'speed' of 14 miles per day is incorporated in the linear programming models.

TABLE 7.12

Expected Prices of Live Pork (cents per pound) at Farm Locations[18]

Location	1880	1890	1900	1910
Brandon	4.85(RE)	4.83	4.32	5.57
Indian Head	0(I)	4.83	4.32	5.53
Scott	0(I)	0(I)	0(I)	5.43
Lacombe	0(I)	4.83	4.32	5.44
Lethbridge	0(I)	4.83	4.32	5.47

TABLE 7.13

Expected Prices of Live Mutton (cents per pound) at Farm Locations[19]

Location	1880	1890	1900	1910
Brandon	5.48	4.58	3.00	5.19
Indian Head	0(I)	4.58	3.00	5.14
Scott	0(I)	0(I)	0(I)	5.04
Lacombe	0(I)	4.58	3.00	5.06
Lethbridge	0(I)	4.58	3.00	5.09

TABLE 7.14

Expected Prices of Wholesale Chicken (cents per pound) at Farm Locations[20]

Location	1880	1890	1900	1910
Brandon	7.50	11.00	9.50	12.50
Indian Head	0(I)	11.00	9.50	12.50
Scott	0(I)	0(I)	0(I)	12.50
Lacombe	0(I)	11.00(RE)	9.50	12.50
Lethbridge	0(I)	11.00	9.50	12.50

[18] Live pork is treated as being used for domestic consumption for the period prior to 1910, and no market therefore existed. For 1910, all locations connected to Winnipeg by railway line are treated as exporting livestock to the market at Winnipeg, and a price gradient reflecting gross transportation costs is therefore reflected in local prices.

[19] Mutton prices at different locations for each period are treated here as being interrelated in the same pattern as pork prices.

[20] Chicken is treated as being a local consumption good only, throughout the period.

TABLE 7.15

Expected Prices of Wholesale Butter (cents per pound) at Farm Locations[21]

Location	1880	1890	1900	1910
Brandon	19.60(RE)	13.50	12.50	18.40
Indian Head	0(I)	13.50	12.50	18.40
Scott	0(I)	0(I)	0(I)	18.40
Lacombe	0(I)	13.50	12.50	18.40
Lethbridge	0(I)	13.50	12.50	18.40

TABLE 7.16

Expected Prices of Wholesale Eggs (cents per dozen) at Farm Locations[22]

Location	1880	1890	1900	1910
Brandon	22.00(RE)	16.20	15.90	20.00
Indian Head	0(I)	16.20	15.90	20.00
Scott	0(I)	0(I)	0(I)	20.00
Lacombe	0(I)	16.20(RE)	15.90	20.00
Lethbridge	0(I)	16.20	15.90	20.00

[21] Butter is treated as being a local consumption good only, throughout the period.

[22] Eggs are treated as being local consumption goods only throughout the period.

CHAPTER 8

RESULTS

Construction of Programs

Using the information outlined in the preceding five chapters, linear programs were prepared to represent 20 hypothetical Prairie farms. Five different locations were chosen to depict distinct geographical areas - Brandon (Manitoba), Indian Head (Saskatchewan), Scott (Saskatchewan), Lacombe (Alberta) and Lethbridge (Alberta)[1]. For each of these locations four analyses were run, to represent farms first started in 1880, 1890, 1900 and 1910. In each case, the model was built to represent a farm started on previously untouched land. The results therefore should not be interpreted as portraying the evolution of the value of a farm which was first started in 1880, viewed again one, two or three decades later. Such values would be greater than those calculated by the models due to the investment in land, buildings, stock and equipment which would have occurred over each succeeding decade.

The purpose of each program was to calculate the capitalized rental value of the particular farm. The linear program calculates a value for net profit, without deductions for the costs of any fixed inputs. These values include returns to land, labour and capital, and therefore the opportunity costs of the farmer's own labour and capital must be deducted to obtain the value of the land.

The calculated values are static in the sense that they are meant to portray the instantaneous worth of the farm envisaged by the hypothetical settler considering taking the land at that point in time. However the calculations involve an intertemporal problem, since it took the new settler several years to break in the tough Prairie soil, and he could only sow crops on land which had previously been broken. Hence each year the settler faced the question of how

[1] These locations were chosen both because of their geographical separation and also the availability of good crop seasonality data from the Experimental Farms Reports.

much of his scarce time to spend on breaking in land, as opposed to immediate revenue-earning agricultural activities.

Each linear program is assembled from a series of annual sub-programs which differ from each other principally by the amount of broken land which is carried forward from one year to the next. In the literature, there is discussion of settlers taking ten or more years to break in a farm. I think that such references are generally to farms which initially had significant areas covered with trees[2]. Due to the difficulty of representing different qualities of land within a farm, the intangible nature of the issue of how much wooded area to allow and the subsequent problem of comparability of the results, I decided not to include in the models any area which needed clearing of anything heavier than bush or scrub. Every farm is assumed to have some land which was completely unsuitable for agricultural production and some which was good only for native pasture, but other than that all land within each farm was treated as being of equal quality[3].

The programs for the 1880 and 1890 homesteads were given a maximum of seven years to break in their land, while those for 1900 and 1910 were given only five years. For all the programs run, the analyses predicted that the farm would by the fifth year have already reached the full area at which it would be operated until the twentieth year (at which point a son joined the labour force, further increasing the area of land cropped). This estimated duration for the operation of breaking in the farm may be somewhat shorter than what in fact commonly occurred, since it was not feasible to apply a cash flow constraint to the models[4]. The programs

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[2] See Chapter 4, section a for a discussion of the issue of tree clearing costs.

[3] The land in different geographical areas is allowed to differ in the models through the variation of yields.

[4] Many farmers faced cash flow constraints which forced them to spend more time on revenue earning activities in the early years than the programs indicate, although the difference in the capitalised values of the farms does not appear to be significant. Imposition of a cash flow constraint involves the calculation of a net cash flow. Since that is also the objective function, the linear programming problem becomes computationally indeterminate.

may therefore represent settlers as spending more time breaking land in the first few years than they could in fact afford to. Many were very short of capital at first, and had to put as much time as possible into raising cash crops. The overall effect of this was possibly to increase the calculated values of the farms slightly, although the possible divergence is in fact quite small over the full value of the models, and does not materially affect the overall results. Also the values of the 1880 and 1890 farms, prior to the availability of breaking using steam traction plowing, would have been increased proportionately more than those for 1900 and 1910, thereby biasing against overestimation of the increase in farm values.

In each program, the first year is set up to give the settler a very limited set of options. He is assumed to arrive in mid-May, and to have only a short period during that first summer to break in land, before having to stop in the middle of June. The programs offer the settler the option of planting some flax in that year, but that option was not taken up in any of the solutions. During the first summer the settler broke in as much land as possible, cut some native hay, worked to build a shelter for the coming winter, and then backset the broken land.

After the first year, the programs offer the settler a similar problem in each year, the only changes being the gradual build-up of the area of useable land, the change from oxen to horse power in the fourth or fifth year, and then in the twenty-first year the addition of an adult son to the farm labour force[5]. Each year of the programs contains from 130 to 230 variables and 93 to 120 constraints. A program assembled from more than five such annual sub-programs exceeded the size limitations of the LIP software package on the UBC mainframe computer, forcing the reduction of the scope of the programs. This reduction was achieved without excessive loss of accuracy by the inclusion of only a single representative year for each of the 'phases' of the growth of the farm. After the first year, the programs for 1880 and 1890 include one representative year typical of the problem facing the farmer during years 2, 3 and 4, whilst

[5] See Chapter 5 for the reason for the addition of a son to the farm labour force in the 21st year.

he was still using oxen. Another typical year covered years 5 and 6, after he had switched to horse power, and then another represented years 7 to 20, after all the land which the farmer could subsequently use had been broken in. A final representative year covered the period from year 21 to year 40, during which the farmer had a son also working on the land.

The amount of land permitted for the farmer to crop in each representative year incorporates approximately the correct area of broken land for the midpoint of that period - i.e. for the representative year for years 2 to 4, he is allowed all the land broken in years 1 and 2 only. For the year representing years 5 and 6, he is allowed all land broken up to year 4, plus half of the area broken in year 5. Since the farmer had the option of contract breaking in 1900 and 1910, farms were developed more quickly, with the breaking in period including only the period preceding year 6. For the 1900 and 1910 models therefore only four 'phases' are included in the programs - year 1, 2 to 5, 6 to 20 and 21 to 40.

The choice of motive power affected all the productivities in the models, and therefore influenced the program in a comprehensive manner. Given that the programs were already close to the feasible size limits it was necessary to specify both the type (oxen versus horses) and amount of motive power used on the farms in all the programs. For similar reasons, it was also not feasible to get the programs to calculate integer values for the numbers of livestock kept. Restrictions were applied to prevent the programs selecting numbers of young animals in excess of the reproductive capabilities of the older livestock, but many of the solutions contain non-integer numbers of cows and pigs. Some checks were made on the ramifications of these inaccuracies, by using the shadow prices to reduce or increase the number of animals to an integer value, adjusting other livestock numbers to prevent violation of the time, feed, manure and reproductive constraints. In all cases the difference to the overall values was trivial, and I do not consider that the non-use of integers presents a significant problem of inaccuracy in the results.

No deduction was made from the calculated values for the effects of any direct taxation. An interest rate of 8% was used to discount future values, since that appears to be a reasonable median rate for long term borrowing rates during this period[6]. The most important justification for the use of this rate is that it was the rate charged by the CPR on its land sale mortgages. Short term loans of working capital often carried higher rates of interest, but these formed a small proportion of financial transactions.

One typical program, that for Brandon for the year 1900, is included as Appendix 13.

Adjustments to Values Calculated by Linear Programs

a) Capital Costs

The values calculated by the linear programs were gross, without any deductions for the capital costs necessary to establish the farms. The first adjustment to be made to the calculated values was therefore to deduct for those fixed costs. The total amount deducted for the fixed costs differs for each date and between a farm run for 20 and 40 years. It also varies depending on the way in which the farm evolved, in that if the cultivated area of the farm exceeded the initial amount of land available, then additional land would have had to be bought. In those circumstances, allowance was made for the purchase of an extra 160 acres from adjacent railway grant land. Appendix 13 contains the breakdown of the fixed costs for a typical 1900 farm, and Table 8.1 below summarizes the fixed costs for all cases.

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[6] For example:- The Weekly Manitoban, (Winnipeg) 13 May 1871 noted that the mortgage rate was unchanged at 7 to 8%. In the Manitoba Free Press (Weekly) on 19 May 1877 an advertisement for Woods Reapers and mowers offered credit at 7%. The Farmer's Advocate November 1877 noted (p. 250) : "Money is worth 8%". An advertisement in the Brandon Weekly Mail on 25 February 1886 offered money to loan at 8%. On 1 February 1883 the market report in the Manitoba Free Press noted that the rate for loans on improved farms ran from 9 to 10%. On 26 December 1883 the same paper noted that the rate on first class mortgages was 8 to 10%. On 1 January 1887 an advertisement in the Manitoba Free Press by the Trust and Loan Co. of Canada offered money on the security of improved farms at 8%. The Brandon Sun, 1 December 1887, noted that the discount rate at banks had been at 7%, but was back up to 8%. The Farmer's Advocate, 21 September 1904 notes that farmers' first mortgages were at that stage running from 6½ to 7%, with short date paper at 8%. On 24 January 1905 (p. 114) the Farmers' Advocate noted that while manufacturers were borrowing from banks at about 6%, they tried to get 9% from farmers on credit from implement sales.

TABLE 8.1

Summary of Capital Costs

	1880	1890	1900	1910
20 years operation:				
No extra land:	2285	2192	1866	2843
With extra 160 acres:	-	-	2081	3939
40 years of operation:				
No extra land:	2972	2993	2401	3631
With extra 160 acres:	-	-	2616	4727

b) The Opportunity Cost of Settlers' Labour

Since all of the calculated farm values include the returns to both land and labour, the opportunity cost of the settler's labour must be deducted in order to arrive at the correct value of the decision to take a homestead. Settlers came from a wide variety of places and occupations, and there would have been great diversity of alternative opportunities foregone. However a large proportion of migrants to the Prairies are believed either to have started their journeys in eastern Canada, or to have stopped and worked there for some period of time before continuing on to the Prairies. A reasonable order of magnitude for a lower bound to a suitable opportunity cost can therefore be ascertained by using the capitalised value of an agricultural labourer's wages in eastern Canada. The work of Green and Green[7] would suggest that in fact the immediately preceding location of the majority of Prairie settlers was Ontario or Quebec.

Information on earnings of agricultural workers in eastern Canada is sparse. In 1885 the Farmer's Advocate[8] noted that labourers in Ontario were earning $1.25 per day in summer, and

[7] Greene A.G. and Greene, D.A. Balanced Growth and the Geographical Distribution of European Immigrant Arrivals to Canada, 1900-1914. Paper presented at the 16th Conference on the Use of Quantitative Methods in Canadian Economic History, University of Toronto, March 1989.

[8] Farmer's Advocate (Eastern Edition), January 1885, p. 12.

$1.00 per day for the rest of the year, plus their board, which the Farmer's Advocate valued at 25¢ per day. If the labourer found a full 50 weeks work a year, and worked 6 days a week, with summer running from 1 April to 31 October[9], this would translate into the high annual income of $414. Another article in the same journal[10] noted that farm hands could earn $30 to $35 per month in the summer, but that there was little work for the rest of the year. That would suggest that an annual wage of about $230 (7 months at $32.50) might be closer to an accurate figure for the 1880s, but that figure would appear to exclude the value of board and lodging. Between 1883 and 1905 the Parliamentary Sessional Papers contain periodic reports from the Immigration agents at several eastern Canadian cities. An 1883 report from the agent in Montreal reported that farm labourers in that area were earning between $15 and $25 per month, "and board". The agent in Hamilton reported that farm labourers near that city were making about $15 per month, plus board and lodging. Using a figure of $3.00 per week as above for the value of the board and lodging, allowing $18 per month, and assuming that labourers found work 70% of the time, average annual earnings in the early 1880s would have come to $260.

For 1890, the Farmer's Advocate[11] noted that hired help cost $20 or more per month. The reports of the Immigration agents give figures of $120 to $160 per year without board for Toronto[12], from $120 to a maximum of $200 per year for Hamilton[13], and $12 to $18 per month for Ottawa[14]. A reasonable average of these figures would appear to be $235 per year, after allowing for board and lodging at $3.00 per week, and 30% unemployment. In 1899 the

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[9] These dates for summer wages are noted in the Sessional Papers Vol.23, 1890, Number 6, Report of the Minister of Agriculture, Appendix 9, Report of the Immigration Agent for Hamilton, Ontario.

[10] Farmer's Advocate (Eastern Edition), May 1885, p. 133.

[11] Farmer's Advocate, January 1890.

[12] Canada: Sessional Papers Volume 23, 1890, Number 6, Appendix 8.

[13] *Op.cit.*, Appendix 9.

[14] *Op.cit.* Appendix 6.

Immigration agent for Montreal reported[15] that farm labourers in that area were earning about $10 to $15 per month. In 1900 he reported the same figure[16], adding that they also received board and lodging which he valued at $3.00 to $3.50 per week. This would put earnings at the turn of the century at about $225 per year for a full years' work, allowing for 30% unemployment.

The reports of the Immigration agents ceased after 1905. The last value reported in that year by the Montreal agent[17] was $10 to $20 per month, plus board and lodging worth $3.00 to $4.00 per week, suggesting a figure for annual earnings of about $250 for full time work, with a unemployment rate of 30%.

In round numbers we therefore have annual gross earnings of $260 for 1880, $235 for 1890, $225 for 1900 and $250 for 1910. A fall in wages during the depression of the late 19th Century would seem to be entirely plausible, although the paucity of these data could not be used to support such a hypothesis. Before deducting these opportunity values from the calculated farm values, it is necessary first to capitalize the sum of the potential migrant's future earnings. There are no data available on the average age of migrants, and two different calculations of farm values are available - the value to 20 years, with only the labour of the farmer and his wife, and a value to 40 years with the addition of a grown son to the labour force. Two different farm values are therefore calculated here: a value for 20 years of operation, with only the farmer's own labour; and a value to 40 years with the additional labour of a son, but with the opportunity value of the son's time deducted. Using the same interest rate of 8% as was used for the calculation of the linear programs, the following capitalised opportunity values were calculated:-

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[15] Canada: Sessional Papers Volume 33, 1899, Number 13, Appendix 4.

[16] Canada: Sessional Papers Volume 34, 1900, Number 10, Appendix 4.

[17] Canada: Sessional Papers Volume 39, 1905, Number 25, Appendix 3.

TABLE 8.2

Opportunity Costs of Labour

	1880	1890	1900	1910
Farmer only - 20 years	$2757	$2492	$2386	$2651
Farmer plus son - 40 years	$3940	$3561	$3409	$3788

These sums were then deducted from the calculated farm values, allowing for additional years of the appropriate revenue for the 40 years of operation by the farmer alone. The greater of the two calculated residual values was then taken, since the addition of a son to the farm labour force was entirely optional, and could not reduce the real net value of a farm.

Output of Programs

Table 8.3 summarises the calculated net values of the farms.

TABLE 8.3

Summary of Net Farm Land Values[18]

	1880	1890	1900	1910
BRANDON	(1434)[19]	367	2674	9462
INDIAN HEAD	(3172)	(1522)	1111	9325
SCOTT	(3447)	(2101)	(932)	6949
LACOMBE	(2166)	(1537)	241	7424
LETHBRIDGE	(3430)	(226)	1907	8696

Tables 8.4 to 8.8 summarize the output of the 20 programs run. Two alternative values are tabulated for each farm at each date. The first is the capitalised net revenues for a farm operated by a farmer and his wife only, for a total of 20 years from the date of settlement. As an alternative, the second value tabulated adds an additional 20 years of operation, during which one now adult son worked on the farm as well. Whilst this addition doubled the field labour force, the substantial discounting of the delayed revenues, the necessity of deducting the opportunity value of the son's time, the purchase of the additional equipment needed by the son, and in some instances also the purchase of additional land, reduced the effect on the value of the land significantly.

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[18] Calculated on the basis of the capitalized gross value of the farm over a 20 year operating period, less the amount which the settler could have expected to earn as a farm labourer in eastern Canada for the same 20 year period. No costs have been deducted for the move from eastern Canada to the Prairies.

[19] Brackets around figures in this table signify that the calculated value was negative.

The results which I believe to be most pertinent to each date are those relating to the period of operation of the farm up to its twentieth year, since in a period of increasing settlement proportionately more of the farms at each date will have been formed during the preceding 20 years than in the preceding 40 years. The period from the twentieth to the fortieth years is included primarily to account in the models for the presence in the Census data for 1880 and 1890 of 'farmers' sons', who were a part of the aggregate agricultural labour force, but could not realistically be allocated equally to all farms. The capitalized values shown are those after the deduction of capital costs of buildings, equipment and land.

TABLE 8.4
Summary of Linear Program Output
Brandon

YEAR	1880	1890	1900	1910
Capitalized Value:-				
- To year 20	($1434)	$367	$2674	$ 9462
- To year 40	($1603)	$1043	$4797	$15807
Typical Year (7-20)				
- Improved Acreage	46.4	51.9	154.8	163.8
Marketed Output:-				
- Wheat (bu)	343	596	1438	1354
- Oats (bu)	0	0	0	326
- Barley (bu)	86	49	0	0
- Potatoes (bu)	397	113	0	0
- Turnips (bu)	0	201	318	389
- Hay (Native)(ton)	1.9	6.7	0	0
- Hay (Cultivated)(ton)	0	0	15.9	41.2
- Beef (Live, lb)	992	302	340	324
- Pork (Live, lb)	3434	1005	956	1064
- Mutton (Live, lb)	138	138	0	0
- Chicken (lb)	53	238	330	243
- Eggs (Doz.)	113	422	440	433
- Butter (lb)	96	35	32	29
Intermediate Outputs:-				
- Oats (bu)	238	0	411	335
- Barley (bu)	0	119	0	0
- Hay (Nat, ton)	13.2	8.5	0	0
- Hay (Cult, ton)	0	0	5.2	5.3
- Turnips (bu)	23	10	2.9	3.0
- Pasture (Cult, ac)	14.6	9.1	6.6	6.8
Live Stock:-				
- Horses	2	3	3	3
- Cows	2.1	0.6	0.5	0.5
- Calves	1.4	0.4	0.5	0.5
- Sows	2.7	0.8	0.7	0.8
- Piglets	21.9	6.4	5.5	6.1
- Sheep	1.3	1.3	0	0
- Hens	11.8	44.9	45.8	45.1
Shadow Prices:-				
- Spring Labour(day)	6.50	0.00	14.74	0.00
- Summer labour(") (excl.hay)	0.00	0.00	3.25	21.10
- Harvest Labour(")	5.88	16.04	9.30	47.43
- Winter Labour (")	0.00	0.00	0.00	0.00

TABLE 8.5
Summary of Linear Program Output
Indian Head

YEAR	1880	1890	1900	1910
Capitalized Value:-				
- To year 20	($3172)	($1522)	$1111	$9325
- To year 40	($4600)	($1695)	$2638	$13149
Typical Year (7-20)				
- Improved Acreage	29.8	43.2	124.4	113.2
Marketed Output:-				
- Wheat (bu)	193	218	712	1142
- Oats (bu)	0	0	0	0
- Barley (bu)	46	174	363	75
- Potatoes (bu)	199	29	220	108
- Turnips (bu)	0	349	0	215
- Hay (Native)(ton)	0	6.7	26.2	0
- Hay (Cultivated)(ton)	0	0	0	41
- Beef (Live, lb)	1264	302	340	325
- Pork (Live, lb)	103	1117	966	709
- Mutton (Live, lb)	0	138	0	0
- Chicken (lb)	23	27	330	372
- Eggs (Doz.)	48	48	440	476
- Butter (lb)	92	35	32	32
Intermediate Outputs:-				
- Oats (bu)	59	88	155	168
- Barley (bu)	0	0	145	0
- Hay (Nat, ton)	14.5	8.5	8.2	5.2
- Hay (Cult, ton)	0	0	34.4	5.2
- Turnips (bu)	7.6	7.2	2.9	2.5
- Pasture (Cult, ac)	13.2	9.1	9.6	5.5
Live Stock:-				
- Horses	2	3	3	3
- Cows	2	0.6	0.5	0.5
- Calves	2.1	0.4	0.5	0.4
- Sows	0	0.8	0.7	1
- Piglets	1	6.4	5.5	4
- Sheep	0	1.3	0	0
- Hens	5	5	21	50
Shadow Prices:-				
- Spring Labour(day)	0.20	0.00	7.59	0.00
- Summer labour(") (excl.hay)	0.00	0.00	0.00	0.00
- Harvest Labour(")	1.38	15.96	18.41	55.02
- Winter Labour (")	0.00	0.00	0.00	0.00

TABLE 8.6

Summary of Linear Program Output
Scott

YEAR	1880	1890	1900	1910
Capitalized Value:-				
- To year 20	($3447)	($2101)	($932)	$ 6949
- To year 40	($4966)	($3351)	($912)	$10541
Typical Year (7-20)				
- Improved Acreage	15.9	21.3	44.3	80.4
Marketed Output:-				
- Wheat (bu)	54	87	582	927
- Oats (bu)	0	0	0	0
- Barley (bu)	103	111	94	0
- Potatoes (bu)	160	0	216	111
- Turnips (bu)	0	240	0	210
- Hay (Native)(ton)	5.8	6.1	0	0
- Hay (Cultivated)(ton)	0	0	13.3	38
- Beef (Live, lb)	313	334	306	325
- Pork (Live, lb)	82	115	87	709
- Mutton (Live, lb)	0	0	0	169
- Chicken (lb)	23	27	6	372
- Eggs (Doz.)	48	48	48	476
- Butter (lb)	21	26	32	32
Intermediate Outputs:-				
- Oats (bu)	31	0	0	172
- Barley (bu)	0	30	58	0
- Hay (Nat, ton)	6.6	6.3	0	0
- Hay (Cult, ton)	0	0	8.1	8.2
- Turnips (bu)	2.4	2.8	1.5	2.5
- Pasture (Cult, ac)	5.6	6.1	7.9	8.5
Live Stock:-				
- Horses	2	2	3	3
- Cows	0.5	0.5	0.5	0.5
- Calves	0.4	0.4	0.4	0.4
- Sows	0.1	0	0.1	1
- Piglets	0.9	1	0.9	4.1
- Sheep	0	0	0	1.3
- Hens	5	5	5	50
Shadow Prices:-				
- Spring Labour(day)	0.00	0.00	3.50	0.00
- Summer labour(") (excl.hay)	0.00	0.00	0.00	0.00
- Harvest Labour(")	10.62	13.67	12.74	53.02
- Winter Labour (")	0.00	0.00	2.68	0.00

TABLE 8.7
Summary of Linear Program Output
Lacombe

YEAR	1880	1890	1900	1910
Capitalized Value:-				
- To year 20	($2166)	($1537)	$241	$ 7424
- To year 40	($3647)	($1906)	$473	$10767
Typical Year (7-20)				
- Improved Acreage	22.4	39.5	96.2	104
Marketed Output:-				
- Wheat (bu)	101	0	451	680
- Oats (bu)	0	0	0	0
- Barley (bu)	200	219	723	528
- Potatoes (bu)	173	307	222	49
- Turnips (bu)	0	0	0	326
- Hay (Native)(ton)	13	6.3	0	0
- Hay (Cultivated)(ton)	0	0	18	50
- Beef (Live, lb)	314	261	314	325
- Pork (Live, lb)	82	3339	1197	593
- Mutton (Live, lb)	0	138	138	0
- Chicken (lb)	23	81	36	371
- Eggs (Doz.)	48	144	48	475
- Butter (lb)	21	101	38	32
Intermediate Outputs:-				
- Oats (bu)	31	159	103	71
- Barley (bu)	0	41	64	124
- Hay (Nat, ton)	6.6	12.1	0	0
- Hay (Cult, ton)	0	0	8.5	8.2
- Turnips (bu)	2.4	32.7	3.4	2.2
- Pasture (Cult, ac)	5.7	13.9	10.1	8.3
Live Stock:-				
- Horses	2	3	3	3
- Cows	0.5	1.7	0.6	0.5
- Calves	0.4	0	0.4	0.4
- Sows	0.1	2.7	0.9	0.8
- Piglets	0.9	21.2	6.8	6.1
- Sheep	0	1.3	1.3	0
- Hens	5	15	5	50
Shadow Prices:-				
- Spring Labour(day)	0.00	0.00	0.00	0.00
- Summer labour(") (excl.hay)	0.00	0.00	0.00	0.00
- Harvest Labour(")	2.85	15.61	26.03	70.24
- Winter Labour (")	0.00	0.00	0.00	0.00

TABLE 8.8
Summary of Linear Program Output
Lethbridge

YEAR	1880	1890	1900	1910
Capitalized Value:-				
- To year 20	($3430)	($226)	$1907	$ 8696
- To year 40	($5196)	$328	$4110	$15595
Typical Year (7-20)				
- Improved Acreage	31.3	64.9	164.4	147.0
Marketed Output:-				
- Wheat (bu)	0	491	1510	1642
- Oats (bu)	191	0	125	0
- Barley (bu)	0	0	0	0
- Potatoes (bu)	256	261	0	0
- Turnips (bu)	0	0	0	0
- Hay (Native)(ton)	0	3	0	0
- Hay (Cultivated)(ton)	0	0	8	38.6
- Beef (Live, lb)	1290	254	340	325
- Pork (Live, lb)	87	3244	966	710
- Mutton (Live, lb)	0	138	0	0
- Chicken (lb)	23	74	330	372
- Eggs (Doz.)	43	157	440	476
- Butter (lb)	99	99	32	32
Intermediate Outputs:-				
- Oats (bu)	0	0	261	167
- Barley (bu)	85	145	0	0
- Hay (Nat, ton)	14.8	11.9	0	0
- Hay (Cult, ton)	0	0	8.2	8.2
- Turnips (bu)	7.6	31.7	2.9	2.5
- Pasture (Cult, ac)	10.7	13.7	9.6	8.5
Live Stock:-				
- Horses	2	3	3	3
- Cows	2.1	1.7	0.5	0.5
- Calves	2.1	0	0.5	0.5
- Sows	0.1	2.6	0.7	1.0
- Piglets	0.9	20.5	5.5	4.1
- Sheep	0	1.3	0	0
- Hens	5	16.4	46	49.6
Shadow Prices:-				
- Spring Labour(day)	0.00	0.00	0.00	0.00
- Summer labour(") (excl.hay)	3.53	0.00	13.15	44.62
- Harvest Labour(")	0.00	13.80	18.49	45.56
- Winter Labour (")	0.00	0.00	0.00	0.00

Analysis of Output

The two important features of the output of the linear programs are immediately apparent. First, there is a significant increase in the capitalized value of the farm over the period. Note that the figures do not represent the changes in the value of a developed farm over the period: each value is that of an undeveloped section of land prior to settlement. Thus thefigure of -$1434 for the Brandon area farm in 1880.

The second significant feature is the increase in the area of land which the farmer could cultivate. The majority of the important developments of the labour augmenting machinery discussed in Chapter 4 of this thesis had occurred by 1900. The big expansion in acreage therefore came in the decade leading up to 1900, whereas the large increase in the value of the land came closer to 1910, when prices rose.

Figures 8.1 to 8.10 show the evolution of these values and areas graphically.

FIGURE 8.1
Brandon - Values

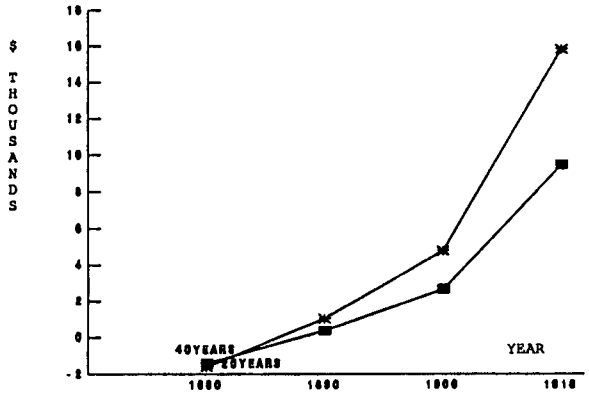


FIGURE 8.2
Brandon - Acreage

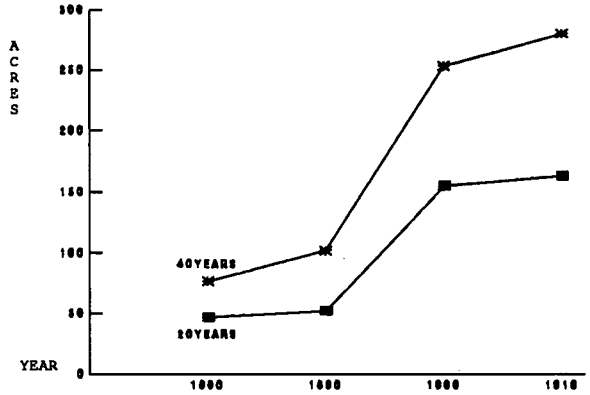


FIGURE 8.3
Indian Head - Values

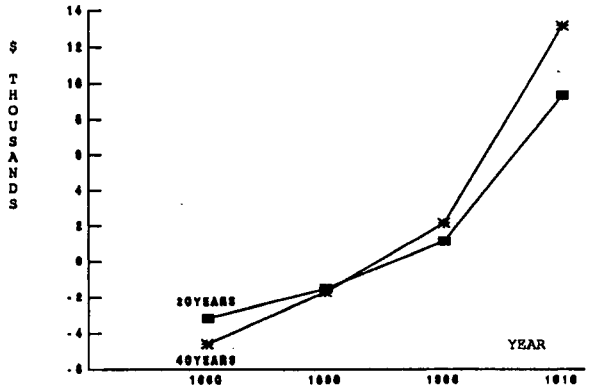


FIGURE 8.4
Indian Head - Acreage

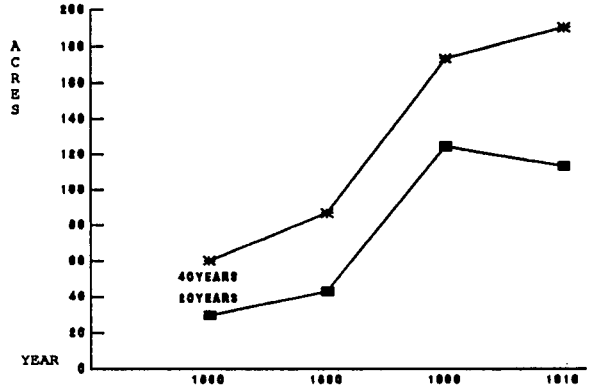


FIGURE 8.5
Scott - Values

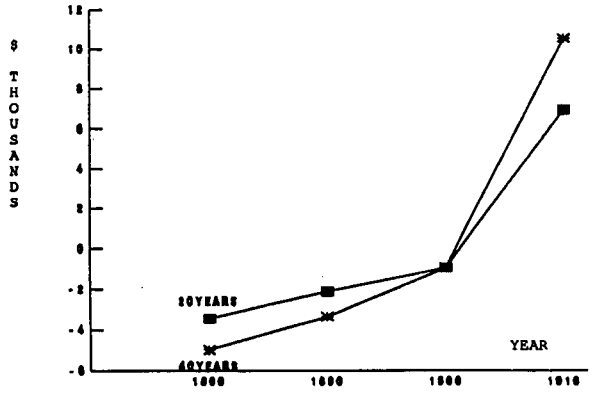


FIGURE 8.6
Scott - Acreage

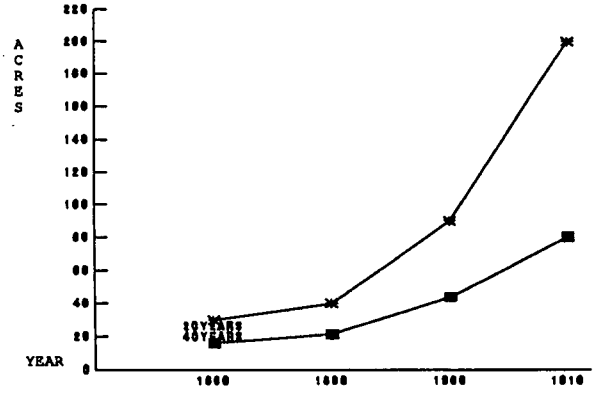


FIGURE 8.7
Lacombe - Value

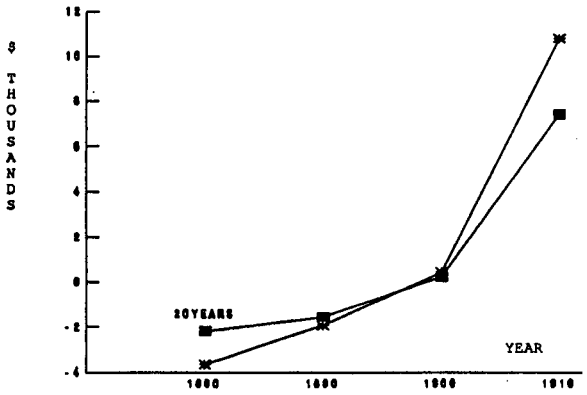


FIGURE 8.8
Lacombe - Acreage

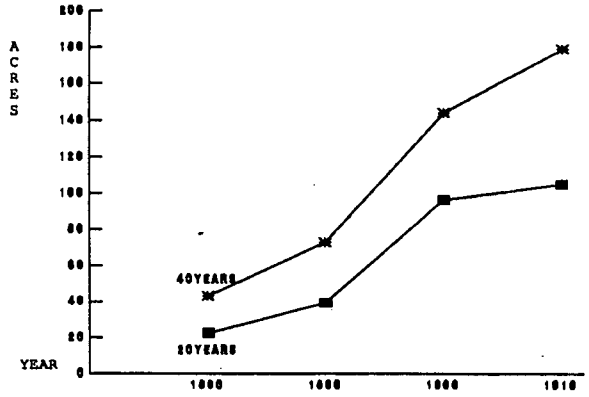


FIGURE 8.9
Lethbridge - Values

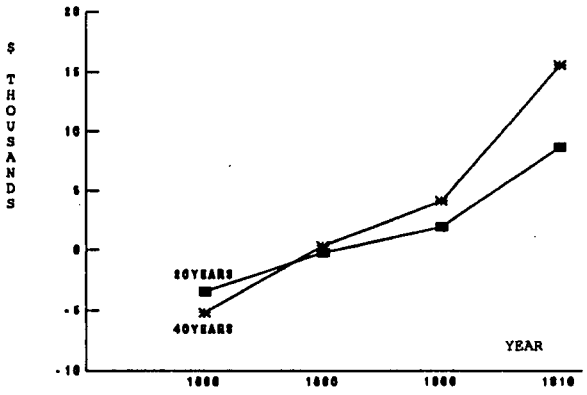
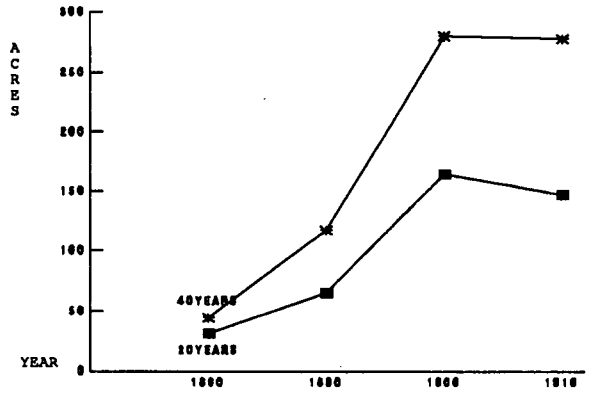


FIGURE 8.10
Lethbridge - Acreage



Figures 8.11 and 8.12 facilitate comparison among the various different locations. In these figures, negative farm values have been set to zero, since a negative value has no meaning in this context. Figure 8.11 shows how the values of all farms rose in a comparable manner over the period, with the largest increase in value occurring between 1900 and 1910. Comparison with Figure 8.12 emphasizes how technical change which had occurred before 1900 facilitated the large expansion in acreage, which the post 1900 price increases then translated into increases in farm values. The important figures in the output are those

FIGURE 8.11
Farm Values

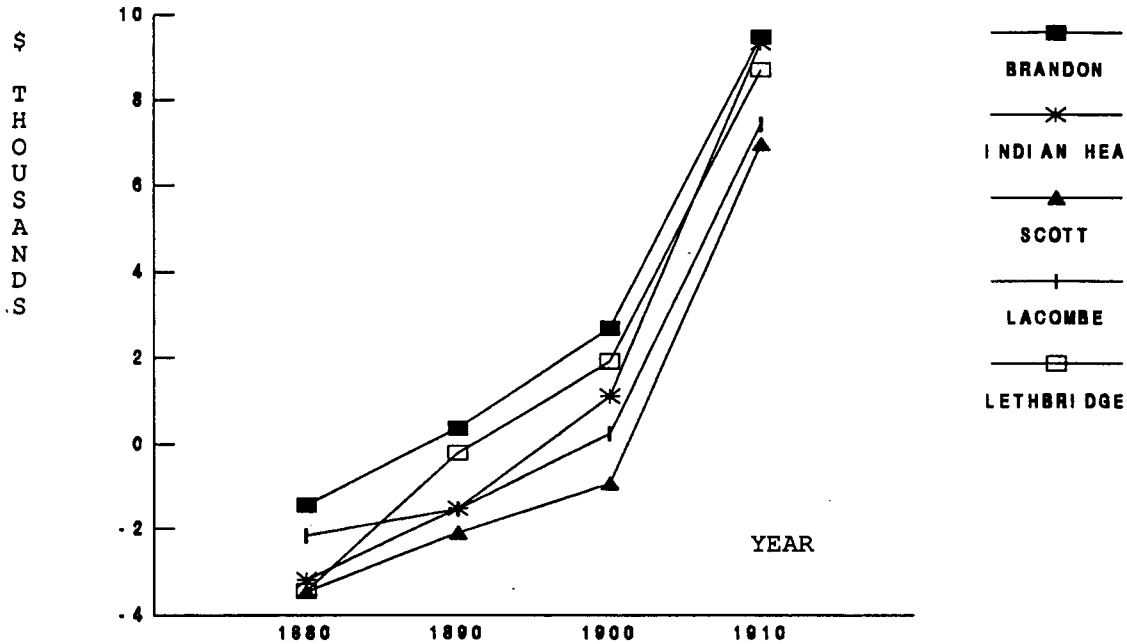
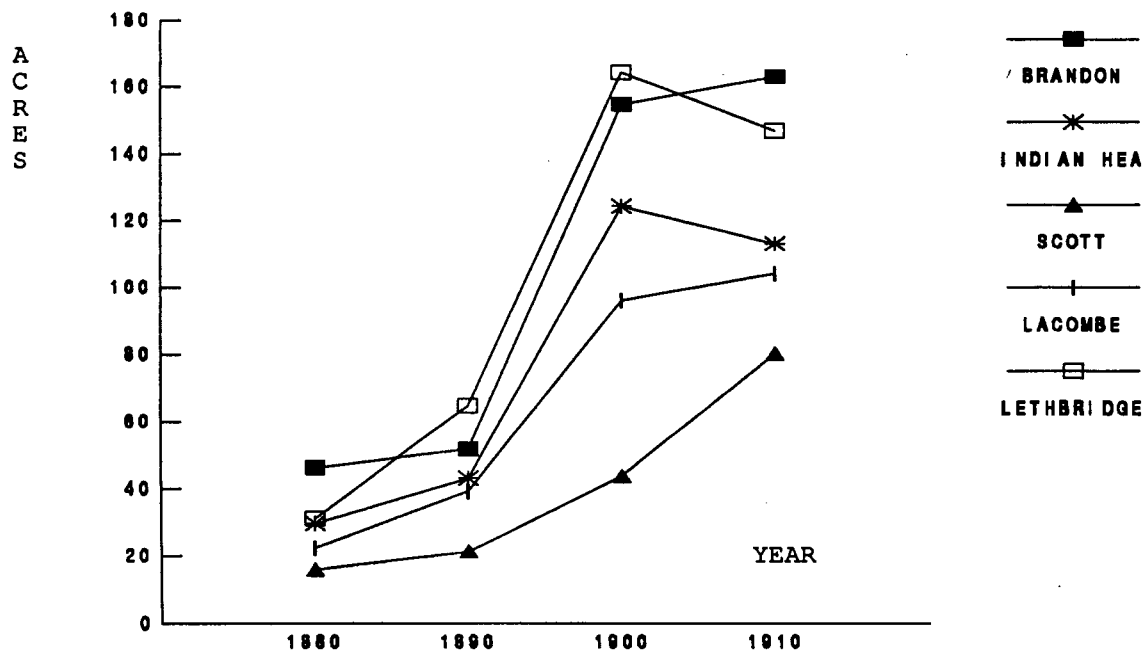


FIGURE 8.12
Farm Cultivated Areas



of the total acreage worked and the total value of the crops produced. The increase in the acreage cultivated comes from improvements in the productivities of plowing and harrowing in the spring, cutting and collecting in the fall, and reduction in the time which the crop took to ripen.

The precise details of the particular mix of outputs chosen by the programs for each farm for each decade are not particularly important to the overall results of the analysis. Tables A12.1 to A12.4 of Appendix 12 compare the output of the linear programs with the contemporary census data, and show that the model's predictions are reasonably consistent with the output mixes shown in the Census[20]. In the majority of cases the programs chose a realistic mixture of crops and animal husbandry activities. They were however not good at selecting a combination of both oats and barley - in most cases the models predict that oats were selected as a feedstuff for use on the farm, whilst barley was grown for sale. Whether this was in fact the case makes little difference to the results in that forcing the program to select the other crop would affect the final value only marginally. What would have been of concern would have been the occurrence of 'corner solutions' - selection by the programs of only a single output such as wheat or beef. This problem did not arise due to the detail of the technological and seasonal constraints incorporated in the programs. A far less detailed program containing only that minimal information would have produced similar figures for the acreage and value, but with only one crop selected in each year, and would therefore be less credible.

The programs reflect the costs of feeding, housing and caring for all animals in terms of money, land or time costs as appropriate. The number of oxen and horses on the farm was specified in the program - getting the program to select that variable was not computationally feasible. Minimum numbers of hens (5), cows and calves (1) and pigs and piglets (1) which each

[20] The acreages predicted by the linear program models appear if anything to overestimate farm sizes in 1880 and underestimate them in 1900 and 1910, thereby avoiding overestimation of the increases in farm size.

farm kept for its own consumption purposes were specified to represent the household's requirement for its own food. The marketable value of the animal products from those animals was included in the calculation of the value of the farm.

The linear programming package calculated the shadow values of the binding constraints, the most important of which are included in Tables 8.4 to 8.8. The precision of the figures generated is uncertain, in that they are really average rather than marginal values, but they do provide some useful information about which labour constraints were restricting output. The availability of harvest labour was critical in almost all the models, and became more of a problem as time went by. By 1910 all the models show shadow values for harvest labour of $45 per day or more, at a time when the going rate for harvest labour was only $2.35 per day. The high shadow price generated is an artifact of the linearization of the constraints, and is likely to be a significant overstatement. Nonetheless it is clear that the shortage of harvest labour was a serious constraint on the Prairie farmer. This prediction of the models would appear to be realistic in light of the amount of effort put into obtaining extra labour by farmers, the railway and the government, as discussed in Chapter 5.

The big improvements in threshing equipment had little effect on this harvest constraint, since threshing could always be done at a later stage of the year. The technology of cutting the grain was improved significantly over the period, but there was no change in the method of collecting it and moving it to a central area for storage or threshing, which task took a large amount of time. This bottleneck was not removed until the advent of the combine harvester in the 1920s.

Spring labour was critical only in a few of the models - those for the years 1880 and 1900 - which indicates that plowing was a limiting factor for those places in 1880, but that by 1890 the problem was removed through the use of fall plowing. In 1900 the improved reaping equipment threw the pressure back onto the spring plowing period, but the development of the disc seeder, with its greater productivity, then removed the pressure on spring activities again by 1910.

The shadow value listed for summer labour excludes the periods for haying, since the modelled constraint for haying is somewhat artificial. The period for which haying was feasible was short - generally only about 7 to 10 days. Since haying was almost always a highly profitable activity, the output of the linear programs indicated that increasing the time spent cutting hay would yield significant additional revenue, even though such an increase would not in fact have been possible. Summer labour became a critical consideration in some of the models for 1900 and 1910, because of pressure on time for plowing the fallowed land.

During the winter the settler was finishing off the threshing of the grain, and delivering his produce to market (on days in which the weather was good enough). Winter labour was never critical other than for Scott in 1900, and that constraint was binding only because Scott was still 100 miles from the nearest railway station at that date, and each round trip to deliver grain would have taken about 20 days across the snow, if there really had been any settlers there.

Implications of Output

a) Dates of Settlement

In order to comment on the behaviour of settlers, it is necessary to calculate the value of the land on the date at which it was first occupied. For that, we need to know the date on which that first possession occurred. All the original ledgers of the Department of the Interior are still preserved at the National Archives in Ottawa, and a portion of them for the period from 1872 to April 1902 are available on microfilm. A 1% sample of those microfilmed records was taken, recorded in a machine readable form, and then searched for pertinent records. All townships within a 12 mile radius of each of the five localities were searched, and Appendix 15 lists the homesteads found for each location.

For the Brandon area, 11 records were found, with dates of first occupation from June 1881 to June 1889. Since the farm values were calculated on the basis of the Census average yield for the area, a simple arithmetic average of these dates was taken as relevant for the average farm, to avoid problems of differing land quality. The mean of the 11 settlement dates found was May 1883. Six records for the Indian Head area were found, with an average date of settlement of April 1890. No records were found for the Scott area, which is not surprising given that the data set covers the period up to 1902 only. The maps of settlement in Martin[21] show that initial settlement of that area occurred between 1906 and 1910. A date of 1907 in used here as an average date for Scott. For the Lacombe area 16 records were found with a mean date of first occupation of 1896.

No records were found for the Lethbridge area, not because no one had gone there, but because a very high proportion of the land around Lethbridge was taken by the CPR as part of their land grant, and it would therefore not appear in the free homestead registers. From the

[21] Martin, Dominion Lands Policy, p. 246.

maps of settlement in Martin[22], it is apparent that settlement in the Lethbridge area began in about 1885, when the Lethbridge to Dunmore line of the North-West Coal and Navigation Company was opened[23], and a substantial area was occupied by 1891. A mean date of first settlement of 1888 has therefore been used for that area.

b) Farm Value at Date of Settlement

TABLE 8.9

Farm Value At Date of Settlement

	Date of Settlement	Value at Decade Before	Value at Decade After	Approximate Value at Date of Settlement
Brandon	1883	-$1,603	$367	< $ 0
Indian Head	1890			-$1,522
Scott	1907	-$932	$7,615	> $ 0
Lacombe	1896	-$1,537	$486	$ 0
Lethbridge	1888	-$3,430	-$226	< $ 0

The median date of first settlement of the Brandon area was 1883, when the calculated area of a farm in that area would have been between the 1880 value of -$1,434 and the 1890 value of $367. For Indian Head the calculated value at the mean date of settlement of 1890 was -$1,522. The value of a farm in the area of Scott, Saskatchewan in 1907 would have been between the 1900 calculated value of -$932 and the 1910 value, after the railway had been built, of $7615. Lacombe, Alberta would in 1896 have had a value of between -$1537 and $486. In 1887, the value of a free homestead in the Lethbridge, Alberta area would have been between the 1880 value of -$3430 and the 1890 value -$226. Table 8.9 shows the relationship between these settlement dates and the calculated farm values.

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[22] *Op.cit.* p. 246.

[23] M.L.Bladen, "Construction of Railways in Canada to the Year 1885". In Contributions to Canadian Economics, Volume 5, 1932, p. 59.

c) Indexation of Farm Values

The figures listed in this chapter are all in nominal terms, since there is no suitable price or cost-of-living index by which to relate them to other values. It is not at all clear exactly what these farm values should be compared with. As far as this thesis is concerned, the relevant comparisons are between the different farms at each date, and then the values of each farm at the different dates. The requisite index would therefore be a Prairie cost-of-living index, which does not exist. Since I am suggesting that the real value of a Prairie farm increased over the period, the calculated figures should be compared with some series of alternative values representing the costs of living in the places of origin of the migrants who came to the Prairies. Since settlers came from such a wide variety of places, there is no index available which would adequately summarize the cost of living at their points of origin. Since no Canadian, American or English price index available shows any significant inflation during this period, I decided that the issue of indexation of the calculated values was not important.

d) Assumptions About Labour Availability

The assumptions made about labour availability are fairly important in determining the outcomes of the calculations. The two significant assumptions are that farmers' sons worked on their parents' farms, and that the modelled farms were not able to hire any full time labour. Both are obviously open to question. I am assuming that those people who classified themselves in the Census as farmers' sons were adults who worked on farms, but did not own their own farm (or they would have called themselves farmers). If they worked for someone other than their parents it would appear more likely that they would have called themselves labourers. Given that I want to represent a typical newly arrived settler, it

appears reasonable to attribute these workers to their parents' farms, and not to the labour force on new homesteads[24].

The decision to exclude the small numbers of full time farm labourers who were available was made for similar reasons of representativeness. If at most one farm in four was able to hire such a worker, it is not realistic to include such labour for the typical new farm. Clearly some farms did have full-time hired labour, but it was likely to be the larger, better capitalised farms, (which may in fact have employed several labourers, further distorting the picture) which are not representative of the marginal settler I want to depict. In this instance, the decision to exclude these workers has fairly well-defined effects, in that allowing every farm (for example) 20% of a full time worker would make the calculated values into meaningless 'averages', not representative of any particular farm. The inclusion of these labourers would 'scale-up' all the farm values (and acreages) by similar amounts, not changing the relative picture significantly.

[24] Another reason for treating these people as not being available to the new settler's workforce is that this classification only appears in the 1880 and 1890 Censuses. It is not clear how such workers were classified in the 1900 and 1910 Censuses.

CHAPTER 9

CONCLUSIONS

Analysis of the Pattern of Settlement

Settlement experience on the Canadian Prairies differed from that in the United States in that climatic conditions initially posed a constraint which did not exist south of the border. On the American Prairies and in the Midwest, farmers had from two to five times as long for their planting and harvesting, and the duration of summer was therefore not a binding constraint. Factors such as soil fertility, the availability of water and summer temperatures determined the feasible region for any set of economic conditions. Over time, the evolution of railway construction, prices and technology induced the expansion of the feasible region across the northern states.

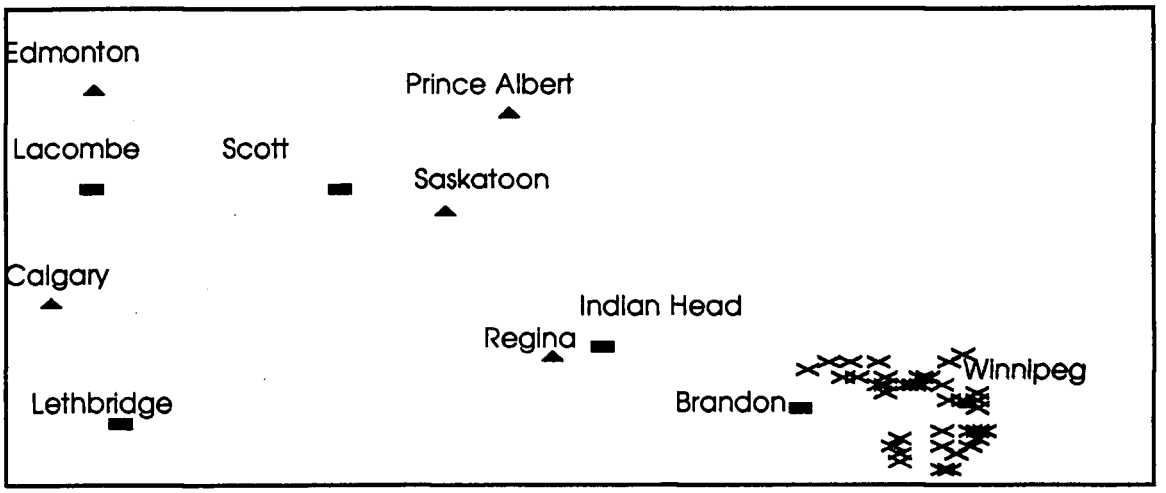
Settlement of a new area of land is sequential, in that once land is occupied it is then no longer available for future immigrants. The fact that at one moment conditions were suited to immigrants moving into an area does not mean that the continuation of those conditions would result in continuing settlement. For example the construction of a new railway line or the development of improved technology might result in a new area of land becoming economically feasible. That land would then be occupied over the following period, and, once it was full, settlement would cease again until some further development occurred.

The analysis of the programming results in Chapter 8 has demonstrated that the initial absence of appropriate agricultural technology made farming on the Canadian Prairies unprofitable in 1880, other than in the area between Brandon and Winnipeg. As technology evolved, potential rents in other areas of the Prairies rose, and settlers were induced to migrate by the increased economic opportunities available.

The temporal and spatial pattern of settlement on the Prairies is illustrated by Figures 9.1 to 9.6 which show a sample of the homesteads being first occupied during a series of period between 1872 and 1902[1]. These maps show only that settlement which occurred during each period, not cumulative settlement.

[1] Produced from the 1:100 sample of the Dominion Lands Department Homestead records for 1872 to 1902 discussed in Chapter 8. Because of a large number of missing dates of first occupation, the dates from which these schematic maps were prepared were in fact the dates on which the Homestead Application was filed. A statistical analysis of those records for which both the date of first occupancy and the date of application were available showed that this did not bias the dates used - as many applicants filed before occupying the land as after.

Figure 9.1

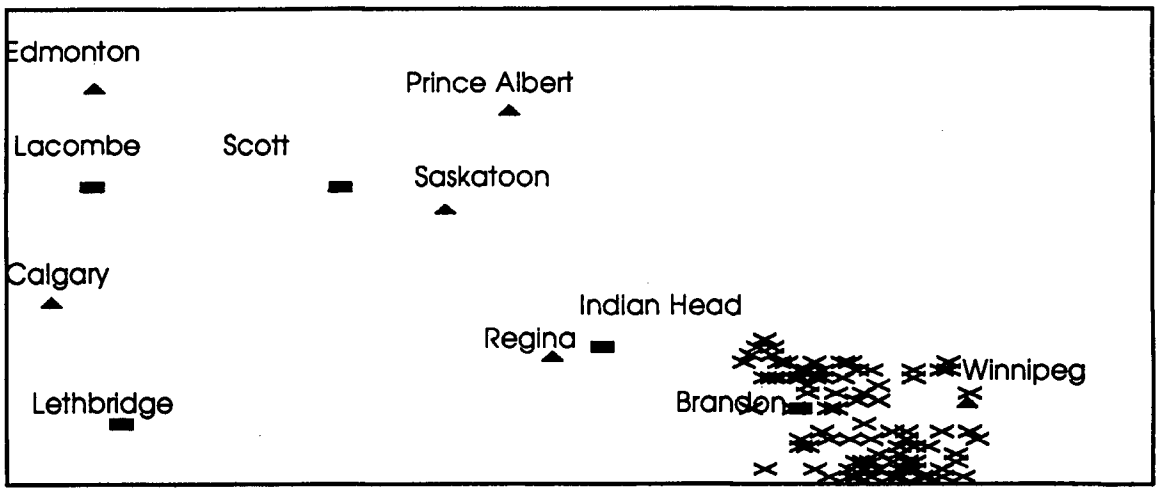


Settlement 1872-1877

The period from 1872 to 1877 covers the time from the start of the homestead records to the year before the first railway on the Prairies was completed. Settlement was slow, and occurred only in the area of south-eastern Manitoba where the frost-free period lasted for more than 135 days, the soil was the best 'Black Prairie Meadow', and where there was some transportation access to Winnipeg via the Red or Souris rivers. The Winnipeg market was at that time connected by river boat to St.Paul in the United States, and thence by railway to the rest of the world. The average rate of settlement during this period was 705 homesteads per year.

Settlement in areas with less than 135 frost-free days in summer was unnecessary, since there was good land available near Winnipeg.

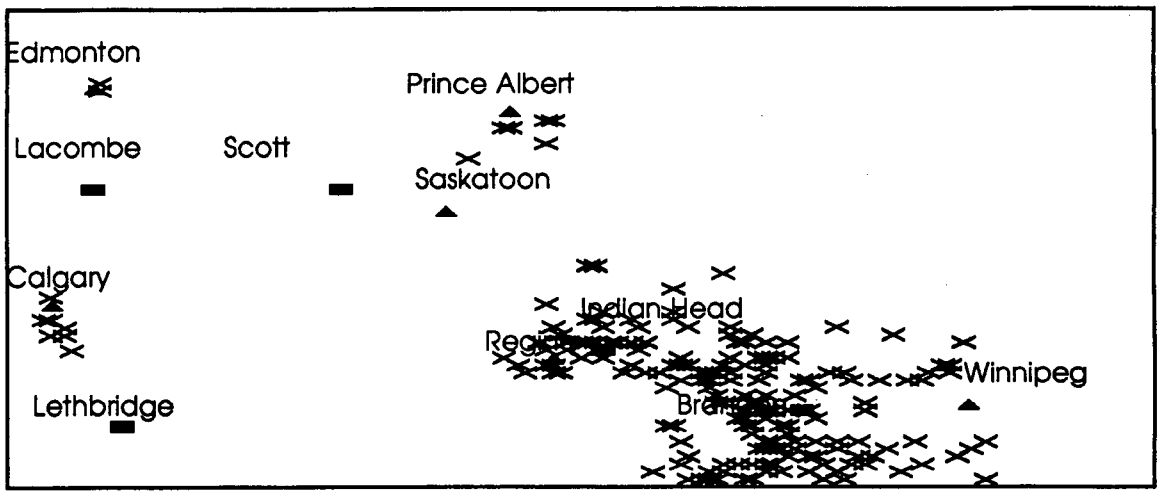
Figure 9.2



Settlement 1878-1881

The first railway to reach the Prairie provinces was completed from the U.S. border to Winnipeg in 1878, and three years later in 1881 a second route was available when the CPR line to Port Arthur was built. Settlement during this period was concentrated in the areas around Brandon and close to the U.S. border, in areas of park very dark brown soil, and where there was a frost-free period of more than about 120 days. Settlement was more rapid than during the preceding period, largely due to the announced construction of the CPR. The average rate of settlement between 1878 and 1881 was 2671 homesteads per year.

Figure 9.3

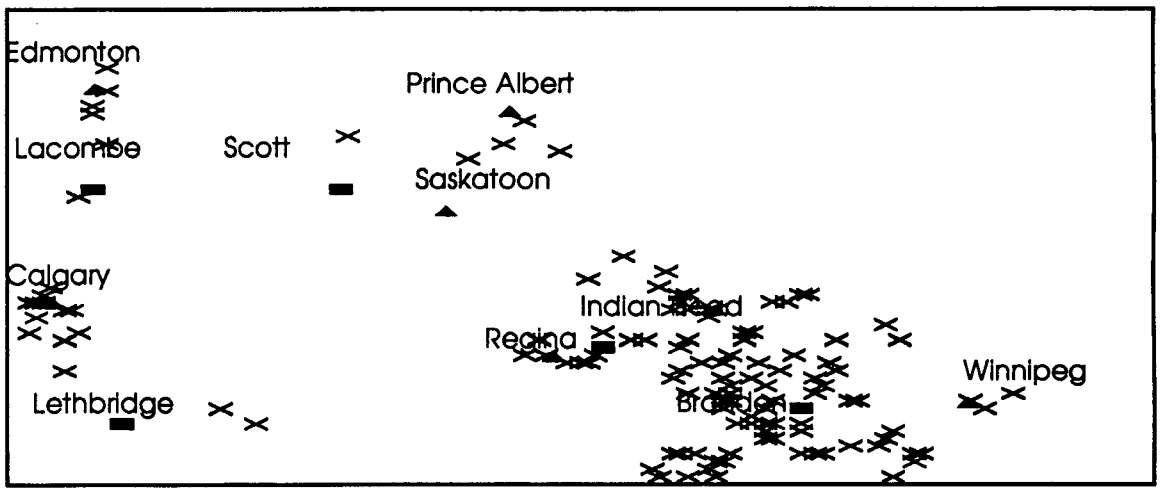


Settlement 1882-1886

During the period from 1882 to 1886 the Canadian Pacific Railway across the Prairies was completed, and settlement progressed rapidly. The influence of the route of the transcontinental railway line is clearly visible, with land being taken in the Indian head, Regina and Calgary areas, which prior to the building of the railway had not been economically attractive. Railways to Edmonton and Prince Albert were being organised, and settlement in those areas was also beginning, albeit prematurely. Homesteads were taken in areas where the frost-free period in summer lasted for more than 120 days, and the soil was the high quality 'Park very dark brown' soil. The average rate of settlement during this period was 4363 homesteads per year.

Settlement in areas with less than 115 frost-free days in summer was not economically feasible unless yields were very high. Although the route of the CPR ran from Regina to Calgary, no settlement occurred in the climatically unsuitable area of Palliser's Triangle.

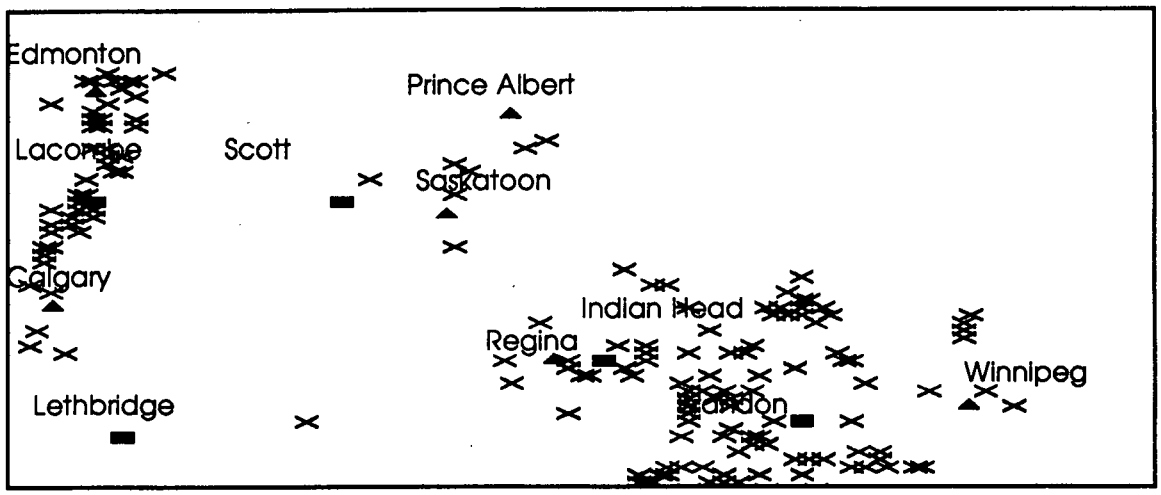
Figure 9.4



Settlement 1887-1890

During the first few years after the completion of the CPR, settlement continued, but at a less rapid pace. The majority of the best land (that with more than 125 days free of frost in the summer and with good soil) had been taken, and farming in areas with summer periods of less than about 115 days was not yet profitable, since the appropriate labour-augmenting technology had not yet been developed. The settlement which did take place was therefore in areas with more than 115 days free of frost, and on 'Park very dark brown soil'. Some branch lines such as that from Saskatoon to Prince Albert (completed in 1891) and the line from Lethbridge to the US border (completed in 1890) were built during this period. The average rate of settlement during this period was 3016 homesteads per year.

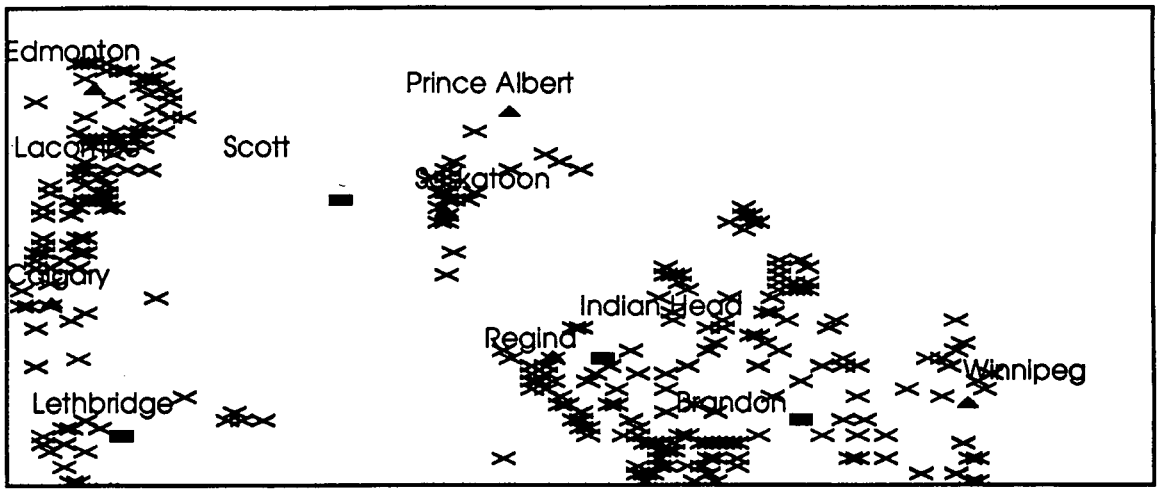
Figure 9.5



Settlement 1891-1896

From 1891 to 1986, relatively little land in the south-eastern area of the Prairies was available, and settlement proceeded only slowly. The Edmonton branch line was completed in 1891, inducing rapid settlement in that area. Better technology was being developed, making areas such as Lacombe and Saskatoon more attractive, but areas with less about than 115 frost free days were still marginal, and the area available for settlement was therefore still restricted to areas with longer summers. The average rate of settlement prior to the start of the 'Wheat Boom' was 3315 per year.

Figure 9.6



Settlement 1897-1902

By about 1896, the technology for coping with a frost free period of less than about 115 days had become available. Although commodity prices had not yet begun to rise, farmers could now grow enough crops on what had previously been sub-marginal land, particularly in Saskatchewan, to make settlement economically feasible. In spite of the route of the CPR main line across southern Saskatchewan and Alberta, settlement occurred around Palliser's Triangle and not across it. During these first few years of the 'Wheat Boom' the average rate of settlement rose to 6616 per year.

Interpretation of Results

a) Context of the Results

The number of data points generated by the work of the preceding eight chapters is small - twenty points - and in this final chapter these are reduced to only five points - the values of the five hypothetical farms on the dates at which they were first occupied. That is a very small number of observations from which to base any useful conclusions. Nonetheless, the preparation of those figures involved the collection and utilization of a large amount of information, which has the effect of ensuring that the values calculated are meaningful. Every element of the linear programs has been generated from a balanced average of information from several sources, and should therefore yield realistic overall predictions.

The use of dynamic programming to analyze the incentives facing potential immigrants yields significantly more information than the simple dissection of Census data. The programs distinguish intermediate from final outputs, and ensure that sufficient quantities of intermediate inputs are either produced or purchased. More importantly, the rate of capital investment in land preparation is estimated, which facilitates the calculation of the capitalised value of the homestead.

The programs generate useful information about the causes of the initially low profitability. As the optimised solution vector is calculated, it is straightforward to calculate the shadow values of the binding time constraints. Examination of which of the seasonal constraints were binding at each location at each point in time furnishes useful understanding of the reasons why settlers were not coming to that place.

A far simpler formulation of the programming problems, offering fewer crops and animal activities, and dividing the year into fewer seasonal time periods, would have yielded similar capitalised land values. This would however have been at the expense of a significant loss of credibility of the results.

The question of the reasons for the delays in settlement can be tackled more effectively than the ex-post approach of Lewis[2]. In that paper Lewis examined a time period and an area in which settlement was actively progressing. An analysis such as this can never really account for the reasons for the absence of settlement in the earlier time periods, since no analysis of conditions at the earlier date is attempted. Using only Census data, such an analysis cannot be undertaken, since there are no data for the dates when there was no-one on the land. The use of programming simulations avoids this problem, since it is possible to calculate what the value of land was for times and places in which there were no settlers. This enables us to understand the economic reasons why settlement did not occur before the dates on which we observe settlers arriving.

The calculated output figures appear generally to be quite realistic in both the quantities and the mix of produce. There are no instances in the program solutions of the commonly occurring problem of 'corner solutions' - the selection by the program of just one crop. Whilst the principal product of Prairie agriculture was wheat for export, that was by no means the only output produced. In order to enjoy a reasonable standard of living, the Prairie farmer needed not only the cash flow generated by wheat sales, but also the fresh foodstuffs and the various animal feeds grown on the farm. It is only by examining the production unit as a whole that it is possible to accurately analyze the economic potential of farming.

b) Farm Value at the Date of Settlement

Whilst it is impossible to specify the exact values at the dates of first settlement, it would appear from Table 8.9, reproduced here as Table 9.1, that for those places settled before 1900, it is most unlikely that those values were significantly if at all positive. In the framework of a static expectations model, looking only at the behaviour of settlers, and taking railway construction as

[2] Lewis, F.D. "Farm Settlement on the Canadian Prairies 1898-1911." Journal of Economic History XLI, No. 3 (September 1981): pp. 517-535.

given, it would appear therefore that the hypothesis of Gibbon Wakefield, exposited by Southey, was probably correct, and that settlement generally occurred at an earlier date than was economically optimal.

TABLE 9.1
Farm Value At Date of Settlement

Value	Date of Settlement	Value at Decade Before	Value at Decade After	Approximate at Date of Settlement
Brandon	1883	-$1,434	$367	< $ 0
Indian Head	1890			-$1,522
Scott	1907	-$932	$6,949	> $ 0
Lacombe	1896	-$1,537	$241	$ 0
Lethbridge	1888	-$3,430	-$226	< $ 0

When making their settlement decisions, it would appear that migrants valued the land which they took at most at its market price of zero, and probably in fact, because of competition for the better land, occupied their farms at an even earlier date than was indicated by that zero price. This conclusion must be qualified in that I have taken railway construction as given. Some lines such as the CPR main line may in fact have been economically premature, and some of the branch lines may have been delayed past their socially optimal date of construction due the behaviour of monopolistic entrepreneurs, as Lewis and Robinson[3] suggest.

Amongst the modelled farms the only one which was settled after 1900 was Scott, and it appears that for that location the value on the date of occupation was greater than zero. This would suggest that the effect of the increase in prices which began in about 1905 was to raise the value of farms in unoccupied locations rapidly, and increase the economically feasible region of settlement more rapidly than settlers could follow, resulting in a lag between the economic feasibility of settlement, and the arrival of a homesteader.

[3] Frank D. Lewis and David R. Robinson. "The Timing of Railway Construction on the Canadian Prairies". Canadian Journal of Economics Volume 17 No.2, May 1984, pp. 340-352.

c) Endogeneity of Technical Change

The availability of appropriate technology was an important determinant of the rate of agricultural expansion on the Prairies. It is possible however that this technological change was endogenous to the growth process, in which case the delays in settlement cannot be attributed to it. The dry farming techniques eventually used on the Prairies were developed locally, and there is little reason to suggest that their development could not have occurred earlier, if the incentives to do so had existed. However the same cannot be said of the agricultural equipment which came into use between 1880 and 1910. The issue of the importance of technological change in determining the rate of Prairie settlement hangs on whether the items of equipment discussed in Chapter 4 could have been produced at earlier dates than they in fact were.

The new labour-augmenting equipment was largely developed in the U.S., primarily through cost-saving efforts on existing farms. The economic incentives for labour augmenting technical change on the Canadian Prairies can be traced from the shadow prices of labour in each season generated from the linear programs[4]. Whilst the absolute values of these shadow prices are unreliable due to the linearization of the farming processes, they nonetheless yield some indication of the importance of the labour constraints on production.

In 1880 labour was scarce in spring and at harvest time, but not in summer or winter[5]. An examination of the details of the program output shows that the limiting factor in spring was plowing, and in the fall was harvesting, rather than threshing, since the threshing could be completed later in the winter if necessary. The desirable completion time for threshing was

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[4] The most important of these shadow prices are listed in Tables 8.4 to 8.8.

[5] In estimating here the importance of the various labour constraints, only activities at locations which were inside or 'not far outside' the feasible region are considered. Shadow prices of labour at places which were not occupied for another 5 or 10 years are not pertinent to the process. Therefore for 1880 the values at Brandon were treated as relevant, but not those at the other farms. For 1890, values from the linear programs for Brandon, Indian Head and Lethbridge are considered. For 1900 Lacombe is also used, and the farm at Scott is added for 1910.

probably in fact earlier than is represented by the programs, since farmers frequently had to meet a cash flow constraint of making the credit repayments on the equipment which commonly fell due in November, necessitating the sale of sufficient grain by that date.

Spring plowing and fall harvesting were then the two most critical elements of the agricultural year. There was a great deal of technical change in both areas, though improvements in plowing were slower to become useable. As discussed in Chapter 4, (Section b), the thrust of the experimentation in plowing technology in the 1870s and 1880s was to harness two plowshares to a single frame, which assembly had to have a light enough draft for one team of horses to pull. It does not appear that this development originated on the Canadian Prairies. Rogin[6] documents the development of the sulky plow, and discusses its introduction into Illinois and Missouri in the late 1870s[7], though it is not clear whether it came into general use at that date. In the same work[8], Rogin notes that sulky gang plows began to be used in the Red River Valley in 1879, and that in 1881 they were "universally" employed in California. The development of this type of plow then took place primarily in the U.S.. Evenson[9] tabulates the patent activity in the U.S. and Canada for plows prior to 1939[10]. Between 1870 and 1899, 1419 patents for plows were taken out in the U.S., compared with 10 in Canada.

This by itself does not establish that the sulky gang plow was developed in the U.S.. However when combined with the information in Rogin, it would appear extremely likely that that is what happened. Some of the American patent activity would have been endogenous to

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[6] *Op.cit.*, pp. 36-44.

[7] Rogin's study was concerned only with farming in the U.S., and he made no mention of Canadian sources, so his data contains some bias.

[8] *Op.cit.*, p. 43.

[9] Evenson, Robert E. "Government Policy and Technological Progress in U.S. Agriculture," in Nelson Richard (ed.) Government Support of Technological Progress; A Cross Industry Analysis, New York: Pergamon Press, 1982.

[10] Reproduced as Appendix 16 of this thesis.

Prairie settlement, in that it took place in the American Prairie states. The majority however occurred elsewhere in the U.S., for differing local conditions. The sulky gang plow was clearly an item of equipment which was cost saving under a variety of farming conditions, and its development reflected farming needs in many areas of the continent.

The other important component of agricultural technology was the binder. Here again it would appear that most of the improvements in the basic technology were initiated in the U.S.. In all of the linear programs, labour at harvest time was critical to total output. The first relevant component of technological change for this work came with the introduction of the wire binder in the late 1870s. Rogin[11] notes that by 1878 five large American companies had produced about 20,000 useable binders, which were in use primarily on the larger farms in the western states and in the Red River Valley. The wire binder however never became widely used, and within a few years it had been completely superceded by the superior twine binder.

Rogin notes that the first patent for an effective twine binder was issued in the United States in 1875, but that the machine did not appear on a commercial scale until 1880[12]. The twine binder appeared in Canada at almost exactly the same time as it did in the U.S.. An article in the Farmer's Advocate[13] in 1880 discussed the use of the 'Toronto Harvester and (twine) Binder', which was new to the market.

It would appear from advertisements in the newspapers and trade journals that a substantial proportion of the binders sold on the Prairies were made in Eastern Canada. The deterrent effect of the tariff on American imports was quite significant - in 1880 the tariff rate on implements was increased from 17½% to 25%, and in 1885 it went up again to 35%. There is no evidence that the twine binder was developed in Canada. As with the sulky gang plow this

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[11] *Op.cit.*, p. 111.

[12] *Op.cit.* p. 115.

[13] Farmer's Advocate, Eastern Edition, September 1880, p. 201.

piece of equipment generated major cost savings for American farmers, and was adopted in both countries at the same time.

There were strong incentives to complete the threshing as early in the winter as possible, both in order to have grain ready for sale in time to meet credit payments, and to avoid slow, unpleasant mid-winter threshing. Whilst it would appear that the principal improvements to the basic elements of the thresher - the cylinder and the screens - originated in the United States, some of the important ancillary equipment may well have been developed in Canada. The onset of winter on the Canadian Prairies was more rapid than further south, and the need to finish the threshing was therefore more acute. Items such as the self-feeder and the wind-stacker were particularly appropriate to Prairie conditions, and may well have originated there. These items were relevant however only because of the increases in the capacity of the cylinder and the screens, brought about primarily by the development of better steam engines, which development was clearly exogenous to Canadian Prairie growth.

Whilst late 19th Century improvements in agricultural technology were probably induced primarily by economic incentives in farming activities, most of the new equipment would appear to have originated in the U.S.. The absence of this equipment retarded the profitability of Canadian Prairie farming, and was an essentially exogenous factor causing delay in settlement.

d) Causes of the Increases in Capitalised Farm Values

The principal purpose of this thesis is to examine the economic circumstances which influenced the rate and pattern of settlement on the Canadian Prairies at the time of the 'Wheat Boom'. The most explicit question to be analysed in this area is the reasons for the delay between the construction of the Canadian Pacific Railway in the early 1880s and the beginning of widespread settlement at the turn of the Century.

The analysis of this thesis has shown that this delay can be explained by the low profitability of farming on the Prairies in 1880, which was due to the absence of suitable farming

technology. There were however many different components to the technological changes which led to the increases in profitability between 1880 and 1900. The effects of these changes were highly interrelated, and it is not possible to uniquely disaggregate the influences of each different component.

It is never realistic to attempt to account for long run adjustments in human behaviour by dissecting possible reasons for these adjustments and attempting to ascribe explicit proportions of the total to different sources. People reorganise their activities in accordance with the constraints they face, and the contribution of each item of change depends on the other components of technology to which it is added. The value of each component of technical change is therefore path dependent, and no unique proportion of the overall change in value can be assigned to individual components of the change.

Nonetheless, some indication of the importance of the principal elements of the changes which occurred can be found by evaluating what farm values would have been in the absence of these elements. Only three principal divisions of the changes are considered here. After some experimentation it was found any significantly finer division rapidly became meaningless, due to the problem of path dependency.

Table 9.2 summarises a simple analysis of the contributions of three important elements of the changes in the value of the Brandon farm between 1880 and 1900[14].

[14] The Brandon farm was used for these comparisons since there was no change in the access to railway transportation during the period.

Table 9.2

Counterfactual Values for Brandon Farm in 1900

Evaluation	Value	Acreage
"Actual value" 1900	$ 2,674	155
No price changes 1880 - 1900	$ 2,805	153
No dry farming techniques	$ 495	88
No new equipment	$ -462	64
"Actual value" 1880	$-1,434	46

The "actual" calculated value of the farm in 1880 was -$1,434, which increased to an "actual value of $2,674 by 1900. If prices had remained at their 1880 levels, but all other actual changes had occurred, the counterfactual 1900 value would have been $2,805 - greater than the "actual" value. Price changes therefore had a negative effect on settlement.

The effect of railway construction in areas which did not initially have branch lines would have been to increase local commodity prices. That however does not mean that those price changes were an exogenous contribution to increased settlement. As Lewis and Robinson[15] have shown, railway branch lines were built when farming in the area became feasible, and therefore in all likelihood would have been built at earlier dates if the necessary technological changes had occurred earlier. Delays in railway construction were therefore not an exogenous cause of delayed settlement[16].

[15] Lewis, F.D. and Robinson, D.R. "The Timing of Railway Construction on the Canadian Prairies." Canadian Journal of Economics 17, No. 2 (May 1984):340-352.

[16] Except in so much as technological change may have resulted in reductions in railway construction and operating costs, as was hypothesised by Lewis and Robinson (*Op.cit*) and Green (Green, A.G. "Productivity and Technological Change in the Canadian Railroad Industry." Paper delivered at the Canadian Economics Association Annual Meeting, Vancouver, 1983.).

Under the category of dry farming techniques are included all changes in field cropping practice which were not embodied in physical equipment. This division then includes such developments as fallowing, fall plowing and the development of more efficient crop rotations. If these changes had not occurred, the value of the Brandon farm in 1900 would have been $495, $2,179 less than the "actual" value. Dry farming techniques were therefore an important component of the increases in the value of Prairie farms.

The absence of the new equipment discussed in this thesis would have resulted in the Brandon farm being worth -$462 - i.e. still not worth occupying. The technical equipment embodied in this physical equipment was therefore of greater importance than the development of dry-farming techniques in the increase in the value of Prairie farms, but not by a substantial margin.

e) Agricultural Land Prices

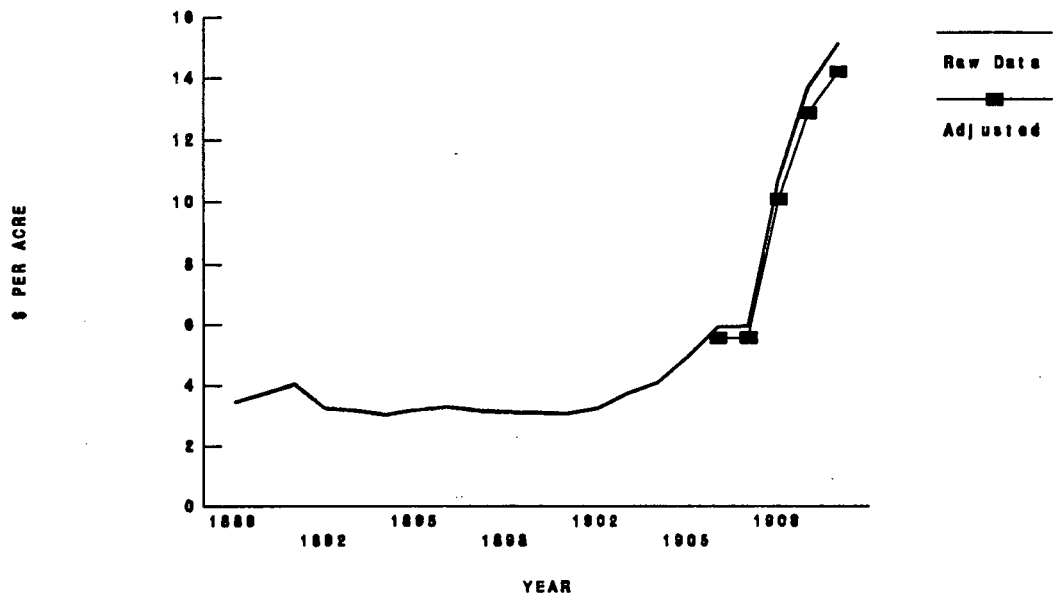
A useful corroboration of the calculated farm values would be a series of comparable land prices. Since the market was distorted by the presence of the free homestead land, such a series does not exist. Any land which was sold at some positive price would have been taken at a later date than that on which the comparable free land was first occupied. Without an extremely detailed analysis of individual plots of land, only a very generalised comparison can be made.

The Canadian Pacific Railway kept detailed records of the sale of its lands, and these are preserved in the Archives of the Glenbow Museum in Calgary. There are about 100,000 records, and these have never been individually analyzed. Summaries of each year's sales are available

in the annual reports of the C.P.R., and Figure 9.7 shows a graph of the average price at which CPR land was sold in each year from 1887 to 1910[17].

These data appear to support the farm values calculated in this thesis, in that they show that the value of unprepared Prairie farm land remained low until about 1905/1908, when it rose rapidly. There are however a number of problems which bias these figures, with the result that their evidence can yield only casual backing.

Figure 9.7



Average Price of Land Sold by the Canadian Pacific Railway 1889 - 1910

The principal problem is that of the quality of the land being sold. The CPR was able to choose which land it took for its grant, and the average quality of the CPR land is likely therefore

[17] Data taken from Hedges, J.B. Building the Canadian West. New York: Russell & Russell, 1939, Table 1, p. 388.

to have been of a higher quality than that of the remaining free homestead land. It is also probable that the CPR land was more valuable in that it was more likely to be serviced by a railway line, so that the CPR would have received the revenues from the freight traffic generated by farmers' activities. These biasses may have varied over time, resulting in changes in land values which would not necessarily have affected the free homestead land. Another issue which clearly biasses CPR land prices upward in the period after 1906 is that of the large blocks of irrigated land in south-west Alberta. In these areas the CPR received solid blocks of land[18] rather than the alternating sections typical of the remaining areas of land grant. The land in these areas was generally too dry for successful field cropping, but by the expenditure of large capital sums on the creation of canals could be made highly productive due to the reliability and controllability of their water supply.

Sales of this irrigated land began in earnest in about 1906[19], and since this land sold for approximately twice the price of adjacent non-irrigable land, the average price of CPR land will from that date have been biassed upwards, and not be comparable to the price of free homestead land.

The total area of irrigable sold up to 1938 was 233,701 acres, of a total of 20,204,045 acres[20]. This land was sold primarily between 1907 and 1912, during which period the total area of land sold by the CPR was 3,636,766 acres. Even if all the irrigable land was sold during this period, it therefore formed no more than 6½% of all sales, and if its price was twice that of the non-irrigable land, then the correction of this bias would reduce the average price of CPR land by about 6.1%. A price series with this correction made is shown also in Figure 9.7.

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[18] Hedges, J.B., *Op.cit.* p. 172.

[19] Hedges, J.B., *Op.cit*, p. 180.

[20] Hedges, J.B., *Op.cit.* Table V, p. 393.

This data series therefore does provide some support for the values calculated in this thesis, although the CPR land prices are not directly comparable with the calculated values.

f) Premature Settlement

The assumption used by Lewis[21] that land was occupied as soon as it became feasible to occupy appears to be incorrect for the earlier part of the time period he examined, in that settlers in fact took land even before the capitalized value of its future rents had reached zero. The definition of feasibility used by Lewis also differs significantly from that used here, in that he looks for an instantaneous zero profit, whereas this thesis uses an intertemporal model to evaluate a zero value of capitalized rents. Application of the more rigorous definition of feasibility used in this work would suggest that settlers would arrive at an earlier date than Lewis assumes, since Lewis does not allow for the time taken to break in the land before commencing wheat growing.

Lewis started his analysis with the year 1898, which was after the major proportion of the necessary development of agricultural technology had occurred. His analysis of the period 1989 to 1911 is therefore affected only to a relatively small extent by the changes in technology analyzed here. However Lewis's analysis cannot explain the occurrence of the 'Wheat Boom', or its initial failure to materialize, since it does not examine the conditions prevailing on the Prairies during the period from 1880 to 1898, which had inhibited the occurrence of earlier settlement.

Norrie's[22] hypothesis of the importance of the development of dry farming techniques is confirmed by the work of this thesis. Those techniques were clearly useful, though they can only be captured somewhat crudely by the approach used here. There were however many

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[21] Frank Lewis "Farm Settlement on the Canadian Prairies. 1898 to 1911", Journal of Economic History, Volume XLI, No.3, September 1981, pp. 517-535.

[22] K.H.Norrie, "The Rate of Settlement on the Canadian Prairies 1870 - 1911". Journal of Economic History, Vol.XXXV, No.2, June 1975, pp. 410-427.

innovations during the initial period of settlement, particularly in the area of labour augmenting implements, which were of greater importance than the development of dry farming techniques.

The stipulation in this thesis of static expectations is important in the determination of the calculated farm values, and it is quite likely that in fact the expectations of settlers were optimistic - anticipating higher prices for grains and more rapid railway construction than in fact occurred. Prior to about 1905, however, such optimism was unjustified, and correct forward looking expectations would have predicted lower prices, and therefore lower farm values. It would appear less likely that settlers foresaw the technical change which occurred, since each development was of a quite specific nature, and not amenable to anticipation.

g) The Price of Wheat at the Extensive Frontier

Harley[23] analyzed the evolution of the price of wheat at the extensive margin in the United States, and found that it was a statistically significant determinant of settlement. Whilst also important in Canada, the effect of the wheat price is more difficult to interpret, since the Canadian Prairie frontier did not move in the same manner as that in the United States. In Canada, the frontier was 'stalled' in the area near Winnipeg between 1860 and 1880, and then burst rapidly across the Prairies during the 1890s.

Data on prices and technology have been prepared only for decadal intervals, and since settlement of the farms modelled did not generally take place at those particular intervals, it is not possible to provide an accurate listing of the evolution of the price of wheat at the (moving) Canadian Prairie frontier. Using the data that are available, an outline of the movement of the price of wheat can be approximated as in Table 9.3.

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[23] Harley, C.K. "Western Settlement and the Price of Wheat 1872-1913." Journal of Economic History XXXVIII, No. 4 (1978): pp. 865-878

TABLE 9.3

Evolution of the Price of Wheat at the Extensive Frontier

Date	Location of Frontier	Expected Price of Wheat
1880	Winnipeg	64c
1890	Regina/Indian Head	69c
1900	Lacombe	54c
1910	Scott	90c

All that can be deduced from this table is that the relationship between the price of wheat and the rate of settlement is obscured by other factors. The price in fact rose slightly during the period of very slow settlement during the 1880s, but was at a low point in 1900, as the Wheat Boom started[24]. It is apparent that the price of wheat did not play an important role in the determination of the rate of Prairie settlement.

h) Railway Construction

The literature on the process of settlement generally treats railway construction as exogenous. Lewis and Robinson[25] correct this view, demonstrating that railways were built once they were profitable, and not before. Some branch lines could have been built earlier, but as Lewis and Robinson note, advancing construction by more than one or two years would have resulted in losses for the railway entrepreneur.

The work of Lewis and Robinson is entirely compatible with the predictions generated in this thesis. Railways were built by profit-maximizing entrepreneurs, who were not prepared to

[24] The price of wheat did not begin to rise until about 1904 - 1906, clearly after the start of the Wheat Boom.

[25] Lewis, F.D. and Robinson, D.R. "The Timing of Railway Construction on the Canadian Prairies." Canadian Journal of Economics 17, No. 2 (May 1984): pp. 340-352

invest in construction unless they could expect an adequate return on their money. As Lewis and Robinson show, the construction of branch lines was delayed until expected profits were positive, and had risen to a maximum. The lack of branch line construction in the 1880s and 1890s was then due to the fact that railway entrepreneurs knew that construction would be unprofitable. Once the technology was in place by the end of the century, many branch lines were built, since they could now yield their owners an adequate return. It is therefore not realistic to attribute the delay in Prairie settlement on the failure of railway entrepreneurs to seize profitable opportunities.

j) Dominion Lands Policy

Analysis of the free homestead component of the Dominion Lands Policy is complex, and unavoidably means proposing some counterfactual positive land sale price. With developing technology, changing commodity prices, and a growing railway network, land values were changing continuously. Suggesting that the government should have charged some positive price for the land it disposed of then involves proposing some alternative particular price. The higher that price the longer the resultant delay in settlement which it would have caused. Any such analysis therefore lacks precision.

It is also possible to use the results generated in this thesis to examine some aspects of the Dominion Lands Policy, in particular the land grants which were given to many Prairie branch lines in the 1880s and 1890s. In many cases, those land grants were given in order to induce the construction of a line which would otherwise not have been built. The results developed in this thesis, and those of Lewis and Robinson, suggest that the reasons that those lines were not being built was that railway entrepreneurs were aware that insufficient settlement would follow construction of the line for it to generate enough freight traffic to be profitable.

Conclusion

This thesis has shown that a major economic factor causing delay to the settlement of the Canadian Prairies was the need for the development of technology appropriate to the climatic and economic conditions of the region. Profitable settlement could not occur without those changes, and to that extent the Dominion Lands Policy had relatively little effect on the rate at which occupation occurred, although some aspects of the Policy may have assisted in the inception of the 'Wheat Boom'. Settlers took the free land which was offered, but took it as soon as its value had risen to that zero price, if not before.

Taking the land whilst its value was still less than zero implies that settlers may have been optimistic about what they could do on their farms, or about likely future prices or railway construction. Alternatively they may have seen their opportunity cost as being significantly lower than the level at which it is represented in this thesis. Migrants had other opportunities open to them - particularly the homestead lands available in the U.S.. The absence of settlers in the 1880s and 1890s reflected the fact that profitability on Canadian Prairie land was low in comparison to values in the American West.

For economic feasibility a farm needed at least about 50 acres of grains, for marketing, subsistence and animal feed. The short Prairie summer left only a short period in spring and fall for field preparation and crop collection. Because of this, in 1880 only a small area in the southwest of the Prairies was economically viable for grain farming. Farming technology improved rapidly during the period from 1880 to 1910, as farmers and equipment manufacturers in both Canada and the U.S. sought to cut costs. Seasonal labour constraints - particularly at harvest time - were binding on both sides of the border, but the effect was less critical further south. In the small grain areas of the United States the improved plows and reapers cut costs, facilitated greater acreages, and increased the profitability of existing farms. However on the Canadian Prairies and some of the marginal areas of the U.S. the effects of the improved

technology were more drastic. The technological change which occurred shifted large ares of land inside the extensive frontier of economic feasibility, and the inherent fertility of the Prairie soil resulted in the profitability of farming increasing significantly, resulting in the rapid settlement of the 'Wheat Boom'.

APPENDICES

APPENDIX 1

Seasonality Data - Experimental Farms

I) Brandon Manitoba (1889-1914)

CROP	STRAIN	AVERAGE DATE OF START OF SOWING	AVERAGE DATE OF START OF HARVESTING	AVERAGE DURATION (DAYS)
Wheat	Red Fife	April 25	August 24	122
	Marquis	April 28	August 14	109
	Preston	April 25	August 22	120
	Ladoga	April 24	August 18	117
	Stanley	April 26	August 21	118
Oats	Banner	May 7	August 23	102
Barley	Odessa	May 17	August 17	92
Peas	McKay/PA	April 29	September 7	132
Flax	Common	May 26	August 28	94
Turnips	Halls/Carters			
	Early Planting	May 19	October 11	145
	Late Planting	June 2	October 12	132
Mangels	Gate Post			
	Early Planting	May 20	October 1	134
	Late Planting	June 2	October 1	121
Potatoes	Empire State	May 22	September 26	127

II) Indian Head Saskatchewan (1889-1914)

CROP	STRAIN	AVERAGE DATE OF START OF SOWING	AVERAGE DATE OF START OF HARVESTING	AVERAGE DURATION (DAYS)
Wheat	Red Fife	April 22	August 29	129
	Marquis	April 19	August 19	122
	Preston	April 23	August 26	125
	Ladoga	April 23	August 24	123
	Stanley	April 23	August 27	126
Oats	Banner	May 3	August 25	114
Barley	Odessa	May 8	August 15	99
Peas	MacKay/PA	May 5	September 1	119
Flax	Common	May 22	August 29	99
Turnips	Halls/Carters			
	Early Planting	May 22	October 9	140
	Late Planting	May 31	October 9	131
Mangels	Gate Post			
	Early Planting	May 21	October 4	136
	Late Planting	June 1	October 4	126
Potatoes	Empire State	May 18	September 30	135

SEASONALITY DATA - EXPERIMENTAL FARMS

III) Rosthern Saskatchewan (1911-1920)

CROP	STRAIN	AVERAGE DATE OF START OF SOWING	AVERAGE DATE OF START OF HARVESTING	AVERAGE DURATION (DAYS)
Wheat	Red Fife	April 20	September 3	136
	Marquis	April 20	August 24	126
Oats	Banner	May 3	September 3	122
Barley	Duckbill	April 28	August 27	121
Peas	Prussian Blue	April 27	September 18	144
Turnips	Halls	May 16	October 15	152
Potatoes	Empire State	May 29	October 1	125

IV) Scott Saskatchewan (1911-1920)

CROP	STRAIN	AVERAGE DATE OF START OF SOWING	AVERAGE DATE OF START OF HARVESTING	AVERAGE DURATION (DAYS)
Wheat	Red Fife	April 20	September 3	136
	Marquis	April 20	August 24	126
Oats	Banner	May 3	September 3	123
Barley	Duckbill	April 28	August 27	121
Peas	Prussian Blue	April 27	September 18	144
Turnips	Halls	May 16	October 15	152
Potatoes	Empire State	May 29	October 1	125

V) Lethbridge Alberta (Non-Irrigated) (1908-1915)

CROP	STRAIN	AVERAGE DATE OF START OF SOWING	AVERAGE DATE OF START OF HARVESTING	AVERAGE DURATION (DAYS)
Wheat	Red Fife	April 7	August 10	125
(Spring)	Marquis	April 6	August 5	121
(Winter)	Kharkov	September 3	July 29	330
Oats	Banner	April 16	August 6	112
Barley	Odessa	April 21	August 4	104
Peas	Mackay	April 12	August 17	123
Corn	Longfellow	May 18	September 11	116
Sugar	Klein	May 9	October 18	162
Beet	Wanzleben			
Turnips	Halls	May 10	October 20	161
Potatoes	Empire State	May 18	October 20	144

SEASONALITY DATA - EXPERIMENTAL FARMS

VI) Lethbridge Alberta (Irrigated)(1908-1915)

CROP	STRAIN	AVERAGE DATE OF START OF SOWING	AVERAGE DATE OF START OF HARVESTING	AVERAGE DURATION (DAYS)
Wheat	Red Fife	April 10	August 17	129
(Spring)	Marquis	April 8	August 12	126
(Winter)	Kharkov	August 28	July 26	332
Oats	Banner	April 17	August 13	118
Barley	Odessa	April 24	August 9	107
Peas	Mackay	April 11	August 20	130
Corn	Longfellow	May 17	September 10	116
Sugar	Klein			
Beet	Wanzleben	May 4	October 15	164
Turnips	Halls	May 11	October 19	161
Potatoes	Empire State	May 18	October 7	142

VII) Lacombe Alberta (1907-1915)

CROP	STRAIN	AVERAGE DATE OF START OF SOWING	AVERAGE DATE OF START OF HARVESTING	AVERAGE DURATION (DAYS)
Wheat	Red Fife	April 11	September 6	147
(Spring)	Marquis	April 11	September 2	144
(Winter)	Kharkov	August 20	August 27	372
Oats	Banner	April 20	September 1	134
Barley	Odessa	April 21	August 19	121
Peas	Mackay	April 25	September 5	134
Indian Corn				
	White Cap			
	Yellow Dent	May 24	September 2	101
Potatoes	Empire State	May 20	September 24	127
Turnips Halls	Westbury	May 29	October 20	144
Sugar Beets				
	Klein Wanzleben	May17	September 30	136

SEASONALITY DATA - EXPERIMENTAL FARMS

VIII) Fort Vermillion Alberta (1911-1915)

CROP	STRAIN	AVERAGE DATE OF START OF SOWING	AVERAGE DATE OF START OF HARVESTING	AVERAGE DURATION (DAYS)
Wheat	Red Fife	April 25	August 26	123
	Marquis	April 26	August 22	120
Oats	Banner	May 1	August 15	107
Barley	Sidney	May 5	August 15	104
Peas	Arthur	May 1	August 19	111
Potatoes	Gold Coin	April 26	September 14	141
Turnips	Good Luck	May 8	September 14	129
Indian Corn		May 1	September 10	133
Sugar Beets				
	Klein Wanzleben	May 3	September 19	139

IX) Grand Prairie (1913-1915)

CROP	STRAIN	AVERAGE DATE OF START OF SOWING	AVERAGE DATE OF START OF HARVESTING	AVERAGE DURATION (DAYS)
Wheat	Marquis	April 14	August 25	135
Oats	Banner	April 21	August 15	117
Barley	Manchurian	April 23	August 8	108
Peas	Arthur	April 28	August 28	123

X) Grouard Alberta (1913-1915)

CROP	STRAIN	AVERAGE DATE OF START OF SOWING	AVERAGE DATE OF START OF HARVESTING	AVERAGE DURATION (DAYS)
Wheat	Red Fife	April 28	August 21	116
	Marquis	April 28	August 27	122
Oats	Banner	April 30	August 17	110
Barley	Odessa	April 30	August 8	101
Potatoes		May 16	September 15	122

APPENDIX 2

Dates of Start and Finish of Agricultural Season

Location	Average Date of Beginning of Spring[1]	Average Date of Last Killing Frost in Spring[3]	Average Date of First Killing Frost of Winter[4]	Average Date of Beginning of Winter[2]
Brandon	April 6	May 25	September 17	October 28
Indian Head	April 6	June 1	September 12	October 27
Lacombe	April 1	June 1	September 7	October 30
Lethbridge	March 25	May 20	September 17	November 9
Scott	April 7	May 27	September 5	October 24

APPENDIX 3

Geographic Details of Locations[5]

Location	Province(Current)	Latitude Degr	Latitude Min	Longitude Degr	Longitude Min
Brandon	Manitoba	49	50	99	57
Indian Head	Saskatchewan	50	32	103	31
Lacombe	Alberta	52	38	113	44
Lethbridge	Alberta	49	42	112	49
Scott	Saskatchewan	52	22	108	50

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[1] W. Burton Hurd and T.W.Grindley, Agriculture, Climate and Population of the Prairie Provinces of Canada., (Ottawa: King's Printer,, 1931), Figure 12, p. 14.

[2] W. Burton Hurd and T.W.Grindley, Agriculture, Climate and Population of the Prairie Provinces of Canada., (Ottawa: King's Printer, 1931), Figure 10, p. 13.

[3] Energy, Mines and Resources, "Canada - Last Frost in Spring", National Atlas of Canada, 5th Edition, Map MCR4035, 1981.

[4] Energy, Mines and Resources, "Canada - First Frost in Autumn", National Atlas of Canada, 5th Edition, Map MCR4036, 1981.

[5] Supply and Services Canada. Canada Gazeteer Atlas, (Ottawa, Canadian Government Publishing Centre: Macmillan of Canada, in cooperation with Energy, Mines and Resources, 1981).

APPENDIX 4a

Census Districts
1880 Census[6]

Location	
Brandon	Manitoba - Selkirk - Assiniboia
Indian Head	Territories - Qu'Appelle
Lacombe	Territories - Bow River
Lethbridge	Territories - Bow River
Scott	Territories - Battleford

APPENDIX 4b

Census Districts
1885 Census[7]

Location	
Brandon	Manitoba - Selkirk - Oakland
Indian Head	North West Territories - Assiniboia - Qu'Appelle
Lacombe	North West Territories - Alberta - Calgary and Red Deer
Lethbridge	North West Territories - Alberta - McLeod
Scott	North West Territories - Saskatchewan - Battleford

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[6] Tackaberry's Atlas of the Dominion of Canada. (Toronto: George N. Tackaberry Ltd., 1876), Territorial Evolution of Canada, MCR2306 (Ottawa: Energy, Mines and Resources Canada, 1969); Canada - Territorial Evolution, MCR4060 (Ottawa: Energy, Mines and Resources, 1982).

[7] Tackaberry's Atlas of the Dominion of Canada. (Toronto: George N. Tackaberry Ltd., 1876), Territorial Evolution of Canada, MCR2306 (Ottawa: Energy, Mines and Resources Canada, 1969); Canada - Territorial Evolution, MCR4060 (Ottawa: Energy, Mines and Resources, 1982).

APPENDIX 4c

Census Districts
1890 Census[8]

Location	
Brandon	Manitoba - Selkirk - Brandon
Indian Head	Territories - Assiniboia - Qu'Appelle
Lacombe	Territories - Alberta - Calgary and Red Deer
Lethbridge	Territories - Alberta - McLeod
Scott	Territories - Saskatchewan - Battleford

APPENDIX 4d

Census Districts
1900 Census[9]

Location	
Brandon	Manitoba - Brandon
Indian Head	Territories - Assininoia East
Lacombe	Territories - Alberta
Lethbridge	Territories - Alberta
Scott	Territories - Saskatchewan

APPENDIX 4e

Census Districts
1910 Census[10]

Location	
Brandon	Manitoba - Brandon
Indian Head	Saskatchewan - Qu'Appelle
Lacombe	Alberta - Red Deer
Lethbridge	Alberta - MacLeod
Scott	Saskatchewan - Saskatoon

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[8] The Home Knowledge Atlas. (Toronto: Home Knowledge Association, 1888), Territorial Evolution of Canada, MCR2306 (Ottawa: Energy, Mines and Resources Canada, 1969); Canada - Territorial Evolution, MCR4060 (Ottawa: Energy, Mines and Resources, 1982).

[9] Territorial Evolution of Canada, MCR2306 (Ottawa: Energy, Mines and Resources Canada, 1969); Canada - Territorial Evolution, MCR4060 (Ottawa: Energy, Mines and Resources, 1982); Atlas of Canada, 1906 (Ottawa: Canada, Department of the Interior, 1906).

[10] Territorial Evolution of Canada, MCR2306 (Ottawa: Energy, Mines and Resources Canada, 1969); Canada - Territorial Evolution, MCR4060 (Ottawa: Energy, Mines and Resources, 1982); Atlas of Canada, 1915 (Ottawa: Canada, Department of the Interior, 1915).

APPENDIX 4f

Census Districts
1920 Census[11]

Location	
Brandon	Manitoba - Division 7, #7, Oakland
Indian Head	Saskatchewan - Division 6, #156, Indian Head
Lacombe	Alberta - Division 8, #397, Lakeside
Lethbridge	Alberta - Division 2, #67
Scott	Saskatchewan - Division 13, #410, Round Valley

[11] Territorial Evolution of Canada, MCR2306 (Ottawa: Energy, Mines and Resources Canada, 1969); Canada - Territorial Evolution, MCR4060 (Ottawa: Energy, Mines and Resources, 1982); Atlas of Canada, 1915 (Ottawa: Canada, Department of the Interior, 1915).

APPENDIX 5

Railway Transportation Charges on Grain to Fort William (Net Difference from Winnipeg)

Location	Mileage to Winnipeg	1880	1890	1900	1910
Manitoba					
Brandon	133	5(E)	3	2	3
Saskatchewan					
Indian Head	320	13(IE)[12]	8	6	7½
Scott	600	20(IE)[13]	15(E)[14]	12[15]	17½
Alberta					
Lacombe	920	22(IE)[16]	17(E)	14	16
Lethbridge	757	20(IE)[17]	12	11	13

[12] CPR incorrectly expected to pass to the north. Nearest incorrectly expected point at Hubbard - 95 miles away.

[13] CPR incorrectly expected at Battleford, 35 miles away.

[14] Nearest (expected) railway at Saskatoon - 100 miles away.

[15] At Saskatoon - 100 miles away.

[16] CPR incorrectly expected at Edmonton - 80 miles away.

[17] Nearest Canadian railway - CPR expected at Battleford - 300 miles away.

APPENDIX 6

Sources of Raw Price Data

ALBERTA
Calgary
Calgary Herald -1 January to 31 December 1899
Edmonton
Edmonton Bulletin -6 December 1880 to 31 December 1889, and 1 January to 31 December 1909
Edmonton Journal -1 January 1896 to 31 December 1898
Lethbridge
Lethbridge News - 27 November 1885 to 31 December 1909
Macleod
MacLeod Gazette -1 July 1882 to 31 December 1889

MANITOBA
Brandon
Brandon Daily Mail -19 December 1882 to 22 September 1883
Brandon Weekly Sun -19 January 1885 to 31 December 1889
Emerson and West Lynne
Southern Manitoba Times - 18 September 1880 to 31 July 1893
Gladstone
Gladstone Age and Westbourne County Advertiser - 1 May 1883 to 31 December 1890
Selkirk
The Inter-Ocean - 1879 to 1880
Winnipeg
Farmers' Advocate (Western Edition)
Manitoba Free Press Daily - 6 July 1874 to 31 December 1899
Manitoba Free Press Weekly - 1 May 1877 to
Manitoba Gazette - 12 October 1878 to 31 December 1879
Manitoba Gazette and Trade Review - 1872 to 1874
Nor-Wester - 28 December 1859 to 24 November 1869
Daily Tribune - 28 January 1890 to 31 December 1900
The Manitoban - 15 October 1870 to 21 November 1874
Winnipeg Daily Times - 12 April 1879 to 30 July 1885
Winnipeg Daily Tribune - 1879 to March 1880
Winnipeg Weekly Times - 1879 to 1885

ONTARIO
Farmers' Advocate (Eastern Edition)

SASKATCHEWAN
Grain Growers Guide -1909
Battleford
Saskatchewan Herald - 25 August 1878 to 31 December 1889
Indian Head
Qu'Appelle Vidette - 9 October 1884 to 31 December 1889
Prince Albert
Prince Albert Times - 1 November 1882 to 31 December 1889
Regina
Regina Leader - 1 March 1883 to 31 December 1889
Regina Standard - 29 January 1891 to 31 December 1899
Saskatoon
Saskatoon Star Phoenix - 17 October 1902 to 31 December 1909

APPENDIX 7

Details of Commodity Price Weighting Schemes

1) Combination of Different Prices for the Same Commodity

The first issue which had to be sorted out was that of combining the individual price series for a commodity when the different prices were for different qualities of the good. This issue arose only for prices in the Winnipeg market, for which the market reports were significantly more detailed than those for other locations. The methodology used for the various commodities is outlined below:

Wheat

Eleven different quality categories appeared in the market reports at various times. Initially, two or three prices for unspecified grades appeared - these were combined on a simple arithmetic average basis. At later dates, prices appeared for No. 1 Hard, No. 2 Hard, No. 1 Northern, No. 2 Northern, and two prices for reject/frozen wheat.

Since the purpose of this work is to generate a producers' price series, the price needed is that of the average quality of wheat grown, rather than of a constant grade of wheat. Formal grading of wheat was not introduced until exports began in 1881, so there is little problem in (and little option to) using an arithmetical average of the ungraded prices published before that time.

After 1881, the quality of the wheat produced varied from year to year. The Manitoba Free Press (February 13, 1890), published the following statistics for wheat grading for the harvests of 1886, 1887 and 1888:

*Man Free Press, January 23, 1884 - '1883 Wheat crop - less than one quarter graded No. 1 Hard - three quarters was damaged or frozen'.

Table A7.1

	1886	1887	1888
No. 1 Hard	61%	10	19
No. 2 Hard	9	11	22½
No. 3 Hard	0	0	17
No. 1 Northern	16	40	0
Nos. 2 & 3 Northern	4	18¼	0
Nos. 1 & 2 Spring	5	5¼	0
Rejected	0	15	6½
Other	0	0	35
	100	100	100

On 1 January 1907, the Manitoba Free Press published the following information on the grades of wheat received by rail at Port Arthur.

Table A7.2

	1905		1906	
	Cars	%	Cars	%
No. 1 Hard	522	1.8	2,461	9.8
No. 1 Northern	17,452	58.6	10,639	42.6
No. 2 Northern	6,827	22.9	6,646	26.6
No. 3 Northern	936	3.1	669	2.7
Sundry	156	0.5	331	1.3
Smutty	2,499	8.4	2,633	10.5
Reject	1,198	4.0	1,510	6.0
No. grade	167	0.6	110	0.4
	29,757		25,000	

It is not correct to take these figures as bearing a strict proportion to the overall harvest, since there is bias in the quality of grain sold. Some of the worst grain would have been too poor to market, and would have been retained on the farm for seed and for animal feed. Some of the better grain would have been sold to local mills for grinding, and would not appear in the export figures.

Given these sources of bias, and a lack of systematic data, it is not possible to accurately determine an 'average' grade of wheat. Nonetheless, it is clear that the use of the top grade,

No. 1 Hard, would exaggerate average receipts. The average grade was therefore taken to be No. 2 Hard.

The relationship of the price of No. 2 Hard wheat to the other grades was then determined by regressing the price of each other grade of wheat on the price of No. 2 Hard. The Cochrane-Orcutt iterative procedure was used to correct for autocorrelation.

Table A7.3

	R2	DW	No. Observations
W2 = 2.5865 + 0.9590W1 (1.1640) (28.903)	0.9857	1.9267	74
W2 = -1.9020 + 1.0257W3 (-2.6057) (94.233)	0.9969	2.0948	61
W2 = 21.945 + 0.7013W4 (7.1059) (15.911)	0.9603	2.0040	44
W2 = 53.541 + 0.2075W5 (7.0433) (1.8401)	0.6493	2.1799	35
W2 = 48.82 + 0.2602W6 (3.2993) (1.1508)	0.0877	2.0305	14
W2 = 68.94 + 0.0049WD (15.174) (0.0840)	0.7475	2.0150	41

Where:

W1 = No. 1 Hard

W2 = No. 2 Hard

W3 = No. 1 Northern

W4 = No. 2 Northern

W5 = No. 1 Reject

W6 = No. 2 Reject

WD = Damaged or Frozen

The wheat price series was then generated by transforming each different quality by these functions, and taking a weighted arithmetic average of these transformed prices. The quantity

weights used were based on the export gradings, with an allowance made for wheat which was not exported.

Wholesale Butter

In this case, prices for six different qualities were found : two prices for "Print" or "Roll", two for "Tub" and two for "Inferior". There was no information as to which quality was most prevalent, so the prices were standardised to the average of the "Tub" prices, that being the medium grade.

Retail Butter

Six different prices were encountered for this commodity: two for "Best" butter, two for "Inferior", and two for ungraded butter. Observations for the ungraded butter never overlapped those for the more specific grades, and so an arithmetic average of the ungraded prices was used whenever those were the only prices available. For the other four prices, the mean quality was assumed to lie between the two grades.

Beef Cattle

Here again six price grades were encountered: two prices for "Common" cattle, two for "Prime" and two for ungraded. The same averaging process as before was used here.

Retail Beef

Eight different price grades were found for this commodity: two for "Meat", two for "Roast Beef", two for "Steak", and two for "Boiling Beef". Here the price was standardised to that of Roast Beef, that being the median price grade.

Flour

Seven prices were encountered here: "Process", "XXXX", "XXX", "Strong", "Superfine", and two for ungraded flour. Ordinary Least Squares was used to estimate the relationship between these different grades, and prices were standardised to the "XXX" grade.

Wood

In this case, various different types of wood were used, including oak, poplar, tamarac, and often an unspecified grade. The average quality was assumed to be poplar or ungraded, if that was the only price available.

2)Seasonal Quantity Weights

Some simple judgement was used in the assessment of the monthly quantity weighting, since I could find very little systematic contemporary information. For some commodities, data on quantities shipped out of the province by rail were available for some period after 1900. These data were used for the pre-1900 period, due to a lack of any better information.

A brief description of the derivation of the weights used for each commodity is outlined below, followed by a schedule of the weights used.

Wheat - The proportions used were taken from Census and Statistics Monthly, December 1924 - 'Seasonal Movement of Wheat, 1920/21 to 1923/4' - 'Cars Loaded in Western Canada'.

Oats, Barley and Peas - These were sold for animal feedstuffs, either directly to nearby farmers or to wholesalers. The bulk of deliveries were in the four month period following the harvest (Oats - October to January; Barley - September to December). Little was sold between June and August, and sales in Winter were light.

Flax - Flax was sold for commercial purposes only. It was harvested in late August and the bulk of sales were from September to November.

Potatoes, Beets - The crop was harvested from August to October with the majority of sales between September and December. Light sales during winter and spring.

Turnips - Sold mostly for animal feedstuff, they were harvested in October and the bulk of sales were from October to December.

Shorts, Chop - These are animal feedstuffs made from oats, barley or low grade wheat. I assumed that sales were constant throughout the year.

Hay - Hay was harvested in June, July and August, with the bulk of sales from July to December.

Flour - Sales assumed constant throughout the year.

Carrots, tomatoes, beans - Highly seasonal. The bulk of sales were assumed to occur between June and November.

Onions - (Imported) - Sales were assumed to be constant throughout the year.

Wood - This was initially used mostly as a heating fuel, but after 1890 sizable quantities were also used to fire the steam engines used to power the threshing machines. I assumed that the principal sales were during winter, from October to March.

Cattle - Proportions based on a report in the Manitoba Free Press, January 1909 "Cattle Received at the Winnipeg Stock Yard (1906 to 1908)". The cattle sales listed in that report are assumed to have been primarily for export to Eastern Canada, and are assumed to comprise 50% of all sales. The remaining 50% of sales are assumed to have been to local butchers, at the seasonal rates outlined below for wholesale and retail meat.

Wholesale and retail beef, pork, mutton - The only apparent systematic seasonal variation in quantity sold was that little slaughtering was carried out during the planting and harvesting seasons. The quantities sold during April, May, July, August, September and October are therefore assumed to have been one third of the quantities sold during the remaining months.

Hogs - Proportions used are based on a report in the Manitoba Free Press, January 8, 1908, page 11 - 'Hogs Received Weekly during 1907 at the Winnipeg Stock Yards'. Adjusted for export/local consumption in the same way as cattle.

Sheep - Assumed to be sold in the same seasonal pattern as cattle.

Calves, veal and lambs - These are inherently seasonal - 50% are assumed to have been sold in May and June, 20% in April and July, with the remainder spread equally over the remaining months.

Ham and bacon - These were preserved meats, and are assumed to have been sold at a constant rate throughout the year.

Chickens - I assumed that 25% were sold in December, the remainder at a constant rate during the rest of the year.

Fish - Caught mostly in the quiet agricultural season. I assumed that 70% of the supply was caught between October and March, and 30% from April to September.

Butter, cheese - The supply of these commodities was constrained by the availability of milk, which was available only during the summer months. I assumed that butter was sold from May to September at three times the rate as the rest of the year.

Eggs - I assumed that eggs were sold at a constant rate throughout the year.

Wool - 70% was assumed to be sold during the two shearing seasons of May - June and October - November, the rest at a constant rate during the remainder of the year.

COMMODITY WEIGHTS

As %

	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEPT	OCT	NOV	DEC
Wheat	5	4	4	4	4	3	2	2	12	26	21	13
Oats	10	9	7	5	5	4	3	4	6	20	15	12
Barley	7	6	5	5	5	4	3	3	15	20	17	10
Flax	5	2	2	2	2	2	1	4	20	30	25	5
Peas	7	6	5	5	5	4	3	3	15	20	17	10
Potatoes												
- wholesale	7	7	6	6	2	2	5	5	10	25	15	10
- retail	7	7	6	6	2	2	5	5	10	25	15	10
Turnips												
- wholesale	8	8	7	6	5	4	3	4	10	20	15	10
- retail	8	8	7	7	5	4	3	4	10	20	15	10
Shorts	8	8	8	8	8	8	9	9	9	9	8	8
Chop	8	8	8	8	8	8	9	9	9	9	8	8
Hay												
- native	5	3	3	3	5	8	15	15	15	10	10	8
- timothy	5	3	3	3	5	8	15	15	15	10	10	8
Flour	8	8	9	8	8	9	8	8	9	8	8	9
Carrots												
- wholesale	3	3	3	3	3	15	15	15	15	15	5	5
- retail	3	3	3	3	3	15	15	15	15	15	5	5
Onions												
- farmers	8	8	9	8	8	9	8	8	9	8	8	9
- wholesale	8	8	9	8	8	9	8	8	9	8	8	9
- retail	8	8	9	8	8	9	8	8	9	8	8	9
Beets												
- farmers	5	5	5	5	5	5	8	10	15	15	12	10
- retail	5	5	5	5	5	5	8	10	15	15	12	10
Tomatoes												
- retail	3	3	3	3	3	10	15	15	15	10	12	8
Beans												
- wholesale	3	3	3	3	3	10	15	15	15	10	12	8
- retail	3	3	3	3	3	10	15	15	15	10	12	8
Wood	17	15	10	5	2	2	2	4	8	10	10	15
Beef - live	7	8	7	4	4	9	6	8	8	13	15	11
- wholesale	12	13	12	4	4	13	4	5	4	4	12	13
- retail	12	13	12	4	4	13	4	5	4	4	12	13

	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEPT	OCT	NOV	DEC
Pigs - live	11	10	11	5	7	12	5	5	3	7	11	13
- wholesale	12	13	12	4	4	13	4	5	4	4	12	13
- retail	12	13	12	4	4	13	4	5	4	4	12	13
Sheep - live	7	8	7	4	4	9	6	8	8	13	15	11
- wholesale	12	13	12	4	4	13	4	5	4	4	12	13
- retail	12	13	12	4	4	13	4	5	4	4	12	13
Calves - live	4	3	4	10	20	15	8	5	8	10	3	10
- retail	3	4	4	10	25	25	10	3	4	4	4	4
Veal												
- wholesale	3	4	4	10	25	25	10	3	4	4	4	4
- retail	3	4	4	10	25	25	10	3	4	4	4	4
Lambs - live	3	4	4	10	25	25	10	3	4	4	4	4
- retail	3	4	4	10	25	25	10	3	4	4	4	4
Ham												
- wholesale	8	8	9	8	8	9	8	8	9	8	8	9
- retail	8	8	9	8	8	9	8	8	9	8	8	9
Bacon												
- farmers	8	8	9	8	8	9	8	8	9	8	8	9
- wholesale	8	8	9	8	8	9	8	8	9	8	8	9
- retail	8	8	9	8	8	9	8	8	9	8	8	9
Chickens												
- wholesale	7	7	6	7	7	7	7	6	7	7	7	25
- retail	7	7	6	7	7	7	7	6	7	7	7	25
Fish												
- wholesale	12	12	11	5	5	5	5	5	5	12	12	11
- retail	12	12	11	5	5	5	5	5	5	12	12	11
Butter												
- wholesale	4	5	4	5	13	14	14	14	13	5	4	5
- retail	4	5	4	5	13	14	14	14	13	5	4	5
Cheese												
- wholesale	4	5	4	5	13	14	14	14	13	5	4	5
- retail	4	5	4	5	13	14	14	14	13	5	4	5
Eggs												
- wholesale	8	8	9	8	8	9	8	8	9	8	8	9
- retail	8	8	9	8	8	9	8	8	9	8	8	9
Wool	4	4	3	4	17	18	4	4	3	17	18	4

APPENDIX 8

Temporal and Spatial Price Patterns

All price data in logarithmic form

	Wheat		Oats		Barley	
R^2	0.9123		0.8977		0.9122	
# Obs	800		836		687	
DW	2.0743		2.1531		2.2617	
D JAN	0.0243	(1.6082)	0.0547	(2.2602)	-0.0144	(-0.7829)
D FEB	0.0320	(1.6994)	0.0469	(1.5682)	0.0096	(0.4233
D MAR	0.0388	(1.8379)	0.0582	(1.7570)	0.0044	(0.1739)
D APR	0.0649	(2.7170)	0.1161	(3.1639)	0.0212	(0.7582)
D MAY	0.0939	(3.9013)	0.1091	(2.8707)	0.0329	(1.1900)
D JUN	0.0795	(3.3892)	0.1220	(3.2193)	0.0152	(0.5522)
D JLY	0.1158	(4.9527)	0.2845	(7.8922)	0.0627	(2.1973)
D AUG	0.0927	(3.8891)	0.2467	(6.7141)	0.0801	(2.6640)
D SEP	0.0699	(3.0737)	0.1116	(3.1105)	0.0525	(1.7344)
D OCT	0.0297	(1.5020)	-0.0254	(-0.8129)	-0.0496	(-1.9050)
D NOV	-0.0058	(-0.3829)	-0.0165	(-0.7025)	-0.0258	(-1.3574)
D 76/77	0.0060	(0.0628)	0.1010	(0.5847)	0.2862	(2.5594)
D 77/78	-0.0726	(-0.8696)	-0.0653	(-0.4326)	0.1078	(1.0730)
D 78/79	-0.2069	(-2.6529)	0.0565	(0.4098)	0.1685	(1.8552)
D 79/80	-0.0803	(-1.1409)	-0.0523	(-0.4324)	0.1329	(1.6628)
D 80/81	-0.0658	(-1.1035)	-0.1891	(-1.9171)	0.0677	(0.9371)
D 81/82	0.0698	(1.4096)	0.1311	(1.6601)	0.2331	(4.1504)
D 83/84	-0.1445	(-5.2210)	-0.2277	(-4.6448)	-0.1072	(-3.2856)
D 84/85	-0.1731	(-3.9991)	-0.2680	(-3.8304)	-0.1412	(-2.7437)
D 85/86	-0.2082	(-4.1076)	-0.4988	(-6.3532)	-0.1817	(-2.9733)
D 86/87	-0.2473	(-4.6693)	-0.4985	(-6.6251)	-0.0945	(-1.4750)
D 87/88	-0.3019	(-5.5590)	-0.6660	(-10.484)	-0.1908	(-2.9939)
D 88/89	-0.1402	(-2.2544)	-0.6007	(-6.7991)	-0.2425	(-3.3608)
D 89/90	-0.2219	(-3.1731)	-0.5194	(-4.9500)	-0.2649	(-2.7049)
DREMOTE	0.7685	(9.8348)	1.2032	(8.9243)	0.6630	(7.3454)
DBRANDN	-0.3014	(-4.4099)	-0.3414	(-2.6834)	-0.1788	(-2.2284)
DGLDSTN	-0.1629	(-2.8467)	-0.1015	(-0.9134)	-0.1592	(-2.3985)
DPRTAGE	-0.1135	(-1.1698)	-0.5786	(-3.3411)	0.0850	(0.8217)
DWSTLYN	0.0276	(0.3950)	-0.4402	(-3.6103)	-0.0698	(-0.8802)
CONST	4.3645	(86.985)	3.8390	(42.235)	3.7683	(64.518)

Temporal and Spatial Price Patterns

All price data in logarithmic form

	Potatoes Wholsl		Flour Wholsl		Hay (Native)	
R^2	0.8405		0.9645		0.8696	
# Obs	650		605		645	
DW	2.1144		2.1776		2.3577	
D JAN	0.0049	(0.0930)	-0.0522	(-4.3407)	0.0127	(0.4124)
D FEB	0.0164	(0.2451)	-0.0691	(-4.3446)	0.0106	(0.2619)
D MAR	0.0642	(0.8489)	-0.0841	(-4.7792)	-0.0010	(-0.0214)
D APR	0.1417	(1.7349)	-0.7265	(-3.9003)	0.0587	(1.1568)
D MAY	0.1835	(2.2572)	-0.0944	(-5.0483)	0.1821	(3.6001)
D JUN	0.1263	(1.5203)	-0.0914	(-4.8225)	0.1398	(2.7592)
D JLY	0.3830	(4.5701)	0.0806	(4.3753)	0.2037	(4.0737)
D AUG	0.2011	(2.4555)	0.0859	(4.6320)	0.1294	(2.3984)
D SEP	0.0597	(0.7671)	0.0775	(4.2604)	0.1008	(1.9417)
D OCT	-0.0807	(-1.1386)	0.0616	(3.6525)	0.1176	(2.6233)
D NOV	-0.0334	(-0.6482)	0.0422	(3.3021)	0.0601	(1.8627)
D 76/77	-0.0888	(-0.2979)	-	-	-0.0152	(-0.0745)
D 77/78	0.2388	(0.9945)	-	-	-0.1707	(-0.9169)
D 78/79	-0.0087	(-0.0383)	-	-	-0.4973	(-2.9738)
D 79/80	-0.4912	(-2.4438)	-	-	-0.3623	(-2.4253)
D 80/81	-0.3654	(-2.2392)	-0.0385	(-0.5257)	-0.4670	(-3.0282)
D 81/82	-0.2675	(-1.4181)	-0.0142	(-0.2750)	-0.2811	(-2.1096)
D 83/84	-0.2685	(-2.4792)	-0.2145	(-9.7769)	-0.2236	(-2.9571)
D 84/85	0.1703	(1.2254)	-0.4556	(-15.871)	-0.5548	(-5.3700)
D 85/86	-0.3463	(-2.2462)	-0.5824	(-16.524)	-0.6226	(-5.2040)
D 86/87	0.1936	(1.4054)	-0.6626	(-14.202)	-0.2582	(-2.3691)
D 87/88	0.0835	(0.6318)	-0.8257	(-12.960)	-0.3283	(-2.9573)
D 88/89	-0.3616	(-2.2035)	-0.9076	(-10.401)	-0.3356	(-2.6783)
D 89/90	0.2582	(1.1417)	-	-	-0.3715	(-2.4415)
DREMOTE	0.2749	(1.0893)	1.0137	(9.0692)	-0.0235	(-0.1347)
DBRANDN	-	-	-0.1581	(-2.0303)	-0.1147	(-0.8366)
DGLDSTN	-0.8305	(-5.4212)	0.2520	(1.7063)	-0.3438	(-3.0976)
DPRTAGE	0.7588	(3.1111)	-0.7256	(-3.2631)	-0.1145	(-0.6287)
DWSTLYN	0.1098	(0.5099)	-	-	-0.0217	(-0.1094)
CONSTNT	3.9774	(28.716)	5.7523	(29.718)	6.8039	(63.679)

Temporal and Spatial Price Patterns

All price data in logarithmic form

	Wood		Beef Retail		Pork Retail	
R^2	0.9505		0.9183		0.9789	
# Obs	584		271		196	
DW	2.1720		2.2403		2.1374	
D JAN	-0.0210	(-1.1020)	-0.0063	(-0.3884)	-0.0237	(-1.7508)
D FEB	-0.0198	(-0.8672)	0.0074	(0.3441)	-0.0241	(-1.3664)
D MAR	-0.0313	(-1.1405)	0.0112	(0.4664)	0.0029	(0.1497)
D APR	-0.0256	(-0.8503)	0.0639	(2.4385)	0.0235	(1.0012)
D MAY	-0.0062	(-0.2092)	0.0493	(1.8554)	0.0462	(2.0792)
D JUN	-0.0188	(-0.6240)	0.0553	(2.0988)	0.0724	(3.5470)
D JLY	-0.0307	(0.9675)	0.2557	(9.5754)	0.1177	(4.6109)
D AUG	0.0597	(1.9198)	0.2330	(8.7616)	0.0710	(2.6593)
D SEP	0.0696	(2.1857)	0.2216	(9.0244)	0.0274	(1.1215)
D OCT	0.0329	(1.4122)	0.1266	(5.1131)	0.0164	(0.7857)
D NOV	0.0231	(1.1637)	0.0123	(0.7204)	0.0079	(0.4795)
D 76/77	-0.3734	(-3.7098)	-	-	-	-
D 77/78	-0.4026	(-4.3208)	-	-	-	-
D 78/79	-0.3096	(-3.9560)	-	-	-	-
D 79/80	-0.3505	(-5.3833)	-	-	-	-
D 80/81	-0.4279	(-7.1450)	-	-	-	-
D 81/82	-0.1844	(-3.5312)	-	-	-	-
D 83/84	-0.0324	(-1.0147)	-0.1736	(-6.9667)	-0.0581	(-2.6475)
D 84/85	-0.3459	(-9.1962)	-0.4040	(-12.456)	-0.2740	(-8.2214)
D 85/86	-0.4177	(-10.999)	-0.6194	(-16.944)	-	-
D 86/87	-0.4089	(-6.9314)	-	-	-1.5562	(-41.472)
D 87/88	-0.3658	(-6.4192)	-	-	-1.1263	(-24.756)
D 88/89	-0.5367	(-7.0947)	-	-	-	-
D 89/90	-0.5432	(-6.5742)	-	-	-	-
DREMOTE	-0.5778	(-6.8915)	0.0412	(0.7471)	0.4813	(10.055)
DBRANDN	0.2486	(3.2475)	0.0059	(0.1203)	0.1723	(4.7918)
DGLDSTN	-0.6941	(-11.069)	-0.0274	(-0.5928)	-	-
DPRTAGE	-0.3312	(-3.9555)	-0.0479	(-0.8133)	-0.0362	(-0.8477)
DWSTLYN	0.1660	(2.3324)	-0.7241	(-14.594)	-	-
CONSTNT	6.4652	(150.18)	2.7370	(71.334)	2.8666	(102.77)

Temporal and Spatial Price Patterns

	Butter Wholsl		Eggs Wholsl	
	All price data in logarithmic form			
R^2	0.8967		0.9061	
# Obs	787		625	
DW	1.9365		2.0534	
D JAN	-0.0027	(-0.0899)	0.0060	(0.1708)
D FEB	-0.0426	(-1.0738)	-0.0474	(-1.0869)
D MAR	-0.0766	(-1.7801)	-0.1630	(-3.5631)
D APR	-0.1096	(-2.2857)	-0.4128	(-8.6657)
D MAY	-0.1634	(-3.5369)	-0.4651	(-9.6109)
D JUN	-0.2293	(-5.0102)	-0.5186	(-10.573)
D JLY	-0.1612	(-3.6433)	-0.4006	(-8.4244)
D AUG	-0.0836	(-1.8616)	-0.3033	(-6.6240)
D SEP	-0.0825	(-1.9009)	-0.2828	(-6.1831)
D OCT	-0.0157	(-0.4012)	-0.1737	(-4.1562)
D NOV	-0.0621	(2.0552)	-0.0700	(-2.1125)
D 76/77	0.0233	(0.1635)	-	-
D 77/78	-0.1834	(-1.4562)	-	-
D 78/79	-0.3140	(-2.5774)	-	-
D 79/80	-0.3012	(-2.5914)	-0.1797	(-1.3787)
D 80/81	-0.3472	(-2.7917)	-0.3347	(-2.8525)
D 81/82	-0.3175	(-2.5619)	-0.2698	(-2.1612)
D 83/84	-0.0678	(-1.2599)	-0.1192	(-1.8108)
D 84/85	-0.3965	(-6.0074)	-0.3043	(-4.0805)
D 85/86	-0.6015	(-7.6352)	-0.6088	(-7.7870)
D 86/87	-0.6765	(-8.4378)	-0.5694	(-7.1968)
D 87/88	-0.6314	(-7.9335)	-0.5585	(-6.5402)
D 88/89	-0.6385	(-5.6299)	-0.5764	(-7.1296)
D 89/90	-0.6946	(-5.1609)	-0.4999	(-5.4901)
DREMOTE	1.0079	(6.0258)	0.4080	(3.1670)
DBRANDN	0.0321	(0.3343)	-	-
DGLDSTN	-0.1108	(-1.4362)	-0.2249	(-4.9443)
DPRTAGE	-0.0121	(-0.0879)	0.2069	(2.2032)
DWSTLYN	-	-	0.0361	(0.2156)
CONSTNT	3.5101	(44.655)	3.6706	(51.587)

APPENDIX 9
Commodity Price Comparisons

FIGURE A9.1a

Comparison of oat prices in Toronto and Winnipeg.The Winnipeg price wasthat of an 'importable' commodity prior to 1875. Occasional importation continued until about 1883, after which there was little systematic importation or export.

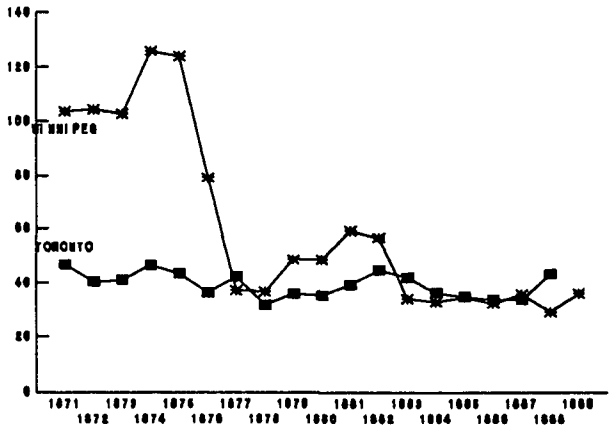


FIGURE A9.1b

Comparison of oat prices in Winnipeg and "Isolated" places. Prices in isolated locations were higher than in Winnipeg, and fell *before* the railway was built connecting that location to the National Market.

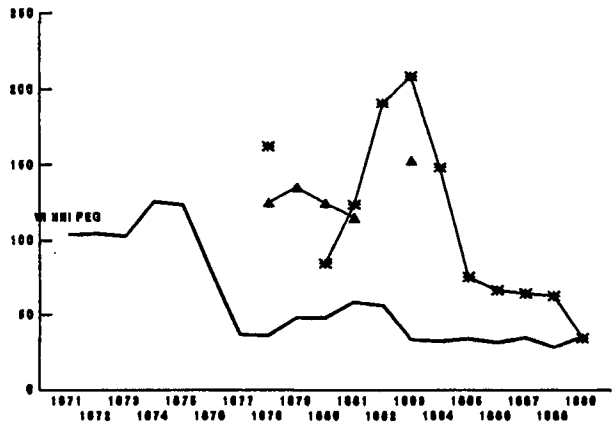


FIGURE A9.1c

Comparison of oat prices in Winnipeg with those in 'nearby' markets. Again the nearby prices were highly correlated with those in Winnipeg, and the difference was closely related to transportation costs.

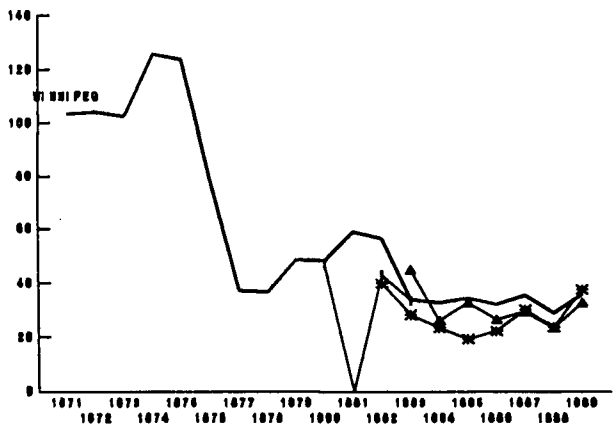


FIGURE A9.2a

Comparison of barley prices in Toronto and Winnipeg. The Winnipeg price changed from being an 'importable' price to an exportable price in 1876

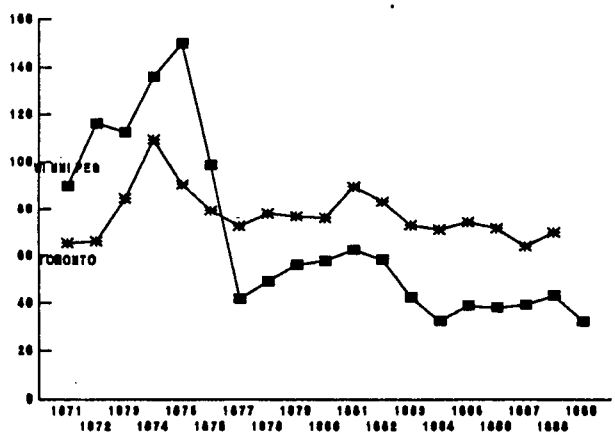


FIGURE A9.2b

Comparison of barley prices in Winnipeg and "Isolated" places. Prices in isolated locations were again higher than in Winnipeg, and fell *before* the railway was built connecting that location to the National Market.

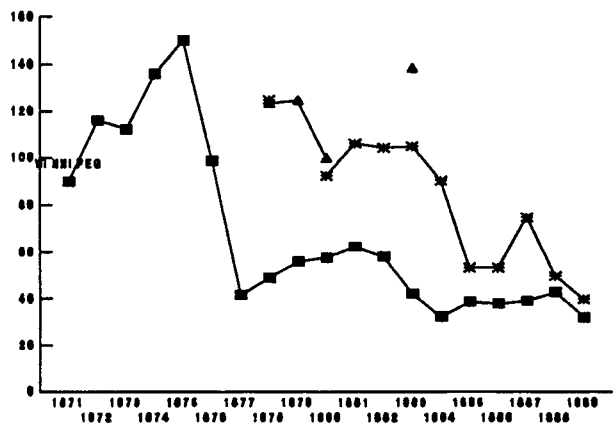
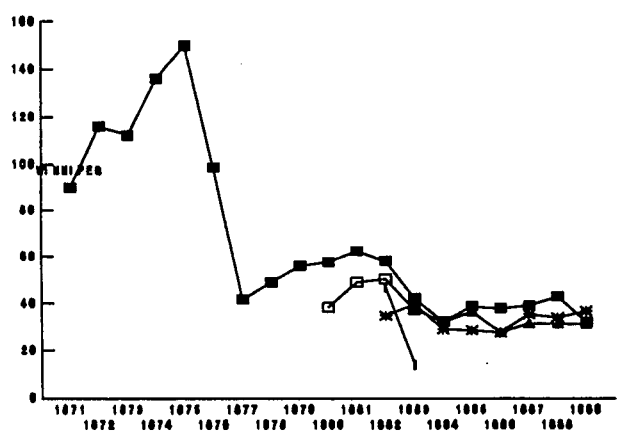


FIGURE A9.2c

Comparison of barley prices in Winnipeg with those in 'nearby' markets, which were already at this time connected by rail with Winnipeg. Nearby prices were again highly correlated with those in Winnipeg, with the difference being closely related to transportation costs.



APPENDIX 10

Access to Railway Transportation

Manitoba

Brandon
1880 - No Access, but CPR expected nearby within one year.
1890 on - CPR Main Line built through Brandon by 15 September 1881[18]

Saskatchewan

Indian Head
1880 - No access, but CPR (incorrectly) expected within one year at Hubbard - 95 miles (direct) away.
1890 on - CPR Main Line built through Indian Head by 1 October 1882[19].

Scott
1880 - No access - nearest (incorrectly) expected railway at Battleford - 35 miles (direct) away.
1890 - No access - nearest expected railway at Saskatoon - 100 miles (direct) away.
1900 - No close access - nearest railway at Saskatoon.
1910 - Grand Trunk Pacific Railway built by 1908[20].

Alberta

Lacombe
1880 - No access - nearest (incorrectly) expected railway at Edmonton - 80 miles (direct) away.
1890 - No access, but railway expected within one year.
1900 on - Calgary and Edmonton railway built by 11 August 1891[21]

Lethbridge
1880 - No access - nearest (incorrectly) expected railway at Battleford - 300 miles (direct) away.
1890 on - Northwest Coal and Navigation Company Railway built 24 September 1885[22].

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[18] Omer LaValée, Van Horne's Road, (Montreal: Railfare Books, 1974), p. 301.

[19] LaValée, op.cit., p. 301.

[20] Bladen, op.cit., p. 100.

[21] Bladen, op.cit., p. 84.

[22] Bladen, op.cit., Volume 5, p. 59.

APPENDIX 11a

Annual Price Data

Wheat

Year	Battleford	Brandon	Edmonton	Emerson	Gladstone	Portage	Rapid City	Stonewall	West Lynne	Winnipeg
1871	NA	NA	NA	NA	NA	NA	NA	NA	NA	106.07
1872	NA	NA	NA	NA	NA	NA	NA	NA	NA	110.66
1873	NA	NA	NA	NA	NA	NA	NA	NA	NA	137.50
1874	NA	NA	NA	NA	NA	NA	NA	NA	NA	133.32
1875	NA	NA	NA	NA	NA	NA	NA	NA	NA	150.88
1876	NA	NA	NA	NA	NA	NA	NA	NA	NA	110.91
1877	NA	NA	NA	NA	NA	NA	NA	NA	NA	70.22
1878	150.00	NA	250.00	NA	NA	45.00	NA	NA	NA	56.27
1879	200.00	NA	NA	NA	NA	NA	NA	NA	NA	66.19
1880	NA	NA	219.83	NA	NA	98.68	NA	NA	71.19	84.01
1881	NA	NA	203.78	NA	NA	NA	NA	NA	88.28	85.13
1882	NA	61.50	210.59	77.50	NA	75.77	69.10	NA	77.11	83.56
1883	NA	68.04	205.11	77.30	63.63	70.86	50.00	74.58	77.41	84.01
1884	NA	53.78	142.86	NA	56.83	NA	NA	NA	NA	72.10
1885	NA	54.42	117.08	NA	45.79	NA	NA	NA	NA	72.52
1886	NA	51.57	93.40	NA	49.01	NA	NA	NA	NA	62.76
1887	NA	52.34	90.42	NA	53.84	NA	NA	NA	NA	58.26
1888	NA	93.38	107.50	NA	74.66	NA	NA	NA	NA	90.29
1889	NA	67.52	112.50	NA	62.47	NA	NA	NA	NA	69.13
1890 to 1896	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1897	NA	NA	NA	NA	NA	NA	NA	NA	NA	77.68
1898	NA	NA	NA	NA	NA	NA	NA	NA	NA	65.42
1899	NA	NA	51.24	NA	NA	NA	NA	NA	NA	54.81
1900 to 1906	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1907	NA	NA	82.84	NA	NA	NA	NA	NA	NA	96.91
1908	NA	NA	85.12	NA	NA	NA	NA	NA	NA	100.58
1909	NA	NA	75.91	NA	NA	NA	NA	NA	NA	101.53

APPENDIX 11b

Oats

Year	Battleford	Brandon	Edmonton	Emerson	Gladstone	Portage	Rapid City	Stonewall	West Lynne	Winnipeg
1871	NA	NA	NA	NA	NA	NA	NA	NA	NA	103.86
1872	NA	NA	NA	NA	NA	NA	NA	NA	NA	104.33
1873	NA	NA	NA	NA	NA	NA	NA	NA	NA	102.64
1874	NA	NA	NA	NA	NA	NA	NA	NA	NA	125.83
1875	NA	NA	NA	NA	NA	NA	NA	NA	NA	123.86
1876	NA	NA	NA	NA	NA	NA	NA	NA	NA	79.12
1877	NA	NA	NA	NA	NA	NA	NA	NA	NA	37.31
1878	125.00	NA	162.44	NA	NA	NA	NA	NA	NA	36.70
1879	135.56	NA	NA	NA	NA	NA	NA	NA	NA	48.66
1880	125.00	NA	82.84	NA	NA	46.87	NA	NA	33.63	48.48
1881	115.00	NA	124.02	NA	NA	NA	NA	NA	49.78	59.17
1882	NA	40.00	191.07	36.23	NA	43.20	76.13	NA	44.31	56.64
1883	153.13	28.23	209.13	33.60	44.94	33.64	34.00	33.69	34.17	33.96
1884	NA	23.45	148.85	NA	26.37	NA	NA	NA	NA	32.81
1885	NA	19.43	75.71	NA	32.91	NA	NA	NA	NA	34.61
1886	NA	22.31	67.19	NA	26.60	NA	NA	NA	NA	32.19
1887	NA	30.35	65.00	NA	29.53	NA	NA	NA	NA	35.57
1888	NA	23.90	63.18	NA	23.65	NA	NA	NA	NA	29.01
1889	NA	37.69	35.00	NA	32.80	NA	NA	NA	NA	36.16
1890 to 1896	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1897	NA	NA	NA	NA	NA	NA	NA	NA	NA	28.33
1898	NA	NA	NA	NA	NA	NA	NA	NA	NA	36.13
1899	NA	NA	23.27	NA	NA	NA	NA	NA	NA	28.82
1900 to 1906	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1907	NA	NA	35.92	NA	NA	NA	NA	NA	NA	49.65
1908	NA	NA	32.45	NA	NA	NA	NA	NA	NA	42.30
1909	NA	NA	31.18	NA	NA	NA	NA	NA	NA	38.56

APPENDIX 11c

Barley

Year	Battleford	Brandon	Edmonton	Emerson	Gladstone	Portage	Rapid City	Stonewall	West Lynne	Winnipeg
1871	NA	NA	NA	NA	NA	NA	NA	NA	NA	89.83
1872	NA	NA	NA	NA	NA	NA	NA	NA	NA	116.16
1873	NA	NA	NA	NA	NA	NA	NA	NA	NA	112.50
1874	NA	NA	NA	NA	NA	NA	NA	NA	NA	135.98
1875	NA	NA	NA	NA	NA	NA	NA	NA	NA	150.00
1876	NA	NA	NA	NA	NA	NA	NA	NA	NA	98.63
1877	NA	NA	NA	NA	NA	NA	NA	NA	NA	41.81
1878	123.44	NA	125.00	NA	NA	NA	NA	NA	NA	49.12
1879	125.00	NA	NA	NA	NA	NA	NA	NA	NA	56.02
1880	100.00	NA	92.41	NA	NA	NA	NA	NA	38.60	57.86
1881	NA	NA	106.28	NA	NA	NA	NA	NA	49.24	62.49
1882	NA	35.00	104.50	43.07	NA	47.18	47.50	NA	50.66	58.23
1883	138.64	39.81	105.14	39.50	37.95	41.18	47.50	40.20	37.38	42.44
1884	NA	29.08	90.37	NA	32.07	NA	NA	NA	NA	32.39
1885	NA	28.65	53.65	NA	36.78	NA	NA	NA	NA	38.90
1886	NA	27.77	53.66	NA	27.84	NA	NA	NA	NA	38.13
1887	NA	35.76	75.00	NA	31.61	NA	NA	NA	NA	39.35
1888	NA	34.17	50.00	NA	31.64	NA	NA	NA	NA	43.24
1889	NA	36.86	40.00	NA	31.43	NA	NA	NA	NA	32.23
1890 to 1896	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1897	NA	NA	NA	NA	NA	NA	NA	NA	NA	39.76
1898	NA	NA	NA	NA	NA	NA	NA	NA	NA	32.65
1899	NA	NA	40.00	NA	NA	NA	NA	NA	NA	38.50
1900 to 1906	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1907	NA	NA	39.76	NA	NA	NA	NA	NA	NA	59.37
1908	NA	NA	32.65	NA	NA	NA	NA	NA	NA	49.50
1909	NA	NA	38.50	NA	NA	NA	NA	NA	NA	48.88

APPENDIX 11d

Native Hay

Year	Battleford	Brandon	Edmonton	Emerson	Gladstone	Portage	Rapid City	Stonewall	West Lynne	Winnipeg
1871	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1872	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1873	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1874	NA	NA	NA	NA	NA	NA	NA	NA	NA	800.00
1875	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1876	NA	NA	NA	NA	NA	NA	NA	NA	NA	882.10
1877	NA	NA	NA	NA	NA	NA	NA	NA	NA	843.18
1878	NA	NA	NA	NA	NA	NA	NA	NA	NA	737.56
1879	NA	NA	NA	NA	NA	NA	NA	NA	NA	800.36
1880	550.00	NA	NA	NA	NA	NA	NA	NA	NA	710.33
1881	NA	NA	NA	NA	NA	NA	NA	NA	700.00	864.60
1882	NA	850.00	1088.89	NA	NA	750.00	NA	NA	NA	1200.19
1883	NA	718.78	1055.56	600.00	NA	750.00	NA	868.61	NA	775.82
1884	NA	629.55	987.50	NA	350.00	NA	NA	NA	NA	877.27
1885	NA	647.10	1100.00	NA	350.00	NA	NA	NA	NA	660.36
1886	NA	666.67	850.00	NA	NA	NA	NA	NA	NA	495.73
1887	NA	955.56	800.00	NA	500.39	NA	NA	NA	NA	606.63
1888	NA	671.05	788.46	NA	500.00	NA	NA	NA	NA	775.19
1889	NA	875.26	691.07	NA	500.00	NA	NA	NA	NA	820.31
1890 to 1896	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1897	NA	NA	NA	NA	NA	NA	NA	NA	NA	438.73
1898	NA	NA	NA	NA	NA	NA	NA	NA	NA	705.30
1899	NA	NA	532.17	NA	NA	NA	NA	NA	NA	601.83
1900 to 1906	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1907	NA	NA	1312.77	NA	NA	NA	NA	NA	NA	1198.97
1908	NA	NA	852.39	NA	NA	NA	NA	NA	NA	718.05
1909	NA	NA	1102.40	NA	NA	NA	NA	NA	NA	906.13

APPENDIX 11e

Flour

Year	Battleford	Brandon	Edmonton	Emerson	Gladstone	Portage	Rapid City	Stonewall	West Lynne	Winnipeg
1871	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1872	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1873	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1874	NA	NA	NA	NA	NA	NA	NA	NA	NA	366.23
1875	NA	NA	NA	NA	NA	NA	NA	NA	NA	480.09
1876	NA	NA	NA	NA	NA	NA	NA	NA	NA	418.37
1877	NA	NA	NA	NA	NA	NA	NA	NA	NA	409.72
1878	694.12	NA	1250.00	NA	NA	NA	NA	NA	NA	NA
1879	900.00	NA	NA	NA	NA	NA	NA	NA	NA	NA
1880	688.24	NA	NA	NA	NA	NA	NA	NA	NA	235.80
1881	900.00	NA	1150.00	NA	NA	NA	NA	NA	NA	243.92
1882	NA	311.10	1195.36	NA	NA	266.20	222.60	NA	NA	264.37
1883	786.06	288.58	942.20	224.00	275.00	255.72	237.06	200.86	NA	191.36
1884	NA	275.27	647.50	NA	210.21	NA	NA	NA	NA	199.85
1885	NA	200.00	578.13	NA	177.46	NA	NA	NA	NA	168.93
1886	NA	201.15	389.53	NA	187.50	NA	NA	NA	NA	145.23
1887	NA	NA	360.62	NA	161.22	NA	NA	NA	NA	160.32
1888	NA	NA	NA	NA	183.76	NA	NA	NA	NA	192.50
1889	NA	NA	NA	NA	261.26	NA	NA	NA	NA	NA
1890 to 1896	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1897	NA	NA	NA	NA	NA	NA	NA	NA	NA	175.35
1898	NA	NA	NA	NA	NA	NA	NA	NA	NA	211.73
1899	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1900 to 1906	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1907	NA	NA	NA	NA	NA	NA	NA	NA	NA	204.70
1908	NA	NA	301.51	NA	NA	NA	NA	NA	NA	239.06
1909	NA	NA	328.17	NA	NA	NA	NA	NA	NA	242.11

APPENDIX 11f

Wood

Year	Battleford	Brandon	Edmonton	Emerson	Gladstone	Portage	Rapid City	Stonewall	West Lynne	Winnipeg
1871	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1872	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1873	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1874	NA	NA	NA	NA	NA	NA	NA	NA	NA	483.52
1875	NA	NA	NA	NA	NA	NA	NA	NA	NA	600.00
1876	NA	NA	NA	NA	NA	NA	NA	NA	NA	531.46
1877	NA	NA	NA	NA	NA	NA	NA	NA	NA	420.97
1878	NA	NA	NA	NA	NA	NA	NA	NA	NA	432.39
1879	NA	NA	NA	NA	NA	NA	NA	NA	NA	442.18
1880	NA	NA	NA	NA	NA	NA	NA	NA	NA	526.88
1881	NA	NA	NA	NA	NA	NA	NA	NA	487.07	506.26
1882	NA	855.00	258.33	900.00	NA	475.00	375.00	NA	687.57	798.94
1883	NA	822.36	292.46	704.09	350.00	450.96	375.00	294.41	846.93	621.10
1884	NA	543.90	NA	NA	233.30	NA	NA	NA	NA	474.52
1885	NA	NA	250.00	NA	233.30	NA	NA	NA	NA	426.78
1886	NA	NA	250.00	NA	203.49	NA	NA	NA	NA	379.74
1887	NA	400.00	300.00	NA	NA	NA	NA	NA	NA	451.03
1888	NA	492.16	210.43	NA	NA	NA	NA	NA	NA	NA
1889	NA	423.49	NA	NA	NA	NA	NA	NA	NA	371.31
1890 to 1896	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1897	NA	NA	NA	NA	NA	NA	NA	NA	NA	414.95
1898	NA	NA	NA	NA	NA	NA	NA	NA	NA	458.39
1899	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1900 to 1906	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1907	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1908	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1909	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX 12

Comparison of Model Predictions with Census Data

The linear programming models are intended to portray the potential activity of a typical settler - the median settler rather than the mean. It will not necessarily be the case therefore that the activities predicted by the models will correspond closely with the Census averages, both for this reason, and for the reasons listed in Chapter 1 for the non-use of the Census data. The Census data are also subject to the vagaries of the weather in the particular year in which the Census was taken. As mentioned in Chapter 4, it is also not possible to be certain that the technological data used in the programs are exact. It could be the case that all sources exaggerated productivity in a similar fashion, in which case the predictions of the models will reproduce this bias. Whilst I have done as much cross checking as possible to avoid this problem, it is possible that there might still be some (hopefully small) degree of bias in the results. Even if such bias arose, it should be similar in all the models, and the comparability of the results will not be affected.

Tables A12.1 to A12.4 provide a detailed comparison of the predictions of the models for Brandon with the Census data for that area. It is immediately apparent that the Census averages for Brandon for 1880 are lower than the model's predictions, which may well occur because in 1880 most settlement in the Brandon area was relatively recent, and few of the farms would have fully broken in. If there should be a bias in the 1880 model's predictions, then it is preferable that it should be in the direction of overestimating the value of settlement, since that will minimise the estimated increase in farm values over the period to 1910. As noted earlier, the model's selection between oats and barley is not accurate, since these crops are very similar in their characteristics. The totals of the outputs of the two crops are reasonably proportionate to the Census averages of the two crops combined.

TABLE A12.1

Comparison of Linear Program Output With Census Averages - Brandon 1880

	Census	Linear Programs	
		To 20 Years	To 40 Years
Improved Acreage	31	46	77
Wheat (bushels)	125	343	711
Oats (bu)	289	238	248
Barley (bu)	34	86	172
Rye (bu)	0.05	NI[23]	NI
Peas and beans (bu)	0.6	NI	NI
Potatoes (bu)	133	258	397
Turnips (bu)	34	23	26
Hay (tons)	40	15	31
Native Pasture (ac)	5	5	5
Horses	11[24]	2	4
Oxen	4	0[25]	0
Cows and calves	17	3	4
Sheep	6	1.3	2.5
Swine	5	24	28
Hens	ND[26]	5	5

[23] NI - Not Included in linear programming model.

[24] Horses and oxen were the principal method of locomotion and transportation on the Prairies. Treating all horses as if they were on farms, as had to be done here, is not a very meaningful exercise.

[25] The models include oxen for the first few years, but not during the period listed here, from the 7th to the 20th years.

[26] ND - No Data

TABLE A12.2

Comparison of Linear Program Output With Census Averages - Brandon 1890

	Census	Linear Programs	
		To 20 Years	To 40 Years
Improved Acreage	58	52	102
Wheat (bushels)	865	596	1108
Oats (bu)	508	0	0
Barley (bu)	40	168	337
Rye (bu)	0	NI	NI
Peas (bu)	1.0	NI	NI
Potatoes (bu)	93	113	771
Turnips (bu)	53	21	17
Hay (tons)	9	15	31
Native Pasture (ac)	ND	5	5
Horses	7	3	5
Oxen	ND	0	0
Cows and calves	5	1	1.4
Sheep	0.3	1.3	1.3
Swine	0.6	7	28
Hens	47	44	5

TABLE A12.3

Comparison of Linear Program Output With Census Averages - Brandon 1900

	Census	Linear Programs	
		To 20 Years	To 40 Years
Improved Acreage	233	155	254
Wheat (bushels)	1126	1438	2468
Oats (bu)	482	411	414
Barley (bu)	65	0	0
Rye (bu)	0.05	NI	NI
Potatoes (bu)	62	0	341
"Other Roots" (bu)	9	321	3
Hay (tons)	10	21	46
Native Pasture (ac)	ND	5	5
Cultivated Pasture (ac)	7	7	8
Horses	6	3	5
Oxen	ND	0	0
Cows and calves	5.6	1	1
Sheep	0.6	0	0
Swine	4.8	6	6
Hens	41	46	47

TABLE A12.4

Comparison of Linear Program Output With Census Averages - Brandon 1910

	Census	Linear Programs	
		To 20 Years	To 40 Years
Improved Acreage	294	164	290
Wheat (bushels)	1680	1354	2574
Oats (bu)	878	661	420
Barley (bu)	224	0	0
Rye (bu)	0.1	NI	NI
Potatoes (bu)	71	0	0
Turnips (bu)	15	391	680
Hay (tons)	2	47	93
Native Pasture (ac)	ND	5	10
Cultivated Pasture (ac)	3.7[27]	6.8	11.4
Horses	8	3	5
Oxen	ND	0	0
Cows and calves	3.6	1	1
Sheep	0.9	0	0
Swine	6.6	6.8	10
Hens	66.1	45	38

[27] Excluding "Mixed Grains", which may well also have been grown for similar purposes.

APPENDIX 13

Typical Linear Program - Brandon, 1900

```
T = BRANDON 1900, YEARS 2-4 ;5 - 20 ;21 - 40 GROUPED, ALL ROTATIONS
C=360, V=680, DUAL
MAX
  /  CALCULATE ANNUAL REVENUES FROM ANIMALS
  /  COW - (PLUS SKIM MILK, MANURE)
  /    RENTAL COST OF CAPITAL
  /      A) PURCHASE $35 - INTEREST @ 8 % =                  ($ 2.80)
  /      B) DEPRECIATION - SELL OLD COWS FOR BEEF (POOR
  /         QUALITY) AFTER 8 YEARS FOR -1200LBS @ ($0.0288
  /        X 75%) = $25.92 - DEPRECIATE ($9.08/(1.08)7)/8($ 0.66)
  /      C) PREMATURE MORTALITY - 5% OF COWS AT AV
  /         4 YEARS ((($35+$25.92)/2)/(1.08)4) X 5 %         ($ 1.12)
  /      E) FEED CUTTER $0.43, DAIRY EQUIPMENT $1.00
  /         BOUGHT FEED, VET $6.00                           ($ 7.43)
  /      F) CALVES - 0.70/YEAR REARING PRICED SEPARATELY
  /         VALUE OF CALF AT BIRTH $1.00                      $ 0.70
  /      G) BUTTER 63 LBS AT $0.125                           $ 7.88
  /                                                  TOTAL  ($ 3.46)
  /  CALF (A) KEPT UP TO 1 YEAR
  /    - VET, BOUGHT FEEDS $1.65 INITIAL COST $1.00          ( $2.65)
  /    - OUTPUT 560 LBS VEAL AT +20 % = 672LBS/1.08
  /      = 622 LBS @ $0.0288                                  $17.92
  /                                                  TOTAL   $15.27
  /  CALF (B) 0 TO 2 YEARS
  /    - INITIAL COST $1.00, COST VET,
  /    - BOUGHT FEEDS (2 YEARS) $2.70 - /2                   ($ 2.35)
  /    - OUTPUT 940 LBS/(1.08)2 = 806 LBS/2
  /    = 403LBS/YR @ $0.0288 =                               $11.60
  /                                                  TOTAL   $9.25
  /  CALF (C) 0 TO 3 YEARS
  /    - INITIAL COST $1.00, COST - VET, BOUGHT FEEDS
  /    - (3 YEARS) $4.30 / 3                                 ($ 2.43)
  /    - OUTPUT (1300 LBS/(1.08)3) = 1032 LBS /3 =
  /       344 LBS @ $0.0288                                   $ 9.91
  /                                                  TOTAL   $7.47
  /  SOW (PGAT)
  /     A) INITIAL COST $16.00 -INTEREST @ 8 %              ($1.28)
  /     B) DEPRECIATION - SELL FOR PORK AFTER 4 YEARS
  /        400 LBS @ $0.0432 X 90% = $15.52 - $0.45/4      ($0.11)
  /     C) MORTALITY 5% OF SOWS AT AV 2 YEARS
  /        ($16+$15.52)/2 = $15.76/(1.08)2=$13.51 X 5%      ($0.68)
  /     D) VET, BOUGHT FEEDS, SERVICE OF BOAR -             ($3.20)
  /     F) PIGLETS - FIVE SURVIVORS / YEAR WORTH $0.20       $1.00
  /                                                  TOTAL  ($4.27)
  /  PIGLET 0 TO SIX WEEKS (PGBT)
  /     - INITIAL COST $0.20 VET, BOUGHT FEEDS $0.35         ($0.55)
  /     - OUTPUT PORK 20 LBS x 120 % = 24 LBS @$0.0432        $1.04
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/                                                    TOTAL    $0.49
/  PIGLET 0 TO 8 MONTHS (PGCT)
/   - INITIAL COST $0.20 VET, BOUGHT FEEDS $0.35       ($0.55)
/   - OUTPUT PORK 150 LBS @ $0.0432                     $6.48
/                                                    TOTAL   $5.93
/  PIGLET 0 TO 2 YEARS (PGDT)
/      INITIAL COST $0.20/2 YEARS =$0.10 VET, BOUGHT
/      FEEDS $0.60/2YEARS= $0.30/YEAR                  ($0.40)
/      OUTPUT PORK (350 LBS)/(1.08)2 /2 YEARS =
/      150 LBS/YEAR @ $0.0432                           $6.48
/                                                  TOTAL    $6.08
/  SHEEP (MNT)
/     A) INITIAL COST $4.00 - INTEREST AT 8 %            ($0.32)
/      B) DEPRECIATION - SELL AT 4 YEARS FOR 140 LBS @
/        $0.0300 = $4.20/(1.08)4 = $3.09 -$0.91/4        ($0.23)
/      C) MORTALITY 5% OF SHEEP AT AV 2 YEARS
/        ($4.00/(1.08)2) X 5% / 4YEARS                   ($0.17)
/     D) BOUGHT FEEDS, VET, RAM ETC. $1.00/4YEARS        ($0.25)
/      F) LAMBS 0.75 SURVIVORS / YEAR SELL AT 8 MONTHS
/         FOR 100LBS @ $0.0300 + 20%                       $3.60
/      G) WOOL 4 LBS AT 10C                               $0.40
/                                                    TOTAL    $3.03
/   HENS (HNT)
/      - COST $0.35 OVER 2 YEARS                          ($0.19)
/      - COOP AND RUN $2.00 OVER 6 YEARS (0.210)          ($0.42)
/      - MORTALITY 10 % OF COST                           ($0.04)
/      - ROOSTER $0.35 / 2 YEARS $0.18/ 10 HENS           ($0.02)
/      - EGGS 9.6DOZ @ $0.159                               $1.53
/      - CHICKENS 2.4/YR @ 3 LBS = 7.2 LBS @ $0.095         $0.68
/                                                      TOTAL   $1.54
/
/  CALCULATE FIXED COSTS
/
/  FIRST YEAR
/      MATERIALS FOR SHACK                    $ 75
/      CAST IRON STOVE                        $ 38
/      14" BREAKER PLOW                       $ 25
/      PAIR OF OXEN                           $100
/      6FT. SPRING TOOTH HARROW               $ 25
/      7FT. MOWER                             $ 70
/      WAGON                                  $ 80
/      SLEIGH RUNNERS                         $ 35
/      MISCELLANEOUS IMPLEMENTS,
/      HARNESS, YOKE                SAY       $ 40
/      OATS FOR OXEN FOR SUMMER 30 BU @ 32C $ 10
/                                 FIRST YEAR TOTAL $498
/  SECOND YEAR
/      6 FT. SEEDER                           $ 90
/      12" SULKY GANG PLOW                    $ 95
/      MATERIALS FOR BARN                     $ 80
/      FENCING MATERIALS                      $ 40
/      12 FT. SIDE DELIVERY HAY RAKE          $ 58
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/       WELL DRILLING AND PUMP                    $ 60
/       MISCELLANEOUS IMPLEMENTS                  $ 20
/             SECOND YEAR TOTAL $443 /1.08 = $410.19
/  THIRD YEAR
/       BARN AND FENCING                          $ 50
/       REPAIRS AND SERVICING                     $ 25
/       MISCELLANEOUS TOOLS AND IMPLEMENTS        $ 20
/            THIRD YEAR TOTAL $ 95 /(1.08)2 = $81.45
/  FOURTH YEAR
/       7 FT. TWINE BINDER WITH BUNDLE CARRIER$155
/       REPAIRS AND SERVICING                     $ 25
/       7 FT. HAY TEDDER                          $ 45
/       HAY HORSEFORK AND SLINGS                  $ 13
/       LAND ROLLER                               $ 30
/       MISCELLANEOUS                             $ 20
/        FOURTH YEAR TOTAL $288 / (1.08)3 = $228.62
/  FIFTH YEAR
/       SELL OXEN AS MEAT AT 2000LBS@ $0.025
/       x 2 =                                    ($100)
/       BUY 2 HORSES                              $150
/       HORSE YOKE                                $ 15
/       BUY THIRD HORSE TWO YEARS LATER
/         $75/(1.08)2                             $ 64
/       MISCELLANEOUS                             $ 20
/         FIFTH YEAR TOTAL $149 /(1.08)4  = $109.50
/  TYPICAL YEARS 6 TO 19
/       DEPRECIATION ON IMPLEMENTS $811x(5%) $ 41
/       INTEREST AND DEPRECIATION ON
/         BUILDINGS, AND NEW CONSTRUCTION         $ 59
/ TYPICAL YEAR TOTAL $100  - SUM 6 TO 19 = $537.92
/  YEAR 20 - IMPLEMENTS FOR SON
/       2 HORSES                                  $150
/       YOKE                                      $ 15
/       HARROW                                    $ 25
/       MOWER                                     $ 70
/       WAGON                                     $ 80
/       SLEIGH                                    $ 35
/       SEEDER                                    $ 90
/       PLOW                                      $ 95
/       HAY RAKE                                  $ 58
/       BINDER                                    $155
/       HAY TEDDER                                $ 45
/       LAND ROLLER                               $ 30
/      TOTAL $838 DISCOUNT TO YEAR 1 $194.16
/ TYPICAL YEARS 21 TO 40
/  DEPRECIATION ON IMPLEMENTS $1494 x 5%         $ 75
/  INTEREST AND DEPRECIATION ON BUILDINGS,
/  AND NEW CONSTRUCTION                          $ 75
/ TOTAL $150 SUM 21 TO 40       $341.22
/ ADDITIONAL LAND FOR SON -
/  BUY 1 SECTION FROM CPR IN YEAR 10
/  160 ACRES AT (AV CPR PRICE 1899) $3.14 $502
```

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  /  DISCOUNT BACK TO YEAR 1 $215
  /      OVERALL TOTAL $2616
  /  CALCULATE VALUES OF FIELD CROPS
  /  WHEAT 61C - TWINE 73C/19.1BU = 3.8C - SACKS 2C
  /    - THRESHING CONTRACTOR 3.5C - BOUGHT SEED 10% @150%
  /     OF GRAIN PRICE 0.7 = 51C
  /  OATS 27C - TWINE 73C/32.0BU = 2.3C - SACKS 1C
  /     -THRESHING CONTRACTOR 2.5C -BOUGHT SEED 0.3C = 20.9C
  /  BARLEY 29C - TWINE 73C/28.5BU = 2.6C -SACKS 1.5C
  /     - THRESHING CONTRACTOR 2.5C -BOUGHT SEED 0.2C = 22.2C
  /  POTATOES 28C - SACKS 2C -SEED 0.5C = 25.5C
  /  TURNIPS 15C -SACKS 2C -SEED 0.5C = 12.5C
  / CALCULATE PHYSICAL QUANTITIES OF OUTPUT
  / CROPS
  / WHEAT - BASIC YIELD 19.1 BU/AC
  / REPEATED YIELD - 10% = 17.2 - SEED 1.5 = 15.7
  / ROTATION A 1/3((19.1+5%)-1.5)+1/3((19.1-5%)-1.5)=11.7
  / ROTATIONS B,C 1/3((19.1+5%) -1.5) = 6.2
  / ROTATION D 1/4((19.1+7%)-1.5)+1/4((19.1-2%)-1.5)=9.0
  / OATS - BASIC YIELD - 32.3 BU/AC
  / REPEATED YIELD -10% = 29.1 - SEED 2.5 =26.6
  / ROTATION B 1/3((32.3)-2.5)= 9.9
  / ROTATION D 1/4((32.3) -2.5) = 7.4
  / BARLEY - BASIC YIELD - 28.5 BU/AC
  / REPEATED YIELD - 28.5 - 10% - 2.0 SEED = 23.7 BU/AC
  / ROTATION C - 1/3((28.5)-2.0) = 8.8
  / FIRST YEAR
  /  ARRIVE IN LATE MAY
  /  BREAK LAND, CUT NATIVE HAY AND PLANT FLAX ONLY
OBJ REV1
  /  FLAX
  /  YIELD 8.4 BU/AC
C1    8.4FX1 BUFX1 = 0
  /  REVENUE FROM FLAX
  /  73C - SACKS 5C -SEED 18C - THRESH 9C = 41C
C2    -REV1 0.41BUFX1 5.5HY1 -5.25BKC1 = 0
  / 8 DAYS TO PLOW , BACKSET, HARROW (BEFORE END MAY)
C3    3FX1 < 8
  / 4 DAYS TO SEED AND HARROW
C4    0.3FX1 < 4
  / 5 DAYS TO BREAK BEFORE MID JUNE
C5    1.111BK1 < 5
  / CUT NATIVE HAY BY HAND
C6    4HY1 < 10
  / REST OF SUMMER BUILDING SHACK, ETC
  / THRESHING BY HAND - NOT A CONSTRAINT DUE TO
  / SMALL QUANTITIES
  / TOTAL OF BROKEN LAND
C8  AC1 -FX1 = 0
  /              YEARS 2 TO 4
  /  OBJECTIVE
OBJ   2.577REV2
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```
  /  CALCULATE ANNUAL REVENUE
C2100  -REV2 0.51BUWT2 0.21BUOT2 0.22BUBR2
C2100  0.26BUPT2 0.13BUTP2 -0.051BUOTFD2 7.1THYC2
C2100  -0.051BUBRFD2 -3.46CW2 15.27CFA2 9.25CFB2
C2100  7.47CFC2 -4.27PGA2 0.49PGB2 5.93PGC2 6.08PGD2
C2100  3.03MN2 1.54HN2 5.5THYN2 -1.60L2 -5.25BKC2 = 0
   / DRAUGHT ANIMALS
C2101  OX2 = 2
C2102  HS2 = 1
  / CALCULATE PHYSICAL QUANTITIES OF OUTPUT
C2103  -BUWT2 11.7RTA2 6.2RTB2 6.2RTC2 9.0RTD2 15.7WT2 = 0
C2104  -BUOT2 -BUOTFD2 9.9RTB2 7.4RTD2 26.6OT2 = 0
C2105  -BUBR2 -BUBRFD2 8.8RTC2 23.7BR2 = 0
  / POTATOES
C2107 -BUPT2 119PT2 = 0
  / TURNIPS
C2108 -BUTP2 229TP2 -TPFD2 = 0
  / HAY (NATIVE - YIELD = 90% OF CULTIVATED)
C2110 -1.5HYN12 -0.9HYN22 -HYCFD2 HYFD2 THYN2 = 0
C2111  -THYC2 -0.9HYCFD2 1.7HYC102 1.0HYC112 = 0
  / ANIMAL FEED
  / GRAINS
C2112  -GRFD2 22CW2 50HS2 9CFA2 10.75CFB2 14CFC2 10PGA2
C2112  0.25PGB2 5PGC2 10PGD2 4MN2 4.3HN2 = 0
C2113  -GRFD2 BUOTFD2 0.7BUBRFD2 = 0
  / TURNIPS
C2116  -TPFD2 2CW2 0.8CFA2 0.75CFB2 0.83CFC2 0.25PGA2
C2116   0.25PGC2 0.25PGD2 = 0
  / PASTURE
C2117  2.0CW2 1.5CFA2 1.75CFB2 2CFC2 0.25PGA2 0.1PGC2 0.5PGD2
C2117  2OX2 1HS2 -PASA2 = 0
C2118  4MN2 -PASB2 = 0
  / SKIM MILK
C2119  -SKML2 600CFA2 300CFB2 200CFC2 100PGB2
C2119  350PGC2 175PGD2 < 0
  / HAY
C2120 2.0OX2 1.0HS2 3.5CW2 1CFA2 0.75CFB2 1.5CFC2 -HYFD2 = 0
  /             ANIMAL PRODUCTS
  /  MANURE
  /  CALCULATED AS WEIGHT OF DRY FEED - WEIGHT GAIN OF ANIMAL
  /  x 80% (HORSES AND OXEN x 40%)
C2130    -TMNUR2 3.8CW2 1.8CFA2 3.1CFB2 5.0CFC2 0.2PGA2
C2130    0.04PGC2 0.14PGD2 5HS2 5OX2 = 0
C2131    TMNUR2 -10PT2 -10TP2 > 0
  / SKIM MILK
C2132   SKML2 -3400CW2 = 0
  / DEFINITION OF FARMER'S ANIMAL CARE
C2133  -ANCRJA2 0.051CW2 0.017CFA2 0.033CFB2 0.047CFC2
C2133  0.005MN2  = 0
C2134  -ANCRFB2 0.049CW2 0.017CFA2 0.032CFB2 0.046CFC2
C2134  0.004MN2  = 0
C2135  -ANCRMR2 0.040CW2 0.013CFA2 0.026CFB2 0.037CFC2
```

```
C2135  0.003MN2  = 0
C2136  -ANCRAP2 0.041CW2 0.012CFA2 0.023CFB2 0.032CFC2
C2136  0.006MN2  = 0
C2137  -ANCRMY2 0.032CW2 0.010CFA2 0.020CFB2 0.028CFC2
C2137  0.005MN2  = 0
C2138  -ANCRJN2 0.033CW2 0.009CFA2 0.017CFB2 0.024CFC2
C2138  0.003MN2  = 0
C2139  -ANCRJY2 0.026CW2 0.008CFA2 0.015CFB2 0.021CFC2
C2139  0.003MN2  = 0
C2140  -ANCRAU2 0.027CW2 0.008CFA2 0.015CFB2 0.021CFC2
C2140  0.003MN2  = 0
C2141  -ANCRSP2 0.030CW2 0.011CFA2 0.021CFB2 0.029CFC2
C2141  0.003MN2  = 0
C2142  -ANCROC2 0.036CW2 0.012CFA2 0.022CFB2 0.031CFC2
C2142  0.004MN2  = 0
C2143  -ANCRNO2 0.046CW2 0.014CFA2 0.026CFB2 0.036CFC2
C2143  0.005MN2 = 0
C2144  -ANCRDE2 0.051CW2 0.017CFA2 0.033CFB2 0.047CFC2
C2144  0.008MN2  = 0
  /                        SPRING
  / 1 PLOWING SEASON
  / AREA TO BE PLOWED AND HARROWED
C2150  0.667RTA2 0.667RTB2 0.667RTC2 RTD2 WT2 OT2
C2150  BR2 PASA2 0.333HYC2 -GR2 = 0
C2151  -GR2 GRF12 GRF22 GR12 GR22 GR32 GR42 = 0
C2152  -PT2 PT12 PT22 PT32 PT42 = 0
C2153  -TP2 TP12 TP22 TP32 TP42 = 0
C2157  -GRF2 GRF12 GRF22 = 0
  / EXTRA HARROW FOR BARLEY
C2154  -0.333RTC2 -BR2 BRH12 BRH22 = 0
  / 8 APRIL TO 20 APRIL - 13 DAYS GROSS x .69 = 9 DAYS NET
C2160  0.433GR12 0.533PT12 0.533TP12 9ANCRAP2
C2160  0.100GRF2 0.100BRH12                < 9
  / 2  SEEDING
  / A) 21 APRIL TO 4 MAY - WHEAT ONLY - 14 DAYS GROSS - 9.6 NET
C2161  0.433GR22 0.533PT22 0.533TP22 0.267RTAW12 0.267RTBW12
C2161  6.9ANCRAP2 2.9ANCRMY2 0.267RTCW12
C2161  0.267RTDW12 0.100BRH22 0.267WT12 < 9.6
  / B) 5 MAY TO 12 MAY - WHEAT OR OATS - 8 DAYS GROSS - 5.8 NET
C2162  0.433GR32 0.533PT32 0.533TP32 0.267RTAW22 0.267RTBW22
C2162  5.8ANCRMY2 0.267PASA12 0.267RTCW22 0.267RTDW22 0.267RTBO12
C2162  0.267RTDO12 0.267RTDF12 0.267WT22 0.267OT12 0.267HYC12
C2162   < 5.8
  / C) 13 TO 18 MAY - WHEAT OATS BARLEY - 6 DAYS GROSS -4.4 NET
C2163  0.433GR42 0.533PT42 0.533TP42 1.111BK12 0.267RTAW32
C2163  0.267RTBW32 0.267RTCW32 0.267RTDW32 0.267RTBO22
C2163  0.267RTDO22 4.4ANCRMY2 0.267PASA22 0.267RTCB12
C2163  0.267RTDF22 0.267WT32 0.267OT22 0.267BR12 0.267HYC22 < 4.4
  / D) 19 TO 21 MAY - OATS BARLEY TURNIPS - 3 DAYS GROSS - 2.2 NET
C2164  0.267RTBO32 0.267RTDO32 1.111BK22 0.267PASA32 0.85TP2
C2164  2.2ANCRMY2  0.267RTCB22 0.267RTDF32  0.267OT32 0.267BR22
C2164  0.267HYC32 <  2.2
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  / E) 22 TO 24 MAY - OATS BARLEY  POTATOES PASTURE
  /          - 3 DAYS GROSS - 2.2 NET
C2165  1.111BK32 0.267RTBO42 0.267RTDO42 0.267RTCB32 0.75PT2
C2165  0.267PASA42 2.2ANCRMY2 0.267RTDF42 0.267OT42 0.267BR32
C2165  0.267HYC42 < 2.2
  / F) 25 TO 27 MAY - BARLEY, OATS, PASTURE
  /      3 DAYS GROSS - 2.2 NET
C2166  1.111BK42 0.267RTBO52 0.267RTDO52 0.267RTCB42 0.267RTDF52
C2166  0.267PASA52 2.2ANCRMY2 0.267OT52 0.267BR42 0.267HYC52 < 2.2
  / G) 28 MAY TO 6 JUNE - 10 DAYS GROSS - 7 NETT
C2167  0.267RTCB52 0.267PASA62 4.1ANCRJN2 2.9ANCRMY2
C2167  1.111BK52  0.267RTDF62 0.267BR52 0.267HYC62 < 7
  / END OF SOWING SEASON
  / RECONCILE SOWING
C2170  -0.667RTA2 RTAW12 RTAW22 RTAW32 = 0
C2171  -0.333RTB2 RTBW12 RTBW22 RTBW32 = 0
C2172  -0.333RTC2 RTCW12 RTCW22 RTCW32 = 0
C2173  -0.5RTD2 RTDW12 RTDW22 RTDW32 = 0
C2174  -0.333RTB2 RTBO12 RTBO22 RTBO32 RTBO42 RTBO52 = 0
C2175  -0.25RTD2 RTDO12 RTDO22 RTDO32 RTDO42 RTDO52 = 0
C2176  -0.333RTC2 RTCB12 RTCB22 RTCB32 RTCB42 RTCB52 = 0
C2177  -PASA2 PASA12 PASA22 PASA32 PASA42 PASA52
C2177  PASA62 = 0
C2178  -0.25RTD2 RTDF12 RTDF22 RTDF32 RTDF42 RTDF52
C2178  RTDF62 = 0
C2520  -WT2 WT12 WT22 WT32 = 0
C2521  -OT2 OT12 OT22 OT32 OT42 OT52 = 0
C2522  -BR2 BR12 BR22 BR32 BR42 BR52 = 0
C2523  -0.333HYC2 HYC12 HYC22 HYC32 HYC42 HYC52 HYC62 = 0
  /  ROTATIONS
C2512  FAL2 -0.333RTA2 -0.333RTB2 -0.333RTC2 = 0
  /
  /  3                    SUMMER
  /
  /  A)  7 JUNE TO 12 JUNE - 6 DAYS GROSS - 4.2 NET
  /       CULTIVATE CROPS, NEW BREAKING, BUILD FENCES, BUILDINGS
C2180  1.111BK62 0.100CTGR12 0.200CTRT12 BUILD12
C2180  4.2ANCRJN2 0.333FAL12  < 4.2
  /  B)  13 TO 30 JUNE - 18 DAYS GROSS - 12.4 NET
C2181  0.100CTGR22 0.200CTRT22 BUILD22 12.4ANCRJN2
C2181 0.333FAL22                                  < 12.4
  /  C)  1 TO 10 JULY - 10 DAYS GROSS - 6.9 NETT
C2182  0.858HYN12  0.200CTRT32 BUILD32
C2182  0.333FAL32 0.858HYC102         6.9ANCRJY2  < 6.9
  /  D)  11 JULY TO 6 AUGUST
  /     27 DAYS GROSS - 19.3 NETT (PLOW GREEN FALLOW)
C2183  0.267BS12 BUILD42 4.0PT52 3.5TP52 14.5ANCRJY2 6.9ANCRAU2
C2183   0.333FAL42                    < 19.3
  /  E)  7 TO 11 AUGUST  - 5 DAYS GROSS - 3.9 NETT
C2184  BUILD52 0.267BS22 4PT62 3.5TP62 0.858HYN22 3.9ANCRAU2
C2184  0.333FAL52 0.858HYC112 < 3.9
  / RECONCILE PLOWING OF FALLOW
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C2185  -FAL2 FAL12 FAL22 FAL32 FAL42 FAL52 = 0
  /  RECONCILE BREAKING AND BACKSETTING
C2190  -BK2 BK12 BK22 BK32 BK42 BK52 BK62 = 0
C2191  -BK2 BS12 BS22 = 0
  / RECONCILE CULTIVATION
C2192  -GR2 PASA2 CTGR12 CTGR22 = 0
C2193  CTRT12 CTRT22 CTRT32 -PT2 -TP2 = 0
C2194  PT52 PT62 -PT2 = 0
C2195  TP52 TP62 -TP2 = 0
  / RECONCILE BUILDING INCLUDING STONING, MISC
  / DELIVERIES, REPAIRS, MAINTENANCE
C2196 BUILD12 BUILD22 BUILD32 BUILD42 BUILD52 > 15
  /
  / THRESHING OUTPUTS
  / ROTATION A -  14.2 BU/AC X(6MEN/1500BU/D) = 0.057
  / ROTATION B -  7.3X(6/1500)+11.6X(6/2000) = 0.065
  / ROTATION C -  7.3X(6/1500)+10.3X(6/2000) = 0.060
  / ROTATION D -  11.0X(6/1500)+8.7X(6/2000) = 0.070
  / WHEAT (6 MEN/1500 BU/DAY) X 17.2 BU/AC = 0.069 D/AC
  / OATS  (6 MEN/2000 B/D) X 29.1 = 0.087
  / BARLEY (6 MEN/2000 B/D) X 25.7 = 0.077
  / 4                HARVEST SEASON
  / 12 AUGUST TO 15 SEPTEMBER - 35DAYS GROSS - 25.8 NETT
C2200  0.444WT2   0.2WT202   0.069WT302
C2200  0.444OT2   0.2OT202   0.087OT302
C2200  0.444BR2   0.2BR202   0.077BR302
C2200  0.296RTA2  0.2RTA202  0.057RTA302
C2200  0.296RTB2  0.2RTB202  0.065RTB302
C2200  0.444RTC2  0.2RTC202  0.060RTC302
C2200  0.333RTD2  0.2RTD202  0.070RTD302
C2200  15.4ANCRAU2 10.4ANCRSP2        -LA2      < 25.8
  /
  /      THRESHING PLOWING AND DELIVERING SEASON
C2202  -DLVRA2 -DLVRB2 -DLVRC2 0.224CFA2 0.188CFB2 0.173CFC2
C2202  0.04PGA2 0.008PGB2 0.06PGC2 0.07PGD2 0.054MN2 0.4THYC2
C2202  0.012BUWT2 0.007BUOT2 0.010BUBR2 0.4THYN2 = 0
  /  16 SEPTEMBER TO 12 OCTOBER -27 DAYS GROSS - 17.6 NETT
C2203  0.057RTA312 0.065RTB312
C2203  0.060RTC312 0.070RTD312 0.069WT312 0.087OT312
C2203  0.077BR312
  / DIG PLOW MANURE POTS TPS
C2203  2.103PT2 2.933TP2
  /   DELIVERIES
C2203  DLVRA2 0.433GRF12
  / ANIMALS, MISC
C2203  10.4ANCRSP2 7.2ANCROC2  -LB2              < 17.6
  / DIG ONLY POTATOES, TURNIPS
C2204  1.67PT2 2.5TP2 2ANCRSP2 2ANCROC2         < 4.0
  /
  /     13 TO 27 OCTOBER - 15 DAYS GROSS - 9 DAYS NETT
C2205  DLVRB2 0.057RTA322 0.065RTB322
C2205  0.060RTC322 0.070RTD322 9ANCROC2  0.433GRF22
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C2205  0.069WT322 0.087OT322 0.077BR322 < 9
  /                        WINTER
  /
  /                  28 OCTOBER TO 5 APRIL
C2210  DLVRC2
  / WINTER THRESHING - 60% OF FALL PRODUCTIVITY
C2210  0.091RTC332 0.110RTA332 0.104RTB332
C2210  0.110RTD332 0.110WT332 0.140OT332 0.123BR332
  / ANIMAL CARE
C2210  2.4ANCROC2 15.3ANCRNO2 15.8ANCRDE2 13.3ANCRJA2 11.2ANCRFB2
C2210  18.6ANCRMR2 4.8ANCRAP2                          < 81.4
  / RECONCILE THRESHING
C2213  -BR2 BR302 BR312 BR322 BR332 = 0
C2214  -WT2 WT302 WT312 WT322 WT332 = 0
C2215  -OT2 OT302 OT312 OT322 OT332 = 0
C2223  RTC302 RTC312 RTC322 RTC332 -RTC2 = 0
C2224  -RTA2 RTA302 RTA312 RTA322 RTA332 = 0
C2225  -RTB2 RTB302 RTB312 RTB322 RTB332 = 0
C2226  -RTD2 RTD302 RTD312 RTD322 RTD332 = 0
  / RECONCILE STACKING FOR LATE THRESHING
C2240  -1.5RTC202 RTC312 RTC322 RTC332 = 0
C2242  -1.5RTA202 RTA312 RTA322 RTA332 = 0
C2243  -1.5RTB202 RTB312 RTB322 RTB332 = 0
C2244  -1.333RTD202 RTD312 RTD322 RTD332 = 0
C2245  -BR202 BR312 BR322 BR332 = 0
C2246  -WT202 WT312 WT322 WT332 = 0
C2247  -OT202 OT312 OT322 OT332 = 0
  / RECONCILE HIRED HARVEST LABOUR
C2250  -L2 LA2 LB2 = 0
C2251  L2 < 16.7
  / LAND
C2260  -AC2 AC1 BK1 BKC1 BKC2 = 0
C2261  -AC2 RTA2 RTB2 RTC2 RTD2 PT2 TP2 HYC102
C2261  WT2 OT2 BR2 PASA2 = 0
C2263  PASB2 < 5
  / WIFE'S ANIMAL HUSBANDRY (HOURS/WEEK)
C2280  1.7CW2 0.163PGA2 0.07PGB2 0.163PGC2 0.349PGD2
C2280  0.21HN2 < 12
  / FAMILY CONSUMPTION
  / BEEF, MILK
C2290  CW2 CFA2 CFB2 CFC2 > 1
  / PORK
C2291  PGA2 PGB2 PGC2 PGD2 > 1
  / EGGS
C2292  HN2 > 5
  / ENSURE CORRECT PROPORTIONS OF OFFSPRING
C2300  -CFA2 0.67CW2 > 0
C2301  -CFB2 0.33CW2 > 0
C2302  -CFC2 0.22CW2 > 0
C2303  -3CW2 CFA2 CFB2 CFC2 < 0
C2304  -PGB2 4PGA2 > 0
C2305  -PGC2 4PGA2 > 0
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C2306  -PGD2 4PGA2 > 0
  /              YEARS 5 TO 20
  /  OBJECTIVE
OBJ   7.0265REV5
  /  CALCULATE ANNUAL REVENUE
C5100  -REV5 0.51BUWT5 0.21BUOT5 0.22BUBR5
C5100  0.26BUPT5 0.13BUTP5 -0.051BUOTFD5 7.1THYC5
C5100  -0.051BUBRFD5 -3.46CW5 15.27CFA5 9.25CFB5
C5100  7.47CFC5 -4.27PGA5 0.49PGB5 5.93PGC5 6.08PGD5
C5100  3.03MN5 1.54HN5 5.5THYN5 -1.60L5 -5.25BKC5 = 0
   / DRAUGHT ANIMALS
C5101  OX5 = 0
C5102  HS5 = 3
  / CALCULATE PHYSICAL QUANTITIES OF OUTPUT
C5103  -BUWT5 11.7RTA5 6.2RTB5 6.2RTC5 9.0RTD5 15.7WT5 = 0
C5104  -BUOT5 -BUOTFD5 9.9RTB5 7.4RTD5 26.6OT5 = 0
C5105  -BUBR5 -BUBRFD5 8.8RTC5 23.7BR5 = 0
  / POTATOES
C5107 -BUPT5 119PT5 = 0
  / TURNIPS
C5108 -BUTP5 229TP5 -TPFD5 = 0
  / HAY (NATIVE - YIELD = 90% OF CULTIVATED)
C5110 -1.5HYN15 -0.9HYN25 -HYCFD5 HYFD5 THYN5 = 0
C5111  -THYC5 -0.9HYCFD5 1.7HYC105 1HYC115 = 0
  / ANIMAL FEED
  / GRAINS
C5112  -GRFD5 22CW5 50HS5 9CFA5 10.75CFB5 14CFC5 10PGA5
C5112  0.25PGB5 5PGC5 10PGD5 4MN5 4.3HN5 = 0
C5113  -GRFD5 BUOTFD5 0.7BUBRFD5 = 0
  / TURNIPS
C5116  -TPFD5 2CW5 0.8CFA5 0.75CFB5 0.83CFC5 0.25PGA5
C5116   0.25PGC5 0.25PGD5 = 0
  / PASTURE
C5117  2.0CW5 1.5CFA5 1.75CFB5 2CFC5 0.25PGA5 0.1PGC5 0.5PGD5
C5117  2OX5 1HS5 -PASA5 = 0
C5118  4MN5 -PASB5 = 0
  / SKIM MILK
C5119  -SKML5 600CFA5 300CFB5 200CFC5 100PGB5
C5119  350PGC5 175PGD5 < 0
  / HAY
C5120 2.0OX5 1.0HS5 3.5CW5 1CFA5 0.75CFB5 1.5CFC5 -HYFD5 = 0
  /              ANIMAL PRODUCTS
  /  MANURE
  /  CALCULATED AS WEIGHT OF DRY FEED - WEIGHT GAIN OF ANIMAL
  /  x 80% (HORSES AND OXEN x 40%)
C5130    -TMNUR5 3.8CW5 1.8CFA5 3.1CFB5 5.0CFC5 0.2PGA5
C5130    0.04PGC5 0.14PGD5 5HS5 5OX5 = 0
C5131    TMNUR5 -10PT5 -10TP5 > 0
  / SKIM MILK
C5132   SKML5 -3400CW5 = 0
  / DEFINITION OF FARMER'S ANIMAL CARE
C5133  -ANCRJA5 0.051CW5 0.017CFA5 0.033CFB5 0.047CFC5
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C5133  0.005MN5  = 0
C5134  -ANCRFB5 0.049CW5 0.017CFA5 0.032CFB5 0.046CFC5
C5134  0.004MN5  = 0
C5135  -ANCRMR5 0.040CW5 0.013CFA5 0.026CFB5 0.037CFC5
C5135  0.003MN5  = 0
C5136  -ANCRAP5 0.041CW5 0.012CFA5 0.023CFB5 0.032CFC5
C5136  0.006MN5  = 0
C5137  -ANCRMY5 0.032CW5 0.010CFA5 0.020CFB5 0.028CFC5
C5137  0.005MN5  = 0
C5138  -ANCRJN5 0.033CW5 0.009CFA5 0.017CFB5 0.024CFC5
C5138  0.003MN5  = 0
C5139  -ANCRJY5 0.026CW5 0.008CFA5 0.015CFB5 0.021CFC5
C5139  0.003MN5  = 0
C5140  -ANCRAU5 0.027CW5 0.008CFA5 0.015CFB5 0.021CFC5
C5140  0.003MN5  = 0
C5141  -ANCRSP5 0.030CW5 0.011CFA5 0.021CFB5 0.029CFC5
C5141  0.003MN5  = 0
C5142  -ANCROC5 0.036CW5 0.012CFA5 0.022CFB5 0.031CFC5
C5142  0.004MN5  = 0
C5143  -ANCRNO5 0.046CW5 0.014CFA5 0.026CFB5 0.036CFC5
C5143  0.005MN5 = 0
C5144  -ANCRDE5 0.051CW5 0.017CFA5 0.033CFB5 0.047CFC5
C5144  0.008MN5  = 0
  /                        SPRING
  / 1 PLOWING SEASON
  / AREA TO BE PLOWED AND HARROWED
C5150  0.667RTA5 0.667RTB5 0.667RTC5 RTD5 WT5 OT5
C5150  BR5 PASA5 0.333HYC5 -GR5 = 0
C5151  -GR5 GRF15 GRF25 GR15 GR25 GR35 GR45 = 0
C5152  -PT5 PT15 PT25 PT35 PT45 = 0
C5153  -TP5 TP15 TP25 TP35 TP45 = 0
C5157  -GRFA5 -GRFB5 GRF15 GRF25 = 0
  / EXTRA HARROW FOR BARLEY
C5154  -0.333RTC5 -BR5 BRH15 BRH25 = 0
  / 8 APRIL TO 20 APRIL - 13 DAYS GROSS x .69 = 9 DAYS NET
C5160  0.271GR15 0.334PT15 0.334TP15 9ANCRAP5
C5160  0.063GRFA5 0.063BRH15              < 9
  / 2  SEEDING
  / A) 21 APRIL TO 4 MAY - WHEAT ONLY - 14 DAYS GROSS - 9.6 NET
C5161  0.271GR25 0.334PT25 0.334TP25 0.163RTAW15 0.163RTBW15
C5161  6.9ANCRAP5 2.7ANCRMY5 0.163RTCW15 0.063GRFB5
C5161  0.163RTDW15 0.063BRH25 0.163WT15 < 9.6
  / B) 5 MAY TO 12 MAY - WHEAT OR OATS - 8 DAYS GROSS - 5.8 NET
C5162  0.271GR35 0.334PT35 0.334TP35 0.163RTAW25 0.163RTBW25
C5162  5.8ANCRMY5 0.163PASA15 0.163RTCW25 0.163RTDW25 0.163RTBO15
C5162  0.163RTDO15 0.163RTDF15 0.163WT25 0.163OT15 0.163HYC15
C5162  < 5.8
  / C) 13 TO 18 MAY - WHEAT OATS BARLEY - 6 DAYS GROSS -4.4 NET
C5163  0.271GR45 0.334PT45 0.334TP45 1.333BK15 0.163RTAW35
C5163  0.163RTBW35 0.163RTCW35 0.163RTDW35 0.163RTBO25
C5163  0.163RTDO25 4.4ANCRMY5 0.163PASA25 0.163RTCB15
C5163  0.163RTDF25 0.163WT35 0.163OT25 0.163BR15
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C5163  0.163HYC25 < 4.4
  / D) 19 TO 21 MAY - OATS BARLEY TURNIPS - 3 DAYS GROSS - 2.2 NET
C5164  0.163RTBO35 0.163RTDO35 1.333BK25 0.163PASA35 0.85TP5
C5164  2.2ANCRMY5  0.163RTCB25 0.163RTDF35  0.163OT35 0.163BR25
C5164  0.163HYC35 <  2.2
  / E) 22 TO 24 MAY - OATS BARLEY  POTATOES PASTURE
  /         - 3 DAYS GROSS - 2.2 NET
C5165  1.333BK35 0.163RTBO45 0.163RTDO45 0.163RTCB35 0.75PT5
C5165  0.163PASA45 2.2ANCRMY5 0.163RTDF45 0.163OT45 0.163BR35
C5165  0.167HYC45 < 2.2
  / F) 25 TO 27 MAY - BARLEY, OATS, PASTURE
  /      3 DAYS GROSS - 2.2 NET
C5166  1.333BK45 0.163RTBO55 0.163RTDO55 0.163RTCB45 0.163RTDF55
C5166  0.163PASA55 2.2ANCRMY5 0.163OT55 0.163BR45 0.167HYC55 < 2.2
  / G) 28 MAY TO 6 JUNE - 10 DAYS GROSS - 7 NETT
C5167  0.163RTCB55 0.163PASA65 4.1ANCRJN5 2.9ANCRMY5
C5167  1.333BK55  0.163RTDF65 0.163BR55 0.167HYC65 < 7
  / END OF SOWING SEASON
  / RECONCILE SOWING
C5170  -0.667RTA5 RTAW15 RTAW25 RTAW35 = 0
C5171  -0.333RTB5 RTBW15 RTBW25 RTBW35 = 0
C5172  -0.333RTC5 RTCW15 RTCW25 RTCW35 = 0
C5173  -0.5RTD5 RTDW15 RTDW25 RTDW35 = 0
C5174  -0.333RTB5 RTBO15 RTBO25 RTBO35 RTBO45 RTBO55 = 0
C5175  -0.25RTD5 RTDO15 RTDO25 RTDO35 RTDO45 RTDO55 = 0
C5176  -0.333RTC5 RTCB15 RTCB25 RTCB35 RTCB45 RTCB55 = 0
C5177  -PASA5 PASA15 PASA25 PASA35 PASA45 PASA55
C5177  PASA65 = 0
C5178  -0.25RTD5 RTDF15 RTDF25 RTDF35 RTDF45 RTDF55
C5178  RTDF65 = 0
C5520  -WT5 WT15 WT25 WT35 = 0
C5521  -OT5 OT15 OT25 OT35 OT45 OT55 = 0
C5522  -BR5 BR15 BR25 BR35 BR45 BR55 = 0
C5523  -0.333HYC5 HYC15 HYC25 HYC35 HYC45 HYC55 HYC65 = 0
  /  ROTATIONS
C5512  FAL5 -0.333RTA5 -0.333RTB5 -0.333RTC5 = 0
  /
  /  3                    SUMMER
  /
  /  A)  7 JUNE TO 12 JUNE - 6 DAYS GROSS - 4.2 NET
  /       CULTIVATE CROPS, NEW BREAKING, BUILD FENCES, BUILDINGS
C5180  1.333BK65 0.063CTGR15 0.126CTRT15 BUILD15
C5180  4.2ANCRJN5 0.208FAL15  < 4.2
  /  B)  13 TO 30 JUNE - 18 DAYS GROSS - 12.4 NET
C5181  0.063CTGR25 0.126CTRT25 BUILD25 12.4ANCRJN5
C5181 0.208FAL25                                  < 12.4
  /  C)  1 TO 10 JULY - 10 DAYS GROSS - 6.9 NETT
C5182  0.744HYN15  0.126CTRT35 BUILD35
C5182  0.208FAL35  0.744HYC105                 6.9ANCRJY5  < 6.9
  /  D)  11 JULY TO 6 AUGUST
  /     27 DAYS GROSS - 19.3 NET5 (PLOW GREEN FALLOW)
C5183  0.267BS15 BUILD45 4.0PT55 3.5TP55 14.5ANCRJY5 6.9ANCRAU5
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C5183   0.208FAL45                    < 19.3
  /  E)  7 TO 11 AUGUST  - 5 DAYS GROSS - 3.9 NETT
C5184  BUILD55 0.267BS25 4PT65 3.5TP65 0.744HYN25 3.9ANCRAU5
C5184  0.208FAL55 0.744HYC115 < 3.9
  / RECONCILE PLOWING OF FALLOW
C5185  -FAL5 FAL15 FAL25 FAL35 FAL45 FAL55 = 0
  /  RECONCILE BREAKING AND BACKSETTING
C5190  -BK5 BK15 BK25 BK35 BK45 BK55 BK65  = 0
C5191  -BK5 BS15 BS25  = 0
  / RECONCILE CULTIVATION
C5192  -GR5 PASA5 CTGR15 CTGR25 = 0
C5193  CTRT15 CTRT25 CTRT35 -PT5 -TP5 = 0
C5194  PT55 PT65 -PT5 = 0
C5195  TP55 TP65 -TP5 = 0
  / RECONCILE BUILDING INCLUDING STONING, MISC
  / DELIVERIES, REPAIRS, MAINTENANCE
C5196 BUILD15 BUILD25 BUILD35 BUILD45 BUILD55 > 15
  /
  / 4                HARVEST SEASON
  /  12 AUGUST TO 15 SEPTEMBER - 35 DAYS GROSS - 25.8 NETT
C5200  0.353WT5   0.2WT205   0.069WT305
C5200  0.353OT5   0.2OT205   0.087OT305
C5200  0.353BR5   0.2BR205   0.069BR305
C5200  0.235RTA5  0.2RTA205  0.057RTA305
C5200  0.235RTB5  0.2RTB205  0.065RTB305
C5200  0.353RTC5  0.2RTC205  0.060RTC305
C5200  0.265RTD5  0.2RTD205  0.070RTD305
C5200  15.4ANCRAU5 10.4ANCRSP5        -LA5      < 25.8
  /
  /      THRESHING PLOWING AND DELIVERING SEASON
C5202  -DLVRA5 -DLVRB5 -DLVRC5 0.224CFA5 0.188CFB5 0.173CFC5
C5202 0.04PGA5 0.008PGB5 0.06PGC5 0.07PGD5 0.054MN5 0.4THYC5
C5202  0.012BUWT5 0.007BUOT5 0.010BUBR5 0.4THYN5 = 0
  /  16 SEPTEMBER TO 12 OCTOBER -27 DAYS GROSS - 17.6 NETT
C5203  0.060RTC315 0.057RTA315 0.065RTB315
C5203  0.070RTD315 0.069WT315 0.087OT315
C5203  0.077BR315
  / DIG PLOW MANURE POTS TPS
C5203  1.941PT5 2.771TP5
  /   DELIVERIES
C5203  DLVRA5 0.271GRF15
  / ANIMALS, MISC
C5203  10.4ANCRSP5 7.2ANCROC5  -LB5              < 17.6
  / DIG ONLY POTATOES, TURNIPS
C5204  1.67PT5 2.5TP5 2ANCRSP5 2ANCROC5         < 4.0
  /
  /     13 TO 27 OCTOBER - 15 DAYS GROSS - 9 DAYS NETT
C5205  DLVRB5 0.057RTA325 0.065RTB325
C5205  0.060RTC325 0.070RTD325 9ANCROC5  0.271GRF25
C5205  0.069WT325 0.087OT325 0.077BR325 < 9
  /                        WINTER
  /
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  /                    28 OCTOBER TO 5 APRIL
C5210  DLVRC5
  / WINTER THRESHING - 60% OF FALL PRODUCTIVITY
C5210  0.091RTC335 0.110RTA335 0.104RTB335
C5210  0.110RTD335 0.110WT335 0.140OT335 0.123BR335
  / ANIMAL CARE
C5210  2.4ANCROC5 15.3ANCRNO5 15.8ANCRDE5 13.3ANCRJA5 11.2ANCRFB5
C5210  18.6ANCRMR5 4.8ANCRAP5                          < 81.4
  / RECONCILE THRESHING
C5213  -BR5 BR305 BR315 BR325 BR335 = 0
C5214  -WT5 WT305 WT315 WT325 WT335 = 0
C5215  -OT5 OT305 OT315 OT325 OT335 = 0
C5223  -RTC5 RTC305 RTC315 RTC325 RTC335 = 0
C5224  -RTA5 RTA305 RTA315 RTA325 RTA335 = 0
C5225  -RTB5 RTB305 RTB315 RTB325 RTB335 = 0
C5226  -RTD5 RTD305 RTD315 RTD325 RTD335 = 0
  / RECONCILE STACKING FOR LATE THRESHING
C5240  -1.5RTC205 RTC315 RTC325 RTC335 = 0
C5242  -1.5RTA205 RTA315 RTA325 RTA335 = 0
C5243  -1.5RTB205 RTB315 RTB325 RTB335 = 0
C5244  -1.333RTD205 RTD315 RTD325 RTD335 = 0
C5245  -BR205 BR315 BR325 BR335 = 0
C5246  -WT205 WT315 WT325 WT335 = 0
C5247  -OT205 OT315 OT325 OT335 = 0
  / RECONCILE HIRED HARVEST LABOUR
C5250  -L5 LA5 LB5 = 0
C5251  L5 < 16.7
  / LAND
C5260  -AC5 AC2 3BKC2 2BK2 = 0
C5261  -AC5 RTA5 RTB5 RTC5 RTD5 PT5 TP5 HYC105
C5261  WT5 OT5 BR5 PASA5 = 0
C5263  PASB5 < 5
  / WIFE'S ANIMAL HUSBANDRY (HOURS/WEEK)
C5280  1.7CW5 0.163PGA5 0.07PGB5 0.163PGC5 0.349PGD5
C5280  0.21HN5 < 12
  / FAMILY CONSUMPTION
  / BEEF, MILK
C5290  CW5 CFA5 CFB5 CFC5 > 1
  / PORK
C5291  PGA5 PGB5 PGC5 PGD5 > 1
  / EGGS
C5292  HN5 > 5
  / ENSURE CORRECT PROPORTIONS OF OFFSPRING
C5300  -CFA5 0.67CW5 > 0
C5301  -CFB5 0.33CW5 > 0
C5302  -CFC5 0.22CW5 > 0
C5303  -3CW5 CFA5 CFB5 CFC5 < 0
C5304  -PGB5 4PGA5 > 0
C5305  -PGC5 4PGA5 > 0
C5306  -PGD5 4PGA5 > 0
  /                YEARS 7 TO 25
  /  OBJECTIVE
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OBJ   2.2748REV9
  /  CALCULATE ANNUAL REVENUE
C9100  -REV9 0.51BUWT9 0.21BUOT9 0.22BUBR9
C9100  0.26BUPT9 0.13BUTP9 -0.051BUOTFD9
C9100  -0.051BUBRFD9 -3.46CW9 15.27CFA9 9.25CFB9
C9100  7.47CFC9 -4.27PGA9 0.49PGB9 5.93PGC9 6.08PGD9
C9100  3.03MN9 1.54HN9 5.5THYN9 -1.60L9 -5.25BKC9 = 0
   / DRAUGHT ANIMALS
C9101  OX9 = 0
C9102  HS9 = 5
  / CALCULATE PHYSICAL QUANTITIES OF OUTPUT
C9103  -BUWT9 11.7RTA9 6.2RTB9 6.2RTC9 9.0RTD9 15.7WT9 = 0
C9104  -BUOT9 -BUOTFD9 9.9RTB9 7.4RTD9 26.6OT9 = 0
C9105  -BUBR9 -BUBRFD9 8.8RTC9 23.7BR9 = 0
  / POTATOES
C9107 -BUPT9 119PT9 = 0
  / TURNIPS
C9108 -BUTP9 229TP9 -TPFD9 = 0
  / HAY (NATIVE - YIELD = 90% OF CULTIVATED)
C9110 -1.5HYN19 -0.9HYN29 -HYCFD9 HYFD9 THYN9 = 0
C9111  -THYC9 -0.9HYCFD9 1.7HYC109 1.0HYC119 = 0
  / ANIMAL FEED
  / GRAINS
C9112  -GRFD9 22CW9 50HS9 9CFA9 10.75CFB9 14CFC9 10PGA9
C9112  0.25PGB9 5PGC9 10PGD9 4MN9 2.25HN9 = 0
C9113  -GRFD9 BUOTFD9 0.7BUBRFD9 = 0
  / TURNIPS
C9116  -TPFD9 2CW9 0.8CFA9 0.75CFB9 0.83CFC9 0.25PGA9
C9116   0.25PGC9 0.25PGD9 = 0
  / PASTURE
C9117  2.0CW9 1.5CFA9 1.75CFB9 2CFC9 0.25PGA9 0.1PGC9 0.5PGD9
C9117  2OX9 1HS9 -PASA9 = 0
C9118  4MN9 -PASB9 = 0
  / SKIM MILK
C9119  -SKML9 600CFA9 300CFB9 200CFC9 100PGB9
C9119  350PGC9 175PGD9 < 0
  / HAY
C9120 2.0OX9 1HS9 3.5CW9 1CFA9 1.5CFB9 1.5CFC9 -HYFD9 = 0
  /             ANIMAL PRODUCTS
  /  MANURE
  /  CALCULATED AS WEIGHT OF DRY FEED - WEIGHT GAIN OF ANIMAL
  /  x 80% (HORSES AND OXEN x 40%)
C9130    -TMNUR9 3.8CW9 1.8CFA9 3.1CFB9 5.0CFC9 0.2PGA9
C9130    0.04PGC9 0.14PGD9 5HS9 5OX9 = 0
C9131    TMNUR9 -10PT9 -10TP9 > 0
  / SKIM MILK
C9132   SKML9 -3400CW9 = 0
  / DEFINITION OF FARMER'S ANIMAL CARE
C9133  -ANCRJA9 0.051CW9 0.017CFA9 0.033CFB9 0.047CFC9
C9133  0.005MN9  = 0
C9134  -ANCRFB9 0.049CW9 0.017CFA9 0.032CFB9 0.046CFC9
C9134  0.004MN9  = 0
```

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C9135  -ANCRMR9 0.040CW9 0.013CFA9 0.026CFB9 0.037CFC9
C9135  0.003MN9  = 0
C9136  -ANCRAP9 0.041CW9 0.012CFA9 0.023CFB9 0.032CFC9
C9136  0.006MN9  = 0
C9137  -ANCRMY9 0.032CW9 0.010CFA9 0.020CFB9 0.028CFC9
C9137  0.005MN9  = 0
C9138  -ANCRJN9 0.033CW9 0.009CFA9 0.017CFB9 0.024CFC9
C9138  0.003MN9  = 0
C9139  -ANCRJY9 0.026CW9 0.008CFA9 0.015CFB9 0.021CFC9
C9139  0.003MN9  = 0
C9140  -ANCRAU9 0.027CW9 0.008CFA9 0.015CFB9 0.021CFC9
C9140  0.003MN9  = 0
C9141  -ANCRSP9 0.030CW9 0.011CFA9 0.021CFB9 0.029CFC9
C9141  0.003MN9  = 0
C9142  -ANCROC9 0.036CW9 0.012CFA9 0.022CFB9 0.031CFC9
C9142  0.004MN9  = 0
C9143  -ANCRNO9 0.046CW9 0.014CFA9 0.026CFB9 0.036CFC9
C9143  0.005MN9 = 0
C9144  -ANCRDE9 0.051CW9 0.017CFA9 0.033CFB9 0.047CFC9
C9144  0.008MN9  = 0
  /                        SPRING
  / 1 PLOWING SEASON
  / AREA TO BE PLOWED AND HARROWED
C9150  0.667RTA9 0.667RTB9 0.667RTC9 RTD9 WT9 OT9
C9150  BR9 PASA9 -GR9 = 0
C9151  -GR9 GRF19 GRF29 GR19 GR29 GR39 GR49 = 0
C9152  -PT9 PT19 PT29 PT39 PT49 = 0
C9153  -TP9 TP19 TP29 TP39 TP49 = 0
C9157  -GRFA9 -GRFB9 GRF19 GRF29 = 0
  / EXTRA HARROW FOR BARLEY
C9154  -0.333RTC9 -BR9 BRH19 BRH29  = 0
  / 8 APRIL TO 20 APRIL - 13 DAYS GROSS x .69 = 9 DAYS NET
C9160  0.271GR19 0.334PT19 0.334TP19 9ANCRAP9
C9160  0.063GRF9 0.063BRH19              < 18
  / 2  SEEDING
  / A) 21 APRIL TO 4 MAY - WHEAT ONLY - 14 DAYS GROSS - 9.6 NET
C9161  0.271GR29 0.334PT29 0.334TP29 0.163RTAW19 0.163RTBW19
C9161  6.9ANCRAP9 2.7ANCRMY9  0.163RTCW19
C9161  0.163RTDW19 0.063BRH29 0.163WT19 < 19.2
  / B) 5 MAY TO 12 MAY - WHEAT OR OATS - 8 DAYS GROSS - 5.8 NET
C9162  0.271GR39 0.334PT39 0.334TP39 0.163RTAW29 0.163RTBW29
C9162  5.8ANCRMY9 0.163PASA19 0.163RTCW29 0.163RTDW29 0.163RTBO19
C9162  0.163RTDO19 0.163RTDF19 0.163WT29 0.163OT19
C9162  0.163HYC19 < 11.6
  / C) 13 TO 18 MAY - WHEAT OATS BARLEY - 6 DAYS GROSS -4.4 NET
C9163  0.271GR49 0.334PT49 0.334TP49 1.333BK19 0.163RTAW39
C9163  0.163RTBW39 0.163RTCW39 0.163RTDW39 0.163RTBO29
C9163  0.163RTDO29 4.4ANCRMY9 0.163PASA29 0.163RTCB19
C9163  0.163RTDF29 0.163WT39 0.163OT29 0.163BR19
C9163  0.163HYC29 < 8.8
  / D) 19 TO 21 MAY - OATS BARLEY TURNIPS - 3 DAYS GROSS - 2.2 NET
C9164  0.163RTBO39 0.163RTDO39 1.333BK29 0.163PASA39 0.85TP9
```

```
C9164  2.2ANCRMY9  0.163RTCB29 0.163RTDF39  0.163OT39 0.163BR29
C9164  0.163HYC39  <  4.4
  / E) 22 TO 24 MAY - OATS BARLEY  POTATOES PASTURE
  /         - 3 DAYS GROSS - 2.2 NET
C9165  1.333BK39 0.163RTBO49 0.163RTDO49 0.163RTCB39 0.75PT9
C9165  0.163PASA49 2.2ANCRMY9 0.163RTDF49 0.163OT49 0.163BR39
C9165   0.163HYC49 < 4.4
  / F) 25 TO 27 MAY - BARLEY, OATS, PASTURE
  /      3 DAYS GROSS - 2.2 NET
C9166  1.333BK49 0.163RTBO59 0.163RTDO59 0.163RTCB49 0.163RTDF59
C9166  0.163PASA59 2.2ANCRMY9 0.163OT59 0.163BR49 0.163HYC59 < 4.4
  / G) 28 MAY TO 6 JUNE - 10 DAYS GROSS - 7 NETT
C9167  0.163RTCB59 0.163PASA69 4.1ANCRJN9 2.9ANCRMY9
C9167  1.333BK59  0.163RTDF69 0.163BR59 0.163HYC69 < 14
  / END OF SOWING SEASON
  / RECONCILE SOWING
C9170  -0.667RTA9 RTAW19 RTAW29 RTAW39 = 0
C9171  -0.333RTB9 RTBW19 RTBW29 RTBW39 = 0
C9172  -0.333RTC9 RTCW19 RTCW29 RTCW39 = 0
C9173  -0.5RTD9 RTDW19 RTDW29 RTDW39 = 0
C9174  -0.333RTB9 RTBO19 RTBO29 RTBO39 RTBO49 RTBO59 = 0
C9175  -0.25RTD9 RTDO19 RTDO29 RTDO39 RTDO49 RTDO59 = 0
C9176  -0.333RTC9 RTCB19 RTCB29 RTCB39 RTCB49 RTCB59 = 0
C9177  -PASA9 PASA19 PASA29 PASA39 PASA49 PASA59
C9177  PASA69 = 0
C9178  -0.25RTD9 RTDF19 RTDF29 RTDF39 RTDF49 RTDF59
C9178  RTDF69 = 0
C9520  -WT9 WT19 WT29 WT39 = 0
C9521  -OT9 OT19 OT29 OT39 OT49 OT59 = 0
C9522  -BR9 BR19 BR29 BR39 BR49 BR59 = 0
C9523  -0.333HYC9 HYC19 HYC29 HYC39 HYC49 HYC59 HYC69 = 0
  /  ROTATIONS
C9512  FAL9 -0.333RTA9 -0.333RTB9 -0.333RTC9 = 0
  /
  /  3                    SUMMER
  /
  /  A)  7 JUNE TO 12 JUNE - 6 DAYS GROSS - 4.2 NET
  /       CULTIVATE CROPS, NEW BREAKING, BUILD FENCES, BUILDINGS
C9180  1.333BK69 0.063CTGR19 0.126CTRT19 BUILD19
C9180  4.2ANCRJN9 0.208FAL19  < 8.4
  /  B)  13 TO 30 JUNE - 18 DAYS GROSS - 12.4 NET
C9181  0.063CTGR29 0.126CTRT29 BUILD29 12.4ANCRJN9
C9181 0.208FAL29                                  < 24.8
  /  C)  1 TO 10 JULY - 10 DAYS GROSS - 6.9 NETT
C9182  0.744HYN19  0.126CTRT39 BUILD39  0.744HYC109
C9182  0.208FAL39                          6.9ANCRJY9  < 13.8
  /  D)  11 JULY TO 6 AUGUST
  /     27 DAYS GROSS - 19.3 NETT (PLOW GREEN FALLOW)
C9183  0.267BS19 BUILD49 4.0PT59 3.5TP59 14.5ANCRJY9 6.9ANCRAU9
C9183   0.208FAL49                    < 38.6
  /  E)  7 TO 11 AUGUST  - 5 DAYS GROSS - 3.9 NETT
C9184  BUILD59 0.267BS29 4PT69 3.5TP69 0.744HYN29 3.9ANCRAU9
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C9184  0.208FAL59 0.744HYC119 < 7.8
  / RECONCILE PLOWING OF FALLOW
C9185  -FAL9 FAL19 FAL29 FAL39 FAL49 FAL59 = 0
  /  RECONCILE BREAKING AND BACKSETTING
C9190  -BK9 BK19 BK29 BK39 BK49 BK59 BK69 = 0
C9191  -BK9 BS19 BS29  = 0
  / RECONCILE CULTIVATION
C9192  -GR9 PASA9 CTGR19 CTGR29 = 0
C9193  CTRT19 CTRT29 CTRT39 -PT9 -TP9 = 0
C9194  PT59 PT69 -PT9 = 0
C9195  TP59 TP69 -TP9 = 0
  / RECONCILE BUILDING INCLUDING STONING, MISC
  / DELIVERIES, REPAIRS, MAINTENANCE
C9196 BUILD19 BUILD29 BUILD39 BUILD49 BUILD59 > 15
  /
  / 4                HARVEST SEASON
  /  12 AUGUST TO 15 SEPTEMBER - 35 DAYS GROSS - 25.8 NETT
C9201  0.235RTA9  0.2RTA209  0.057RTA309
C9201  0.235RTB9  0.2RTB209  0.065RTB309
C9201  0.353RTC9  0.2RTC209  0.060RTC309
C9201  0.265RTD9  0.2RTD209  0.070RTD309
C9201  0.353WT9   0.2WT209   0.069WT309
C9201  0.353OT9   0.2OT209   0.087OT309
C9201  0.353BR9   0.2BR209   0.077BR309
C9201  15.4ANCRAU9 10.4ANCRSP9        -LA9      < 51.6
  /
  /      THRESHING PLOWING AND DELIVERING SEASON
C9202  -DLVRA9 -DLVRB9 -DLVRC9 0.224CFA9 0.188CFB9 0.173CFC9
C9202  0.04PGA9 0.008PGB9 0.06PGC9 0.07PGD9 0.054MN9 0.4THYC9
C9202  0.012BUWT9 0.007BUOT9 0.010BUBR9 0.4THYN9 = 0
  /  16 SEPTEMBER TO 12 OCTOBER -27 DAYS GROSS - 17.6 NETT
C9203  0.057RTA319 0.065RTB319
C9203  0.060RTC319 0.070RTD319 0.069WT319 0.087OT319
C9203  0.077BR319
  / DIG PLOW MANURE POTS TPS
C9203  1.941PT9 2.771TP9
  /   DELIVERIES
C9203  DLVRA9 0.271GRF19
  / ANIMALS, MISC
C9203  10.4ANCRSP9 7.2ANCROC9  -LB9              < 35.2
  / DIG ONLY POTATOES, TURNIPS
C9204  1.67PT9 2.5TP9 2ANCRSP9 2ANCROC9         < 8.0
  /
  /     13 TO 27 OCTOBER - 15 DAYS GROSS - 9 DAYS NETT
C9205  DLVRB9 0.057RTA329 0.065RTB329
C9205  0.060RTC329 0.070RTD329 9ANCROC9  0.271GRF29
C9205  0.069WT329 0.087OT329 0.077BR329 < 18
  /                        WINTER
  /
  /                 28 OCTOBER TO 5 APRIL
C9210  DLVRC9
  / WINTER THRESHING - 60% OF FALL PRODUCTIVITY
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C9210  0.091RTC339 0.110RTA339 0.104RTB339
C9210  0.110RTD339 0.110WT339 0.140OT339 0.123BR339
  / ANIMAL CARE
C9210  2.4ANCROC9 15.3ANCRNO9 15.8ANCRDE9 13.3ANCRJA9 11.2ANCRFB9
C9210  18.6ANCRMR9 4.8ANCRAP9                    < 162.8
  / RECONCILE THRESHING
C9213  -BR9 BR309 BR319 BR329 BR339 = 0
C9214  -WT9 WT309 WT319 WT329 WT339 = 0
C9215  -OT9 OT309 OT319 OT329 OT339 = 0
C9223  RTC309 RTC319 RTC329 RTC339 -RTC9 = 0
C9224  -RTA9 RTA309 RTA319 RTA329 RTA339 = 0
C9225  -RTB9 RTB309 RTB319 RTB329 RTB339 = 0
C9226  -RTD9 RTD309 RTD319 RTD329 RTD339 = 0
  / RECONCILE STACKING FOR LATE THRESHING
C9240  -1.5RTC209 RTC329 RTC339 RTC349 = 0
C9242  -1.5RTA209 RTA319 RTA329 RTA339 = 0
C9243  -1.5RTB209 RTB319 RTB329 RTB339 = 0
C9244  -1.333RTD209 RTD319 RTD329 RTD339 = 0
C9245  -BR209 BR319 BR329 BR339 = 0
C9246  -WT209 WT319 WT329 WT339 = 0
C9247  -OT209 OT319 OT329 OT339 = 0
  / RECONCILE HIRED HARVEST LABOUR
C9250  -L9 LA9 LB9 = 0
C9251  L9 < 16.7
  / LAND
C9260  -AC9 AC5 16BK5 16BKC5 = 0
C9261  -AC9 RTA9 RTB9 RTC9 RTD9 PT9 TP9 HYC109
C9261  WT9 OT9 BR9 PASA9 = 0
C9263  PASB9 < 10
  / WIFE'S ANIMAL HUSBANDRY (HOURS/WEEK)
C9280  1.7CW9 0.163PGA9 0.07PGB9 0.163PGC9 0.349PGD9
C9280  0.21HN9 < 12
  / FAMILY CONSUMPTION
  / BEEF, MILK
C9290  CW9 CFA9 CFB9 CFC9 > 1
  / PORK
C9291  PGA9 PGB9 PGC9 PGD9 > 1
  / EGGS
C9292  HN9 > 5
  / ENSURE CORRECT PROPORTIONS OF OFFSPRING
C9300  -CFA9 0.67CW9 > 0
C9301  -CFB9 0.33CW9 > 0
C9302  -CFC9 0.22CW9 > 0
C9303  -3CW9 CFA9 CFB9 CFC9 < 0
C9304  -PGB9 4PGA9 > 0
C9305  -PGC9 4PGA9 > 0
C9306  -PGD9 4PGA9 > 0
```

APPENDIX 14

Adjustments to Values Calculated by Linear Programs

A. Brandon

	1880		1890		1900		1910
20 Years:-							
Gross Value	3608		5051		7141		16052
Acreage	46	52		154		164	
Less:-							
Labour cost	2757		2492		2386		2651
Capital cost	2285		2192		2081		3939
Nett Value	($1434)		$367		$2674		$9462
40 Years :							
Gross Value	5309		7597		10822		24322
Acreage	77	102		254		290	
Less:-							
Labour cost	3940		3561		3409		3788
Capital cost	2972		2993		2616		4727
Nett Value	($1603)		$1043		$4797		$15807

B. Indian Head

	1880		1890		1900		1910
20 Years:-							
Gross Value	1499		3162		5363		14719
Acreage	30	43		124		113	
Less:-							
Labour cost	2386		2492		2386		2651
Capital cost	2285		2192		1866		2843
Nett Value	($3172)		($1522)		$1111		$9325
40 Years :							
Gross Value	2312		4859		8156		21664
Acreage	60	87		174		190	
Less:-							
Labour cost	3940		3561		3409		3788
Capital cost	2972		2993		2616		4727
Nett Value	($4600)		($1695)		$2131		$13149

C. Scott

		1880		1890		1900		1910
20 Years:-								
Gross Value		1224		2583		3320		12443
Acreage	16		21		44		80	
Less:-								
Labour cost		2386		2492		2386		2651
Capital cost		2285		2192		1866		2843
Nett Value		($3447)		($2101)		($932)		$6949
40 Years :								
Gross Value		1946		3203		4898		19056
Acreage	30		23		79		200	
Less:-								
Labour cost		3940		3561		3409		3788
Capital cost		2972		2993		2401		4727
Nett Value		($4966)		($3351)		($912)		$10541

D. Lacombe

		1880		1890		1900		1910
20 Years:-								
Gross Value		2105		3147		4493		12918
Acreage	22		40		96		104	
Less:-								
Labour cost		2386		2492		2386		2651
Capital cost		2285		2192		1866		2843
Nett Value		($2166)		($1537)		$241		$7424
40 Years :								
Gross Value		3265		4648		6498		19282
Acreage	43		73		144		178	
Less:-								
Labour cost		3940		3561		3409		3788
Capital cost		2972		2993		2616		4727
Nett Value		($3647)		($1906)		$ 473		$10767

E. Lethbridge

	1880	1890	1900	1910
20 Years:-				
Gross Value	1241	4458	6374	15286
Acreage	31	65	164	147
Less:-				
Labour cost	2386	2492	2386	2651
Capital cost	2285	2192	2081	3939
Nett Value	($3430)	($ 226)	$1907	$8696
40 Years :				
Gross Value	1716	6882	10135	24110
Acreage	44	117	281	278
Less:-				
Labour cost	3940	3561	3409	3788
Capital cost	2972	2993	2616	4727
Nett Value	($5196)	$ 328	$4110	$1595

TABLE A14.1

SUMMARY OF NET FARM LAND VALUES[28]

	1880	1890	1900	1910
BRANDON	(1434)	367	2674	9462
INDIAN HEAD	(3172)	(1522)	1111	9325
SCOTT	(3447)	(2101)	(932)	6949
LACOMBE	(2166)	(1537)	241	7424
LETHBRIDGE	(3430)	(226)	1907	8696

[28] Calculated on the basis of the capitalized gross value of the farm over a 20 year operating period, less the amount which the settler could have expected to earn as a farm labourer in eastern Canada for the same 20 year period. No costs have been deducted for the move from eastern Canada to the Prairies.

APPENDIX 15

Settlement Dates

DATA EXTRACTED FROM A 1 IN 100 SAMPLE OF DOMINION LAND HOMESTEAD RECORDS

1) BRANDON - Area searched - Ranges 17 to 21, Townships 8 to 12, West of 1st Meridian

42926 050689140590120294 18 NE 0819W 01 160 N0000JOHNSON AARON

16680 010582-1-1-1-1-1-1 20 SW 0821W 99 160 C0000QUIGLEY THOMAS

16576 120482011081280785 16 SW 0917W 99 160 N0000ROWAN DUNCAN

23901 170383220682061085 28 NW 1021W 01 160 N0000ANDREWS W

15121 020282020382270785 16 SE 1018W 99 160 N0000CARDIFF HENRY

15330 070382070482291085 22 NW 1018W 99 160 N0000WOODCOCK GEORGE

14220 230981240582221090 10 SW 1020W 99 160 N0000BEATON KENNETH

40091 030888200489300693 02 NW 1217W 01 160 N0000BROUGHAM JOHN

12366 110681150781281086 04 NW 1218W 99 160 N0000MOORE JAMES

12868 230681290483050886 14 NE 1218W 99 160 N0000WILSON WILLIAM

21192 131082-1-1-1-1-1-1 30 NE 1220W 99 160 C0000NEWCOME HERBERT

2) INDIAN HEAD - Area searched - Ranges 10 to 13, Townships 16 to 20, 2nd Meridian

58046 200693061293080298 28 NW 1710W 02 160 N0000POULAIN JUSTE

69806 270198-1-1-1-1-1-1 12 NW 1712W 02 160 N0072GRAHAM THOMAS

26210 050783-1-1-1260489 02 SE 1911W 02 160 N0000DICKIN WILLIAM

25685 080683-1-1-1-1-1-1 32 SE 1912W 02 160 C0000MANSIGNE BASIL

51956 250292-1-1-1-1-1-1 20 NW 2011W 02 160 C0000GIBBONS GEORGE

47966 091290091290270499 14 SE 2013W 02 160 N0000CARGO HUGH

3) SCOTT - Area searched - Ranges 18 to 22, Townships 37 to 41, 3rd Meridian

i.e 30 x 30 miles = 900 sq.miles - no settlement records found for this period up to 1902

4) LACOMBE - Area searched - Ranges 18 to 22, Townships 37 to 41

60776 160494010792311095 06 SW 3825W 04 160 N0000LORE	WILLIAM
47231 070790-1-1-1-1-1-1 02 SE 3827W 04 160 C0000BARBER	SAMUEL
48911 160591-1-1-1-1-1-1 26 NE 3827W 04 160 N0000JENKINS	WILLIAM
55316 150992-10883290895 34 SE 3827W 04 137 N0000MCKENZIE	P
70646 070298011298130302 04 NE 3827W 04 160 N0000HANSEN	CARL
93011 260301-1-1-1-1-1-1 06 NE 3924W 04 160 C0000WILLIAMSON	W
72116 210798-1-1-1-1-1-1 24 SW 3926W 04 160 N0000MORDEN	NORMAN
64451 150695-1-1-1-1-1-1 32 SE 3927W 04 160 C0000LALONDE	PHILLIP
85976 150900-1-1-1-1-1-1 34 NE 4024W 04 160 N0072SWANSON	R
59096 140893010495090399 34 NE 4026W 04 160 N0000CHISWELL	JAMES
57941 060693-1-1-1-1-1-1 34 NE 4027W 04 160 C0000BRUCE	CHARLES
71591 130698-10599211201 12 SE 4126W 04 160 N0072HILL	OLIVER
60251 030394-10693251098 10 NE 3801W 05 160 N0000JOHANSSON	ERIK
79361 311099-1-1-1-1-1-1 06 SW 4001W 05 160 N0000VESTINMARK	NES
82406 100300-1-1-1-1-1-1 32 SW 4101W 05 160 N0000LAGORE	GEORGE
95741 211001-1-1-1-1-1-1 30 SE 4101W 05 160 N0000EVERNDEN	JESSE

5) LETHBRIDGE - Area searched - Ranges 19 to 23, Townships 7 to 10,

4th Meridian

1200 sq.miles searched - no settlement records prior to April 1902

APPENDIX 16

Patents Taken Out for Plows, United States and Canada[29]

Table 5.7. Plows, Patent Class: Subclass, 172: 133-203

Time Period	New England	Middle Atlantic	Eastern Corn Belt	Western Corn Belt	Lake States	Appalachia	South	Plains States	Mountain States	Pacific States	Foreign	Canadian
Pre-1830	7	61	7			11	5					
1830-39	9	60	15	1	1	18	3		1			
1840-49	7	45	20	7	2	11	5					
1850-59	11	65	30	32	8	30	46	2		1		
1860-69	43	177	153	294	51	68	76	10		62	8	3
1870-79	36	96 (1)	121	123	44 (3)	90	74	30		46	3	4
1880-89	20	58 (3)	80	94 (4)	39 (1)	37 (2)	58	85	4	13	2	3
1890-99	14 (1)	36 (8)	31 (2)	67 (8)	18	17	53	80 (1)	4	21 (1)	8	3
1900-09	5 (1)	26 (3)	38 (5)	74 (7)	24 (3)	22 (1)	71 (3)	84 (2)	15 (1)	33	11	4
1910-19	5	17 (3)	30 (7)	55 (16)	21 (2)	27 (2)	51 (1)	74	26 (1)	33 (3)	7	10
1920-29	2	5 (1)	21 (7)	34 (6)	20	22	29 (2)	47 (3)	22	26 (2)	8 (1)	5
1930-39	1	7 (5)	9 (4)	23 (10)	12 (3)	4	17	25	16	11 (1)	2	5 (1)

Numbers in parentheses are patents assigned to firms.

[29] Taken from Evenson, Robert E. "Government Policy and Technological Progress in U.S. Agriculture," in Nelson Richard (ed.) Government Support of Technological Progress; A Cross Industry Analysis, New York: Pergamon Press, 1982, p 71.

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