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NAME OF SUPERVISOR/*NOM DU DIRECTEUR DE THÈSE* Dr. TRAVIS W. MANNING

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THE INFLUENCE OF IRRIGATION AND THE RAILROAD ON THE SETTLEMENT OF SOUTHERN ALBERTA

by

© DAVID CHRISTIAN ASANTE-KWATIA

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

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EDMONTON, ALBERTA

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled THE INFLUENCE OF IRRIGATION AND THE RAILROAD ON THE SETTLEMENT OF SOUTHERN ALBERTA submitted by David Christian Asante-Kwatia in partial fulfilment of the requirements for the degree of Master of Science.

.....
Supervisor

.....

.....

Date 4 February 1977

ABSTRACT

Although water deficiency and drought incidence were hindrances to settlement and agricultural production in the semi-arid region of Southern Alberta, other factors influenced settlement. In an attempt to identify these factors, a multiple regression model based on the historical experience of the region was used. Population was the dependent variable used as a measure of settlement. The independent variables were made up of quantitative variables and dummy variables. The quantitative independent variables were irrigated acreage and railway track mileage, while Canadian Pacific Railway Company policies and Prairie Farm Rehabilitation programmes were incorporated as dummy variables.

The equation discussed in the analysis showed that the independent variables explained 94 percent of the variation in settlement in Southern Alberta. The results indicated that the quantitative independent variables influenced settlement.

The study concluded that settlement in Southern Alberta was to an appreciable extent due to the development of irrigation which was itself a sequel to the construction of the railway in the region.

Discounting individual efforts, the conclusion was

that government and corporate policies respecting land grants, railway transportation and water resource development led to settlement and subsequent agricultural development of Southern Alberta. Such policies made it possible to turn the semi-arid region which was "unfit for human habitation" into a productive agricultural area.

ACKNOWLEDGEMENTS

The author acknowledges with appreciation the suggestions and guidance of Dr. Travis W. Manning under whose supervision this thesis was written. The criticisms and suggestions by Professors A.W. Anderson and E. Rapp, both members of my committee, were also deeply appreciated. Occasional discussions with Dr. W.E. Phillips and Dr. W.M. Schultz were found useful. I am grateful to them for allowing me to encroach upon their time.

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The author finds it difficult to identify and thank all persons and organizations whose help contributed to this study. I am particularly grateful to Mr. Earl E. Olson of the Canadian Pacific Railway, Calgary, for suggestions. The late Mr. W.E. Bowser also granted me the opportunity for a fruitful discussion for which I am grateful. I appreciate information received from Dr. Asael E. Palmer. Also through his direction I was able to contact the Secretary of the Lethbridge Historical Society of Alberta Whoop-Up Country Chapter whose assistance I found

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CHAPTER 1

INTRODUCTION

Statement of the Problem

The principal factors responsible for the settlement of Southern Alberta are obscure. Captain John Palliser was commissioned by the British government in 1859 to ascertain the feasibility of agriculture in Western Canada. He reported that the prairie section south of the South Saskatchewan River was not fit for cropping as it was "an extension of the Great American Desert, so the area cannot be settled."[1] S.J. Dawson and Professor H.Y. Hind, who were sent on an expedition between 1857 and 1858, were also of the opinion that the semi-arid belt was unsuited for settlement.[2] In spite of this, in the 1880's, Prime Minister John A. Macdonald's administration promised that the building of the Canadian Pacific Railway would flood the west with settlers, but the expected inundation did not occur

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[1] P.M. Sauder, "Irrigation in Southern Alberta: Vol. 1" (Unpublished Report, Alberta Department of Agriculture, Edmonton, 1972), p. 7.

[2] J.B. Hedges, Building the Canadian West: The Land and Colonization Policies of the Canadian Pacific Railway (New York: Russell and Russell, 1971), p. 4.

immediately because the competing Western United States offered more fertile lands, a more favourable climate, better transportation, and a larger market.[1] However, the discovery of coal, the construction of the railway and the development of irrigation in the area were associated with the settlement of Southern Alberta.[2]

According to the late Earl Bowser, an irrigation project is basically composed of people, land, water and markets.[3] In Western Canada land was available. The water resources of Southern Alberta were enormous but unutilized. Their potential was revealed through impounding water and regulating its use for agriculture and other uses. The construction of a transcontinental railway through Southern Alberta bridged the gap between production centres and major consuming areas. Railway communication in Alberta started in Southern Alberta in the 1880's. Since then an extensive network of railway lines have been built throughout Alberta (Figure 1.1). Marketing was further strengthened through food processing and manufacturing industries which developed

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[1] A.A. den Otter, Irrigation in Southern Alberta 1882-1901, Occasional Paper No. 5 (Lethbridge: Whoop-up Country Chapter Historical Society of Alberta, 1975), p. 7.

[2] R.F.P. Bowman, Railways in Southern Alberta, Occasional Paper No. 4 (Lethbridge: Whoop-up Country Chapter Historical Society of Alberta, 1973), pp. 8-12.

[3] W. Earl Bowser, "Physical Characteristics of Alberta's Irrigated Areas," In Proceedings of Irrigation Economics Conference, Edited by T.W. Manning (Edmonton: University of Alberta, June, 1964), p. 22.

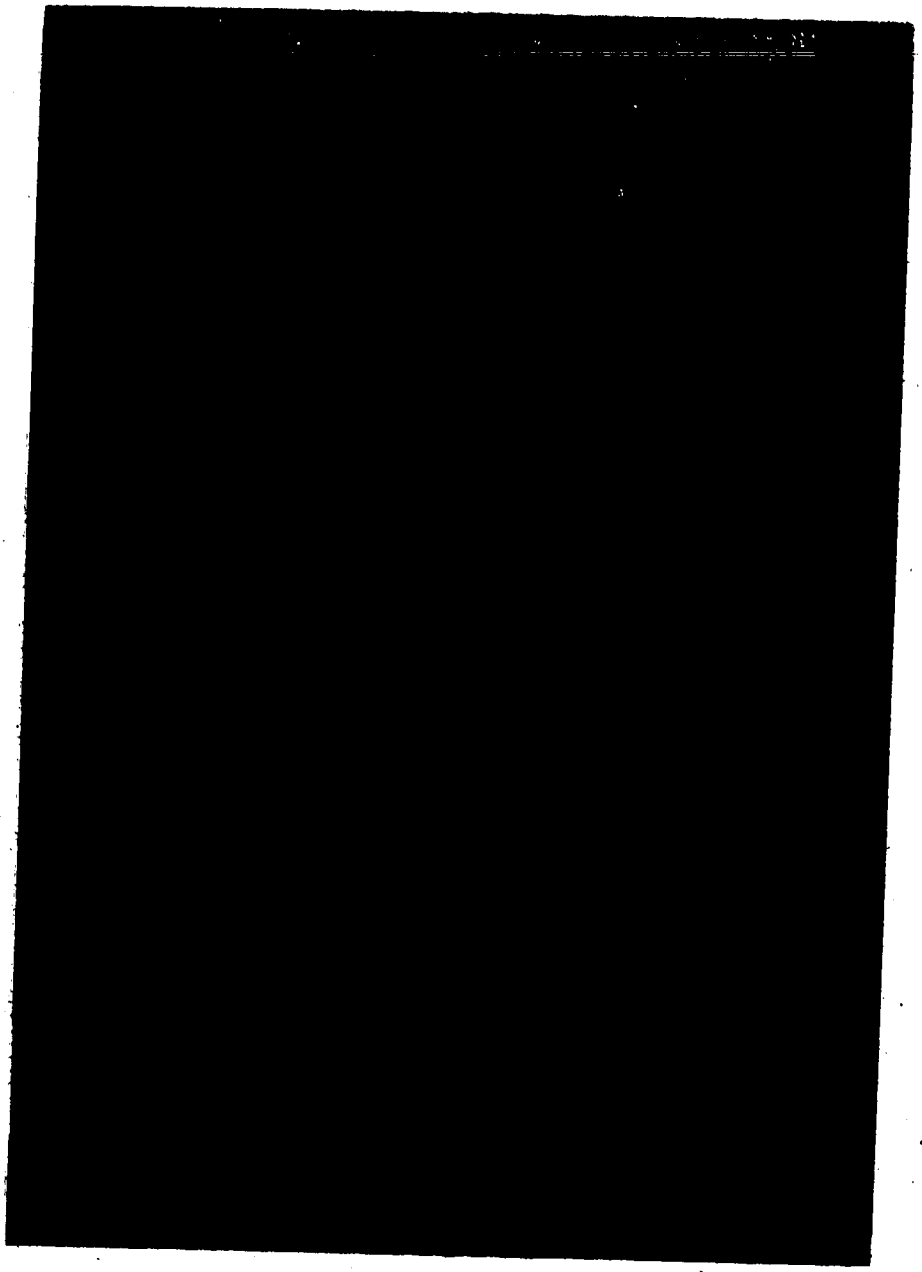

Figure 1.1. Railway Networks of Alberta Showing Study Area

SOURCE: Government of Alberta and the University of Alberta, Atlas of Alberta (University of Alberta/ University of Toronto Press, 1969), p. 120.

in the irrigation block.[1] Factors which influenced settlement and therefore the "people" aspect of irrigation are obscure. This study will attempt to shed light on this problem.

Sewell has indicated that throughout Canadian history water resources have played a vital role in the nation's economic growth. Water resources have influenced settlement patterns and have been a powerful force conditioning industrial and agricultural development.[2] The water resources programmes implemented by the Prairie Farm Rehabilitation Administration have done much to overcome the problems of agricultural readjustment resulting from the drought and economic depression of the 1930's. The close association of water resource development with overall economic growth is further emphasized by the huge investments in water-related activities.[3]

The land boom that accompanied the building of the transcontinental railway brought over 2,000 settlers to Calgary in 1884 and received added impetus as the Canadian

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[1] Evidence appears in an inventory and maps prepared by Alberta Department of Agriculture, Statistics Branch, Alberta Agricultural Processing and Manufacturing Guide, 1973 (Edmonton: A.D.A., n.d.).

[2] W.R.D. Sewell, "Multiple-Purpose Development of Canada's Water Resources," in Water: Selected Readings, Edited by J.G. Nelson and M.J. Chambers (Toronto: Methuen Publications, 1969), p. 261.

[3] Ibid.

Pacific Railway reached the summit of the Rocky Mountains.[1] The granting of lands en bloc to the C.P.R. in 1903 and the subsequent development of irrigation in Southern Alberta contributed to further population expansion.[2] Settlers were certain of transportation for their produce and supplies and also water in periods of drought. By 1910, ranching, which had developed in the dry areas of Southwestern Saskatchewan and Southeastern Alberta in the late 1800's, had reached its peak. The ranching industry declined as homesteaders poured in but remained of considerable importance in the southern and foothills regions of Alberta.[3]

The changing pattern of agriculture in Southern Alberta was greatly influenced by the development of irrigation. Only 4 percent of Alberta's agricultural land is irrigated. This land contributes 20 percent of Alberta's gross agricultural output.[4]

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[1] L.G. Thomas, "The Ranching Period in Southern Alberta" (Unpublished M.A. Thesis, University of Alberta, Edmonton, 1935), p. 61.

[2] J.L. McDougall, Canadian Pacific: A Brief History (Montreal: McGill University Press, 1968), pp. 133 f.

[3] Kenneth Buckley, Capital Formation in Canada, 1896-1930 (Toronto: McClelland and Steward Ltd., 1974), p. 24.

[4] R.L. Francis, "Irrigation Capital Works. Report on Irrigation Development in Alberta -- Past, Present, Potential" (Water Resources Division, Alberta Department of the Environment, Lethbridge, Alberta, February, 1972), p. 8. (Mimeograph).

Location and Characteristics of the Study Area

The study covers Southern Alberta. The Alberta Bureau of Statistics defined Southern Alberta as comprising Census Divisions 1 through 7.[1] A revision of Census Division boundaries was made in 1956. In this study, Southern Alberta was defined as including Census Divisions 1, 2, 3 and 4 in relation to the 17 Census Divisions which existed before 1956. Use of the pre-1956 boundaries ensures that the study area includes as many of the Irrigation Districts of Alberta as possible. These Irrigation Districts are located in the South Saskatchewan River Basin (Figure 1.2).

The study area covers the following regions as indicated in Figure 1.3:

Census Division 1 - Medicine Hat-Coutts
2 - Lethbridge-Pincher Creek
3 - Brooks
4 - High River-Carmangay.

The Irrigation Districts of Southern Alberta all fall within Census Divisions 1, 2, 3, 4 and 6. However, the principal economic influence directing the growth of Census Division 6 originates more from oil and gas explorations

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[1] Alberta Bureau of Statistics, Facts and Figures: Alberta Department of Industry and Labour (Edmonton: A.B.S., 1954), p. 319.

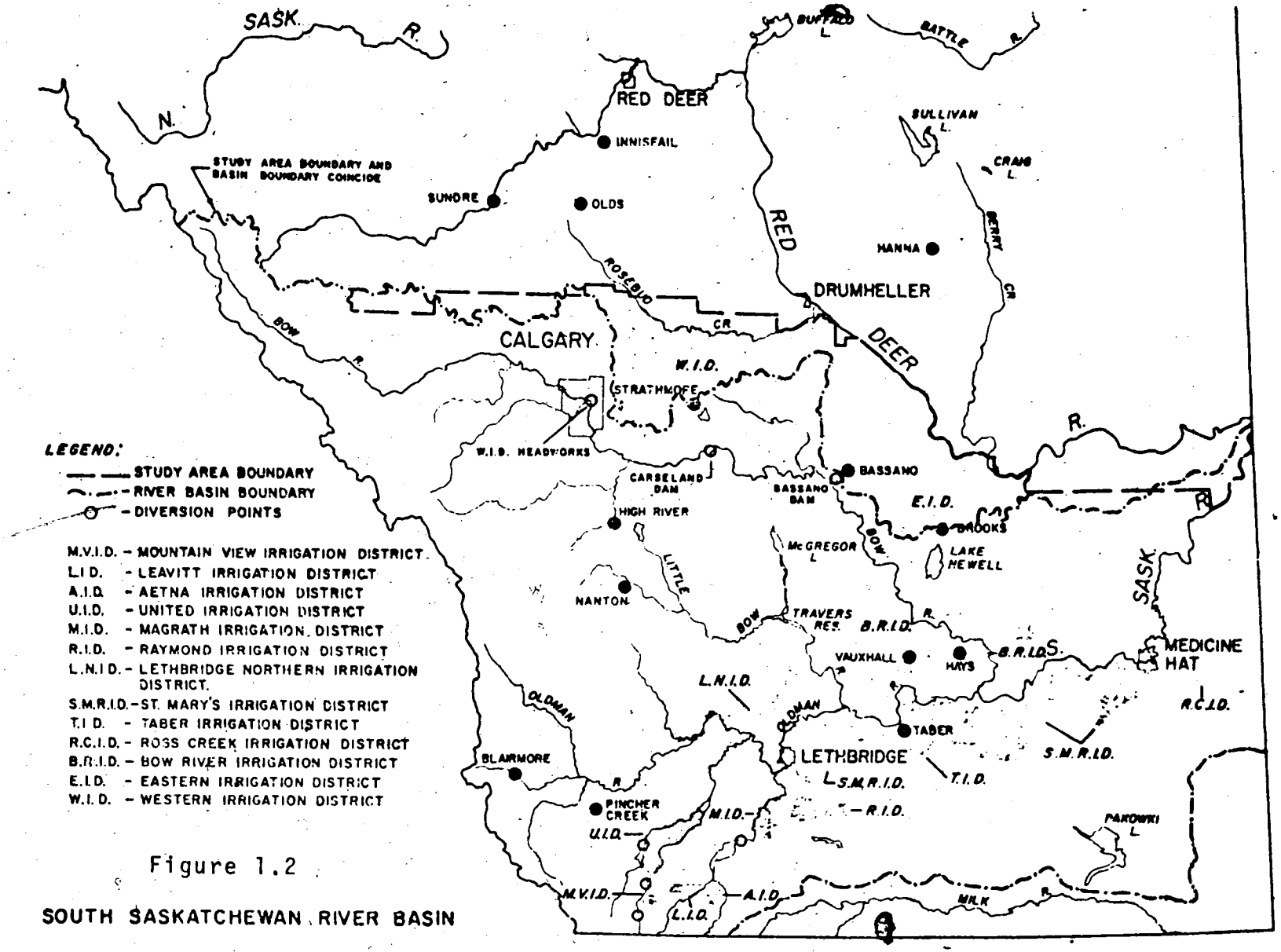

Figure 1.2

SOUTH SASKATCHEWAN RIVER BASIN

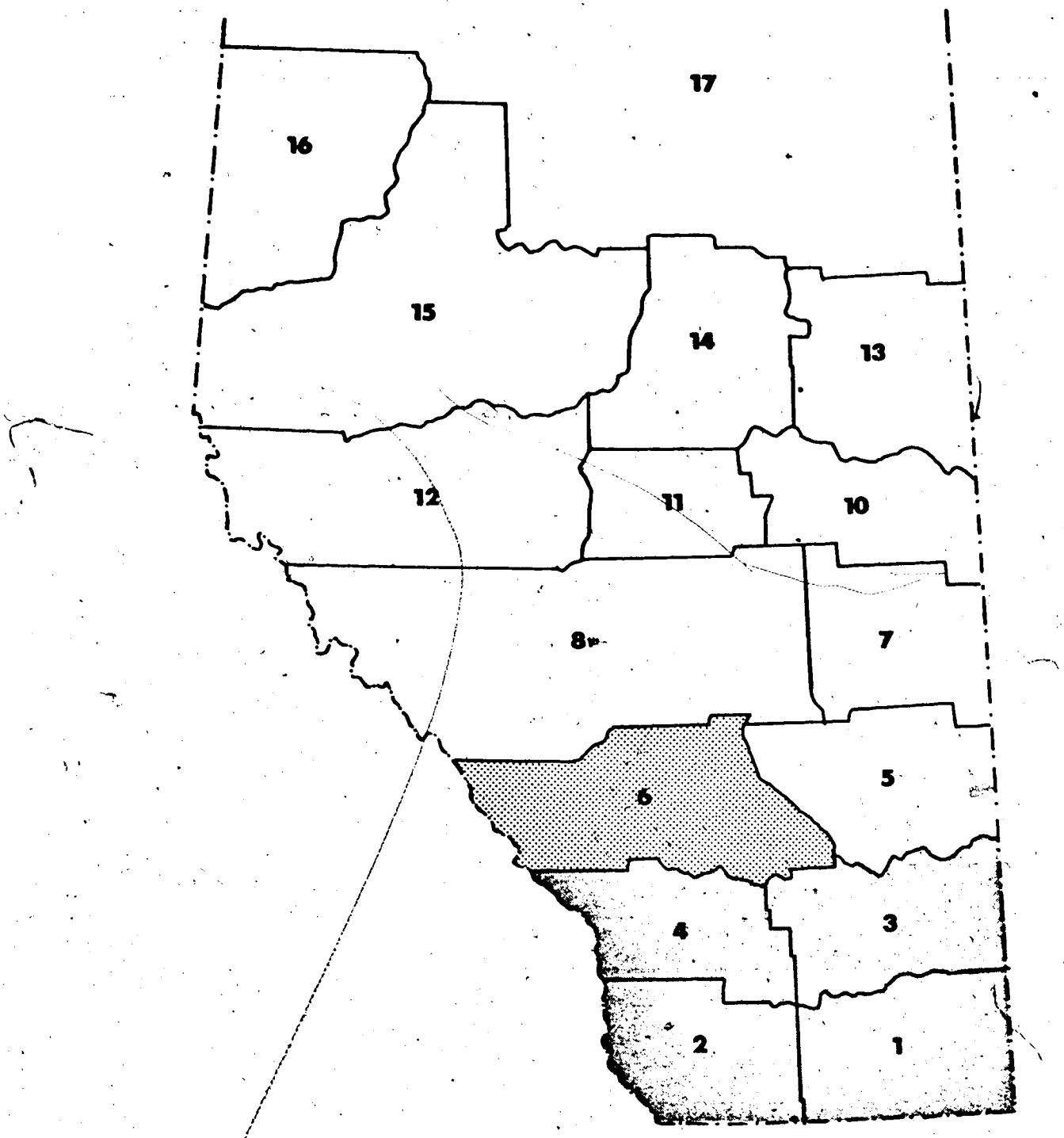

Figure 1.3

Pre-1956 Census Divisions - Alberta

than agriculture. It was therefore necessary to exclude Census Division 6 from the analysis.

The irrigation block of Southern Alberta includes part of the area called the "Palliser's Triangle" which is on the borderline of being desert (Figure 1.4). The average annual precipitation varies from 10 inches in Medicine Hat to about 15 inches in the Lethbridge area.[1] However, the average water requirement for optimum crop production varies from 18 inches to 24 inches. Depending on the crop, water requirement may be as high as 30 inches. A large proportion of this precipitation is snow and most of it is lost through run-off and evaporation and does not contribute to crop production. Irrigation is the only feasible way to supplement the water deficit for crop production.

Nearly 70 percent of the irrigation area is in the Brown Soil Zone (located in the semi-arid, short grass, prairie), and a little less than 30 percent is in the Dark Brown Zone (located in the semi-arid to sub-humid, long grass, prairie). Three to 5 percent is in the Thin Black Zone (the sub-humid, open parkland area).[2] The Brown Zone and the Dark Brown Zone receive an average annual precipitation of 12 inches and 15 inches, respectively, and have a respective average water deficit of about 12 inches and 8

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[1] R.L. Francis et al., op cit., p. 8.

[2] W. Earl Bowser, op. cit., p 22.

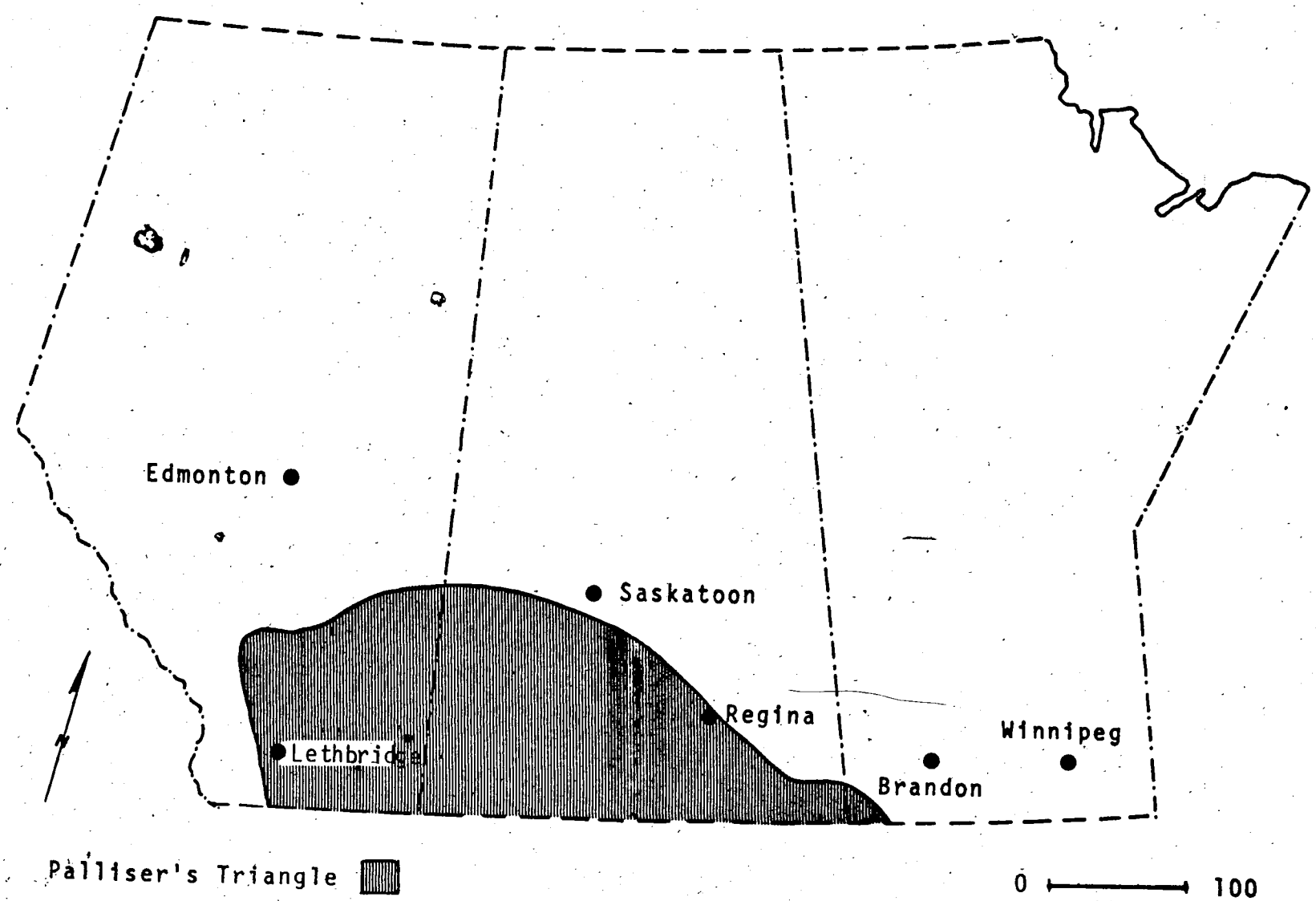

Figure 1.4

Palliser's Triangle

to 9 inches.[1]

The average frost-free period for Medicine Hat is about 120 days and it decreases to the north and west. About 110 frost-free days are found over 80 percent of the irrigation block. Most of the area has a mean annual temperature of about 40°F while the mean growing season average is 55°F (April to September). Unlike most irrigation areas of the world, dry land farming adjoins the irrigation block. Sometimes rainfall within sections of the irrigation block is adequate for crop production.

Objectives of the Study

The principal objective of the study is to determine the influence of irrigation and other selected factors on the settlement of Southern Alberta.

The specific objectives of the study are:

1. To explore the developmental phases of irrigation in Southern Alberta and determine the role of irrigation in the settlement of that region.
2. To investigate the extent to which railway transportation influenced settlement in Southern Alberta.
3. To examine the influence of Canadian land and

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[1] Ibid., p. 22 and R.L. Francis et al., op. cit., p. 8.

water resource development policies on settlement in Southern Alberta.

Sources of Data

Secondary data were used in the analysis. Data sources were diverse. A considerable amount of the data were obtained from Census publications of the Dominion Bureau of Statistics, Canada Sessional Papers, Canada Yearbooks, and Alberta Bureau of Statistics, Facts and Figures and Alberta Industry and Resources. Alberta Department of Agriculture publications, Alberta Agriculture Statistics Yearbook 1973 and A Historical Series of Agricultural Statistics: Alberta, were consulted for data. The Annual Reports of Alberta Department of Agriculture, Alberta Department of Lands and Forests, Alberta Department of Lands and Mines, and Irrigation Districts also provided some of the data used in this study. Citations are made at relevant places.

Scope of Study

This study consists of six chapters. The following chapter presents the historical setting for the study. Chapter III is devoted to a detailed theoretical review of the economic analysis of irrigation and associated conceptual problems. The method of analysis is discussed in

Chapter IV. In this chapter, the theoretical framework of the analysis is developed and an analytical model is formulated. Chapter V discusses the results of the empirical analysis. The last chapter deals with the summary, conclusions and implications of the study.

CHAPTER II

HISTORICAL SETTING

Early History of Irrigation in the World

Irrigation is an age-old method of bringing water to the land for agricultural purposes. The application of water by artificial means to benefit agricultural operations can be traced as far back as the Garden of Eden.[1] The Bible confirms this:

> And a river went out of Eden to water the garden; and from thence it was parted, and became into four heads.[2]

Archeologists explain that it was irrigation which made the land of Goshen such a fruitful land in Joseph's time. As a result, when there was drought and famine elsewhere, people could go to Egypt to buy corn.[3] Historians who accept that civilization first arose in the Euphrates and Tigris River valleys in Asia Minor indicate that the

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[1] Canadian Pacific Irrigation Colonization Company, The Canadian Pacific Railway Company's Irrigation Project, Alberta, Canada; A Handbook of Information Regarding this Undertaking (1914), p. 3.

[2] Genesis 2:10.

[3] Canadian Pacific Irrigation Colonization Company, op. cit., p. 3.

region was once a densely populated region in a state of very high cultivation.[1] This evidence shows that since ancient times, irrigation has contributed towards prosperity, helped to support higher population densities and also provided market outlets. The discovery of profound engineering skills has inspired the greatest admiration and respect for the unknown engineers of antiquity and provided impetus for modern day irrigation.

The westward spread of irrigation was very rapid. The use of canals to water large gardens and plantations in North Africa was reported by the first invaders.[2] Tunis and Algeria then enjoyed advanced irrigation systems. The Romans were great irrigationists who practiced irrigation in the first century A.D.[3] In their colonizing and civilizing activities, they introduced irrigation to parts of Europe with the help of artificers and engineers from the famous systems in North Africa. Nations around the Mediterranean, however, learned irrigation from Egypt.[4] The attention given irrigation in the famous codes of law formulated in the fifth and sixth centuries A.D. exhibited

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[1] Ibid.

[2] R.E. Huffman, Irrigation Development and Public Water Policy (New York: Ronald Press Co., 1953), p. 11.

[3] Canadian Pacific Irrigation Colonization Company, op. cit., p. 4.

[4] Ibid; and R.E. Huffman, op. cit., p. 11.

the importance of irrigation in the Roman economy.[1] Greece and Spain paid special attention to the development of water resources during the tenth century A.D. while Italy and France practiced extensive irrigation during the seventeenth century.[2]

In the Western hemisphere, the Incas were a progressive people who had developed a civilization of considerable importance in Peru before the time of Christ. They built well distributed irrigation systems before the Spaniards under Pizarro conquered them in their search for gold.[3] When the Spanish conqueror, Cortez, reached Mexico, he found a well-governed and advanced agricultural civilization based upon extensive and skillful irrigation.[4] There was a similar scale of irrigation structure in Chile and Argentina.[5] The Pueblo Indians of the Southwest United States left evidence of irrigation structures in New Mexico, Arizona and Southwestern Colorado, which indicates the antiquity of irrigation in the United States.[6]

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[1] Ibid.

[2] Ibid., pp. 11-12.

[3] Ibid., p. 12.

[4] Canadian Pacific Irrigation Colonization Company, op. cit., p. 5.

[5] R.E. Huffman, op. cit., p. 12.

[6] Canadian Pacific Irrigation Colonization Company, op. cit., p. 5.

The Mormons were the first Caucasians to practice irrigation in North America; they irrigated the arid valley of the Great Salt Lake of Utah in 1847.[1] Utah is considered the "Cradle of American Irrigation" due to the institutions of modern irrigation that were first developed there, not because of the date of initial irrigation.[2]

Initial Irrigation Development in Alberta

The history of Alberta until recently was closely associated with the history of irrigation in the province.[3] Small-scale irrigation was practiced in Alberta before the turn of the century by Mormons who had migrated from Utah in 1887.[4] Before then, however, individual efforts had been made to initiate irrigation projects in Southern

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[1] D.W. Hays, "History of Irrigation" in Report, by V. Meeks (Chairman, St. Mary and Milk River Water Development Committee), G. Spence and W.E. Hunter (Ottawa: King's Printer, February, 1942), Appendix E, pp. 113-118.

[2] R.E. Huffman, op. cit., p. 15.

[3] P.M. Sauder, op. cit., p. i.

[4] (Hon.) H. Strom, "Irrigation Policy Problems in Alberta," in Proceedings of Irrigation Economics Conference, Edited by T.W. Manning (Edmonton: University of Alberta, June, 1964). The following references are also relevant: A History of the Mormon Church in Canada (Lethbridge Herald Co. Ltd., 1968), Chapter 6; A.A. den Otter, op. cit., p. 7; Radio and Information Branch, Alberta Department of Agriculture, Irrigation in Alberta, Publication No. 156 (Edmonton: Alberta Department of Agriculture, 1961).

Alberta.[1] These early attempts in ditch construction were directed towards irrigating hay meadows in connection with the ranching industry.

The relative ability of irrigators to acquire capital to finance construction of water works was the principal indicator of success or failure of the early irrigation projects.[2] The cost of digging and maintaining the main canals and laterals and the cost of erecting expensive headgates to control the flow of water into the system was the major part of the expenditure. Early attempts at irrigation were crude because of individual settler's capital limitations to enable the erection of expensive headgates and flumes.[3] The consequence was that such irrigation works were washed away during spring run-off and ditches and canals were destroyed. Irrigators therefore abandoned their systems due to financial inability to reconstruct their structures.

The transformation of Southern Alberta into an organized irrigation region is due partly to William Pearce

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[1] P.M. Sauder, op. cit., p. 6, pp. 21-22; A.A. den Otter, op. cit.; and E.A. Mitchener, "William Pearce: Father of Alberta Irrigation" (Unpublished M.A. Thesis, University of Alberta, Department of History, 1966), pp. 7-8.

[2] E.A. Mitchener, "William Pearce and Federal Government Activity in Western Canada, 1882-1904" (Unpublished Ph.D. Thesis, University of Alberta, Department of History, 1971), p. 278.

[3] E.A. Mitchener (1966), op. cit., p. 8.

who was endeared to irrigation when he visited Utah and Colorado in 1881.[1] The similarity in vegetation and topography between the semi-arid regions of Alberta and those of Utah and Colorado led him to conclude that irrigation could provide an answer for the drought striken areas of Alberta. Consequently, he constantly urged the Dominion Government to encourage irrigation.

In the late 1880's, property rights in Southern Alberta were not well defined. The ranchers and the early homesteaders, however, lived in harmony at the beginning.[2] Most ranchers felt the homesteader was an asset since he provided not only labour for round-ups but also hay and other stock feed. The ranchers welcomed settlement and wished there had been more farmers on the range during the long and disastrous winter of 1881. Their additional supply of fodder would have saved the herds from starvation.

Unfortunately, the positive farmer-rancher relationship was short-lived. The rancher began to look unfavourably upon farming activities which appropriated bottom lands adjacent to the rivers or settlement on vital fresh springs

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[1] P.M. Sauder, op. cit., pp. 8-10. Comprehensive accounts of William Pearce are provided in E.A. Mitchener's M.A. and Ph.D. Theses. Also the University of Alberta Archives has a sizeable collection called "The William Pearce Papers." See also: Canada Department of the Interior, Annual Report, 1895: Part IIIL Irrigation (Ottawa: Queen's Printer, 1896), p. 21.

[2] E.A. Mitchener (1971), op. cit., p. 196.

since the farmers' fences prevented the cattle from obtaining water. William Pearce sought to remedy this conflict regarding demands for priority rights to water usage by introducing some regulations.[1] The need for irrigation became acute when the public demanded stock watering reserves and stock shelter belts. Furthermore, continued immigration in the 1890's helped to emphasize the need for artificial water supply. Pearce proposed the creation of a comprehensive regional land development programme covering hundreds of square miles.[2] He planned that the administration within each region would systematically develop the water resources available. This would eliminate a proliferation of small uneconomical schemes scattered across the plains.

Frustrated by the indifference of the Dominion Government to his proposal, Pearce single-handedly persuaded and educated westerners regarding the benefits of irrigation farming.[3] In fulfilment of this objective, he established

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[1] Ibid., p. 199. William Pearce made this the subject of his proposed address to the Association of Dominion Land Surveyors of Ottawa, January, 1891. His topic was "Irrigation Legislation: Its Primary Objectives" (William Pearce Papers, File No. M.G. 9/2/7/2/6). However, W.P.P. File No. 9/2/6/4/1 indicates that the Deputy Minister of the Interior did not allow him to address the convention on the topic.

[2] E.A. Mitchener (1971), op. cit., p. 279.

[3] W. Pearce, "The Proposed Northwest Saskatchewan Irrigation Project" (Paper presented at the Thirteenth Annual Convention of the Western Canada Irrigation Association, Medicine Hat, August, 1919), p. 6. (File No. 9/2/7/4/6 of William Pearce Papers.) Also see: E.A. Mitchener (1966), op. cit., pp. 37-38 and 55.

the Calgary Irrigation Company in 1893 to visibly demonstrate the superior crop yields promised by irrigation.

The plight of the settlers during the continued drought of the late 1880's and early 1890's ultimately forced the government to recognize the need for irrigation in the West. Pearce and Mr. Fraser of the Department of Justice were commissioned by the government to draft what became the North-West Irrigation Act of 1894.[1]

The change in government's attitude in favour of irrigation was also partly due to the efforts of the Mormons to irrigate lands at Cardston. Ora Card, their leader, made a preliminary visit in 1886 to Southern Alberta, returning the following year with a large number of settlers from Utah to start an irrigation project on the Lethbridge plains. As Superintendent of Mines, Pearce wrote of their coming:

> Their example in the matter of irrigation will be of great importance to other settlers along the foothills of the Rocky Mountains.[2]

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[1] Canada Laws and Statutes, The North-West Irrigation Act, s.c. 1894, Ch. 30. This Act was amended in 1895 and was later consolidated as the North-West Irrigation Acts of 1894 and 1895, s.c. 1898, Ch. 35. It was further replaced by the Irrigation Act when the Provinces of Alberta and Saskatchewan were inaugurated and was superceded by the Water Resources Act when the Natural Resources were transferred to Alberta in 1930. P.M. Sauder has elaborated on the provisions of the North-West Irrigation Act 1894 (see P.M. Sauder, op. cit., pp. 10-24). Also see: W. Pearce, (1919), op. cit., p. 7.

[2] Canada Department of the Interior, "Report of the Superintendent of Mines," Annual Report, 1887, p. 13. See also: A. James Hudson, Charles Ora Card: Pioneer and Colonizer (Cardston, Alberta: Published by the Author, 1963), p. 199.

Card made a favourable impression on Prime Minister Sir John A. Macdonald during a visit to Ottawa in 1888.[1] His faith in irrigation convinced the Prime Minister of the value of this farming technique.[2]

Pressures from other quarters might have also influenced government's decision to support irrigation. By 1893, the agitation for irrigation in the Lethbridge district was so well advanced that the Lethbridge Board of Trade passed a motion that:

> The promotion of irrigation in this district of Southern Alberta is absolutely necessary for the development of the district, and it is deemed advisable to place the matter properly before the government and that a "Joint Commission" comprised of men from the Lethbridge, Macleod and Calgary districts be appointed to collect evidence, statistics, etc. and that we set aside $200 to cover our share of the necessary expenses.[3]

Spence also recorded that private appropriation of water and sometimes land for ranches without licenses led to the passing of the North-West Irrigation Act.[4] Pearce was responsible for influencing the Directors of the Canadian Pacific Railway to embark on their comprehensive

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[1] A. James Hudson, op. cit., p. 124.

[2] E.A. Mitchener (1966), op. cit., p. 35.

[3] P.M. Sauder, op. cit., p. 32.

[4] C.C. Spence, "Historical Development of Irrigation in Alberta," Proceedings of Irrigation Economics Conference, Edited by T.W. Manning (Edmonton: University of Alberta, June, 1964), p. 2.

irrigation projects East of Calgary.[1] He brought to their attention the possibility of receiving the remainder of their land grant en bloc for the purpose of constructing irrigation works in Southern Alberta. He worked strenuously towards this end because he:

> ...could not foresee a densely populated farming community emerging in a semi-arid region where in addition to a deficiency of water there was a noticeable absence of large markets for farm produce.[2]

It was his intention to help make the drought striken areas productive and encourage further settlement in the Canadian Prairies.

Development of Larger Irrigation Systems in Alberta

The history of the development of larger irrigation systems in Alberta is interwoven with the early stages of coal and railway activities.[3] Commerical and financial institutions in Eastern Canada viewed the development of the Western frontier as providing opportunity for investments in transportation, farm implements, housing and marketing facili-

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[1] E.A. Mitchener (1966), op. cit., pp. 88-93.

[2] Ibid., p. 27.

[3] P.M. Sauder, op. cit., p. 25.

ties.[1] Acquisition of capital to finance these services needed skilled Canadian entrepreneurs who could arouse interest among British investors in the enormous potential of Western resources. Sir Alexander Tilloch Galt, a former Canadian High Commissioner to Britain, and his son, Elliot Torrance Galt, and William Lethbridge were foremost in displaying the much needed entrepreneurial ability that inspired some prominent London bankers to provide financial support to several enterprises in the Northwest Territories. Through the creativity of these gentlemen, large-scale irrigation was initiated in Southern Alberta thus preparing the way for the agricultural settlement of the area.[2]

Prior to the passage of the North-West Irrigation Act, five companies had been incorporated by special Act of Parliament for the purpose of utilizing water resources for irrigation or power projects but the Calgary Irrigation Company with Pearce as President was the only one to exer-

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[1] V.C. Fowke, Canadian Agricultural Policy: The Historical Pattern (University of Toronto Press, 1946), pp. 107-108 and 118-120.

[2] A.A. den Otter, "The Galts and Irrigation in Alberta: An Examination of the Entrepreneurial Role in Frontier Development" (Paper presented to the Canadian Historical Association, Edmonton, June, 1975), p. 2.

cise its power of stream diversion.[1] Crop yields on the Pearce estate averaged 70 percent above those produced by his neighbours using dry land farming methods.[2]

In 1882, Sir Alexander T. Galt formed the Northwest Coal and Naviation Company, with William Lethbridge as President and Elliot T. Galt as Manager.[3] As the construction of the Canadian Pacific Railway was then approaching Medicine Hat, the company had planned to mine coal at Coalbanks (now Lethbridge) and transport it advantageously by boat to Medicine Hat. It hoped to supply the requirements of the railroad itself and to ship from Medicine Hat to Eastern points by rail. The volume of trade was large but the water transportation was slow and dangerous in shallow waters so they abandoned water transportation.[4]

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[1] Canada Department of the Interior (1895), op. cit., p. 21. The dates of incorporation of the various companies were: Macleod Irrigation Company, 1891; The High River and Sheep Creek Irrigation and Water Power Company, 1892; Alberta Railway and Coal Company, 1892; Alberta Irrigation Company, 1893; Calgary Hydraulic Company, 1893. The Macleod and High River Companies did not progress beyond the stage of making initial surveys. The Calgary Hydraulic Company successfully diverted water from the Bow River in Calgary for the purpose of generating hydroelectric power until 1897 when floods destroyed their works. The Alberta Irrigation Company was reorganized and refinanced several times until it became Canada Northwest Irrigation and Land Company in 1896 at which time it successfully embarked on irrigation projects on the Lethbridge plains.

[2] E.A. Mitchener (1966), op. cit., p. 87.

[3] P.M. Saunder, op. cit., p. 26.

[4] R.F.P. Bowman, op. cit., pp. 9-12.

They incorporated another company, the Alberta Railway and Coal Company, in 1884 with Sir Alexander T. Galt as President and Elliot T. Galt as Managing Director. These men had the power to construct and operate a railway between Medicine Hat and the coal mines on the Oldman River. Due to Parliamentary delay, it was the Northwest Coal and Navigation Company that built a narrow gauge railway in 1885 which was later known as the "Turkey Trail".[1] The company was granted more than a million acres for the construction of 180 miles of rail lines. The land was in alternate sections within six miles of either side of the railroad. They appealed for a grant in solid blocks of alternate townships because ranching, the principal industry, required large tracts of land. This request was granted.[2]

Later, the Alberta Railway and Coal Company built a railway line from Lethbridge to Coutts opening it to traffic in December 1890. The land grant of about a million acres was made in respect of building the railroad from Medicine Hat to Lethbridge in 1885 and Lethbridge to Coutts in 1890.

The official government policy after the enactment of the North-West Irrigation Act was only to determine the feasibility of irrigation, leaving its development to pri-

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[1] Patrick Webb and Duane Olson, The Turkey Trail, Newsletter No. 5 (Lethbridge: Historical Society of Alberta, Whoop-up Country Chapter, November, 1974), p. 3.

[2] A.A. den Otter (June, 1975), op. cit., pp. 10-11.

vate enterprise.[1] The first Commissioner of Irrigation, Colonel J.E. Dennis, caused surveys to be undertaken to determine the feasibility of utilizing the waters of large streams in Southern Alberta for irrigation.[2] Three projects which were located and surveyed in detail later became the "Lethbridge Section" and the "Western Section" of the Canadian Pacific Railway Company's projects. The first used water from the St. Mary and Milk Rivers while the latter utilized water from the Bow River. The third diverted water from the Bow River south of Carseland to the reservoir called "Lake McGregor". Unfortunately, the policy did not induce sufficient capital and enough people to construct big irrigation systems and colonize lands.[3]

The success of the early Mormon settlers around Cardston demonstrated the potential of irrigation on the plains and encouraged Card and John W. Taylor, the Church President, to purchase land for purposes of irrigation.[4] Sir Alexander T. Galt incorporated the Alberta Irrigation Company for the purpose of constructing and operating irriga-

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[1] Canada Department of the Interior, Annual Report, 1916. Sessional Paper No. 25, Part VII, Irrigation (Ottawa: King's Printer, 1917), pp. 3-21 provides a comprehensive account of early irrigation activities on a large scale.

[2] Canada Department of the Interior, Annual Report, 1894 (Ottawa: Queen's Printer, 1895), pp. xvii-xx.

[3] P.M. Sauder, op. cit., p. 33.

[4] J.B. Hedges, op. cit., pp. 171-172.

tion ditches to assist Mr. Taylor and his associates in their colonization and irrigation enterprise. In 1896, the company received a renewed charter to build an irrigation canal to be completed within ten years. Galt and Magrath then faced the difficulty of raising enough capital to implement the irrigation scheme. A complex series of events occurred simultaneously to make the irrigation scheme attractive.[1] Gold discoveries in South Africa reversed the decline in wheat prices in America from 1893 onwards. Free land in the United States ran out at about the same time and settlers started to look for land in the Canadian Northwest. The agricultural outlook was bright in the Northwest because damages from early frost had been reduced by the development of early maturing grain; moreover, dry farming techniques had been successfully introduced into the region. Also wheat could then be shipped overseas more easily due to the recently developed chain of elevators, wheat pools, railways and large grain ships which made rapid transportation possible. The Canadian government and the Canadian Pacific Railway Company took advantage of this new era of optimism and economic progress to strengthen their immigration programmes and successfully attracted immigrants from Britain, the United States and Europe. Due to the demand for land, the need for irrigation was highlighted by its proponents and the development of the North-

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[1] A.A. den Otter (1975), op. cit., p. 10.

west once again attracted foreign financiers finally making irrigation in Southern Alberta a reality.

Other important factors are that in 1898, the Canadian Pacific Railway offered a bonus of $100,000 to the Alberta Railway and Irrigation Company to be earned according to the number of settlers and the amount of traffic it generated.[1] Due to difficulties entailed in estimating these items, the bonus was changed into an outright grant of $5,000 paid each six months until the total amount was paid. In addition, the Town of Lethbridge offered $30,000 financial assistance to ensure delivery of water for irrigation of 20,000 acres within a radius of ten miles from the centre of the town.[2]

In the summer of 1897, the Alberta Railway and Irrigation Company employed George G. Anderson, an eminent irrigation engineer from Denver, Colorado to undertake a feasibility study of an irrigation system to serve the company's lands.[3] The company contracted with the Mormons in April 1898 to build its original works on an agreement by which they were paid half their remuneration (including the hire of horses and equipment) in cash and the balance in land at $3.00 per acre with water rights, to a total of $75,000 and

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[1] J.B. Hedges, op. cit., p. 173.

[2] P.M. Sauder, op. cit., pp. 36-37.

[3] A.A. den Otter (1975), op. cit., p. 10.

25,000 acres. The properties were to be in two large tracts with their centres twenty and thirty five miles from Lethbridge, each supporting a hamlet of about fifty families recruited by the Mormons.[1]

On August 26, 1898 work started on 115 miles of canal.[2] The Alberta Irrigation Company was dissolved and reincorporated as the Canadian Northwest Irrigation Company while work was in progress.[3] Water was turned in at the head of the canal on July 4, 1900 and reached the ditches of Lethbridge town on September 4, 1900. The following year, after construction of laterals, water finally reached Sterling on July 12 and Magrath on July 25.[4]

Apart from the Canadian Pacific Railway, the Alberta Railway and Irrigation Company was the only one among the various colonization railways receiving land subsidies from the Dominion that vigorously pursued a policy for the sale and settlement of its lands.[5] It was not only a pioneer in irrigation development in Southern Alberta, but it was instru-

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[1] A History of the Mormon Church in Canada, p. 64. See also: P.M. Sauder, op. cit., p. 34 and A.A. den Otter (June, 1975), op. cit., p. 24.

[2] A History of the Mormon Church in Canada, p. 65.

[3] A.A. den Otter (1975), op. cit., p. 15.

[4] Ibid., p. 17. See also: P.M. Sauder, op. cit., p. 37 and J.B. Hedges, op. cit., p. 173.

[5] J.B. Hedges, op. cit., p. 154.

mental in locating Mormon settlement in that area.

By 1915, the company had built 200 miles of main and secondary canals (excluding laterals) at a cost of $1,368,000.[1] Of the 130,000 irrigable acres, only 75,000 acres were actually irrigated by 635 water users. They paid an annual water rental or maintenance charge of one dollar per acre. Irrigable land was offered on liberal terms for $8.00 to $10.00 per acre with an inducement of free use of the land for two years, but this failed to attract immigrants.[2]

Despite the slow rate of selling irrigable lands, the company invested more money into the sluggish Southern Alberta economy.[3] In 1901, it assisted Jesse Knight in financing a sugar factory at Raymond. By 1912, the company had achieved substantial results in land settlement. Having shown irrigation to be successful, other companies were quick to follow.[4] The Canadian Pacific Railway took over the interests of the Canadian Northwest Irrigation Company in 1912 and within a few years, the C.P.R. began to irrigate a larger portion of its Southern Alberta holdings.

Both Pearce and Dennis left government employment to

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[1] Canada Department of the Interior (1916), op. cit., p. 5.

[2] J.B. Hedges, op. cit., p. 174.

[3] A.A. den Otter (1975), op. cit., p. 19.

[4] Ibid.

work for the Canadian Pacific Railway. At that time it was difficult to obtain adequate supplies of water for the locomotives between Calgary and Medicine Hat. Pearce, Sir William White, then General Superintendent of the C.P.R., and William Cross, Master Mechanic, undertook a survey of sources of water supply for steam engines along the main-line between Calgary and Medicine Hat.[1] Pearce discovered that by damming the Bow River near Bassano, the water could be diverted to towers along the railway tracks. A detailed survey of the area revealed its irrigation potential and encouraged Pearce to advocate its implementation. At that time the C.P.R. was prepared to incur the great expense incidental to irrigating the semi-arid lands and to develop the region to the point where its volume of traffic would far exceed that of any similar area in Western Canada.[2] The irrigation block was divided into the Western, Eastern and Central sections but due to topographical difficulties, the Central section was not developed by the C.P.R.[3] The company's expenditure for the construction of the Western and Eastern sections was over $20 million.

The Western section was the first to be developed.

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[1] W. Pearce (1919), op. cit., pp. 7-8.

[2] J.B. Hedges, op. cit., p. 169.

[3] Details of the development of various sections can be found in various sources: Ibid., Chapters VII to X; J.L. McDougall, op. cit., pp. 133-142; Canada Department of the Interior (1916), op. cit., pp. 3-21.

By 1915, the company had spent $4,287,000 on construction works. The project was completed in 1920. The irrigable area was 223,000 acres. In 1915, there were 1,738 water users paying 50 cents each per acre for water rental and maintenance charges. In 1919, 25,191 acres were irrigated; in the mid-twenties, the annual irrigated acreage ranged between 3,000 and 19,000 acres. However, the average total cropped area on land with water rights was 209,000 acres between 1924 and 1926. The reason for lack of patronage was that the western section covered an area in which average rainfall was highest and which therefore had the least need for irrigation. The canals could not be maintained out of the small earnings from the water rates so the project was turned over to the settlers as a corporation, the Western Irrigation District, with a cash payment of $538,600 being made by the Canadian Pacific Railway.

There were 67 water users in the Eastern section in 1915, each paying water rental charges of $1.25 per acre with provision for reduction to 75 cents per acre provided they formed associations in the various districts. The company had spent $9,440,000 on the project which covered 400,000 acres of irrigable land; they had sold 124,000 acres of irrigable land by 1924 and had 733 water users irrigating 73,000 acres. Between 1918 and 1922, irrigated acreage varied from 24,500 to 93,000 acres. For the years 1923 to 1926 inclusive, the irrigated acreage ranged between 43,000 and 84,000 acres.

Fluctuations in irrigated acreage were due to fluctuations in rainfall. Rainfall was exceptionally high in 1923 causing irrigated acreage to drop to 43,000 from its 1922 record high of 93,000 acres. Falling agricultural prices and low rainfall in the late twenties and early thirties led to unbearable financial losses which made the C.P.R. relinquish its interest in the Eastern section. The railway transferred the irrigation works together with 1,233,812 acres of land to the Eastern Irrigation District in 1935 and contributed $300,000 over a period of two years towards the operating expenses of the system.

The Alberta Railway and Irrigation Company holdings taken over by the C.P.R. in 1912 were operated as the "Lethbridge Section" until 1946 when it was transferred to the Government of Alberta with the payment of $100,000 in cash by the company.[1] This project became the Lethbridge Northern Irrigation District. At the time of the transfer there were 940 water users and the gross area covered by water agreement was 114,500 acres out of an estimated irrigable acreage of 163,405 acres.

Another company, Southern Alberta Land Company, planned an irrigation system which would use water from "Lake McGregor" reservoir. Of their land holdings 153,000 acres were irrigable, but the company initially planned to develop

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[1] P.M. Sauder, "Irrigation in Southern Alberta: Vol. II" (Unpublished Report, Alberta Department of Agriculture, Edmonton, 1972), p. 351.

21,000 acres and settle it before embarking upon further development.[1] The Canadian Government assisted with $354,684 against a mortgage of 30,000 acres in 1914 but the company could not raise the additional $800,000 to complete construction work. The work constructed up to 1916 cost over $5 million, but the Southern Alberta Land Company had been unable to irrigate any land.

Within five years, 1910-1914, there had been two extreme droughts in Southern Alberta and Southwest Saskatchewan.[2] The Provincial and Dominion Governments endeavoured to counteract the situation with remedies to relieve actual distress. They also embarked upon long term water resource planning that contemplated the fullest utilization of the available water supply from the St. Mary, Milk, Belly and Waterton Rivers.

The importance of irrigation in Southern Alberta had been recognized by 1919. The demand for irrigation development exceeded the responsibility of the Dominion Government. These responsibilities consisted of surveys which included site location and design of works. However, the Dominion Government was also being asked to either construct the required works or materially assist in financing such con-

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[1] Canada Department of the Interior (1916), op. cit., pp. 7 and 11.

[2] P.M. Sauder, (Vol. I) op. cit., pp. 207-209, 216-217 and 243-244. This reference accounts for the effect of the drought and various actions taken.

struction. The Provincial Government was charged with the responsibility of organizing the irrigation districts, raising money by selling bonds issued with land as security and operating and maintaining the works constructed on cooperative plans.

Discounting initial individual attempts, Southern Alberta has experienced three distinct phases in its irrigation development, each being motivated by different intentions.[1] The commercial phase during which there was corporate involvement in establishing irrigation was experienced between 1900 and 1920. The district phase experienced developments based on community cooperation. Irrigated lands are farmer owned and operate under the supervision and guidance of the Provincial Government. The irrigation areas are administered by autonomous irrigation districts, now fourteen in number, set up by the various Irrigation District Acts. This last phase dates back to the Second World War. Both Provincial and Federal Governments have shown greater concern in this phase and have accepted more responsibility in the development of water projects and the maintenance of important irrigation structures.

Early irrigation projects by companies were handicapped by slow settlement.[2] Occasional wet years encouraged

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[1] W.R. Hanson, A.T. Johnson, Wm. Mackenzie, D.L. Paxman, C. Sibbald, "Report of the Irrigation Study Committee to the Government of Alberta" (Submitted September 19, 1958).

[2] D.W. Hays, op. cit., pp. 117-118.

settlers to continue with dry land farming. Moreover, irrigation was new and land values high. Farming in the dry belt without irrigation caused soil drifting and soil depletion leading to farm abandonment in dry years. Those abandoning farms moved to the irrigation areas and to northern areas.

Aspects of Early Canadian Land Policy

Canadian land policy as it was related to the original Northwest Territories was formulated at a time that the problems of expansion, transportation, and settlement were foremost.[1] The desire for westward expansion of the Dominion necessitated a transcontinental railway. In Chester Martin's opinion:

> In the end both these projects and nationhood itself depended upon effective settlement; and the function of the free-homestead system in that process is perhaps the most interesting problem which survives from the era of 'Dominion Lands'.[2]

In 1872, the first Dominion Lands Act came into force and the Free Homestead Act became law. Later, a series of regulations and acts which introduced preemptions, purchased homesteads, second homesteads, Soldier Settlement Act, Veteran's Land Act and the Schools Lands Act were

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[1] C. Martin, "Dominion Lands" Policy (Toronto: McClelland and Stewart Ltd., 1973), p. 117.

[2] Ibid., p. 140.

passed.

The homestead provisions allowed the head of a family or any male over eighteen years of age eligibility to one quarter-section (160 acres), more or less, with a fee of ten dollars and residence requirements of three years among other regulations for sale, lease and other forms of land administration.[1] Free homesteads were allowed within the railway belt. Patents were issued after fulfilling the homestead duties on payment of ten dollars. Again Martin notes that:

> ...the function of the free homestead under these auspices seems to have been at any cost to provide as rapidly as possible a pioneer population in Western Canada.[2]

Preemption rights were granted for the reservation of an adjoining quarter-section for purchase at a government price of three dollars per acre upon the issue of a patent for the original homestead.[3] The Lands Act did not originally allow for preemption but it was later observed that the 160 acre homestead in many areas where summer fallow was necessary could not prosper. In early 1874, therefore, preemption was added to the free homestead regulations.[4] The

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[1] Canadian Pacific Railway, "Farming and Ranching in Western Canada 1893," pp. 8-9. This reference provides details of homestead regulations.

[2] C. Martin, op. cit., p. 143.

[3] Ibid., pp. 143 and 163.

[4] Ibid., pp. 157-161.

requirements of residence and cultivation were similar to those of the free homestead. It further required the homesteader to cultivate 50 acres in addition to his homestead duties, and to live either upon his homestead or his preemption claim for at least six months in each of six subsequent years to the date of entry to his homestead.

The right of "purchased homestead" was introduced for the benefit of the settler who could not find a contiguous quarter section.[1] In such a situation, he was to be allowed the privilege of having a preemption elsewhere in the form of a "purchased homestead". One-third of the government price was paid before entry with the remainder to be paid in five annual installments. The duties included residence for six months in each of three years subsequent to the date of entry, the cultivation of 50 acres of "purchased homestead" and the building of a house valued at $300.

The introduction of the "second homestead" allowed homesteaders to enlarge their holdings through the purchase of another homestead. This privilege was restridted to those who had "proved" their original homesteads before 1925.[2]

An aspect of the Dominion Lands Act of 1872 was the provision that set aside section eleven and twenty-nine in each surveyed township as an endowment for public schools

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[1] Ibid., p. 164.

[2] Ibid., p. 167.

Figure 2.1).[1] Such lands remained under Federal administration until the "Natural Resources Question" was settled in 1930.[2]

The Volunteer Bounty Act was introduced in 1908. Under its provisions, two adjoining quarter-sections of Dominion lands were granted without fee to volunteers from the South African War.[3] They were, however, required to perform the usual homestead duties. The effective date for land location expired on October 31, 1913, but until December 31, 1914 the grantee was authorized to receive $500 in cash upon relinquishing his rights under the Volunteer Bounty Act.

The Soldier Settlement Act for World War I veterans operated from 1917 until the transfer of natural resources to the province in 1930. It was an act to assist returned soldiers in settling upon the land through authorization of quarter-section homesteads. The usual homestead duties were maintained but no fee was charged. The Veterans' Land Act of 1942, for World War II veterans, became the successor

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[1] Ibid., Chapter 6.

[2] Ibid., Chapter 12. The Federal Government continued to administer public lands after creating the Provinces of Alberta and Saskatchewan for the "purposes of the Dominion". The paying of compensation to the Provincial Governments and the transfer of administrative powers of the public lands in 1930 is what is referred to as the "Natural Resources Question".

[3] Ibid., p. 166.

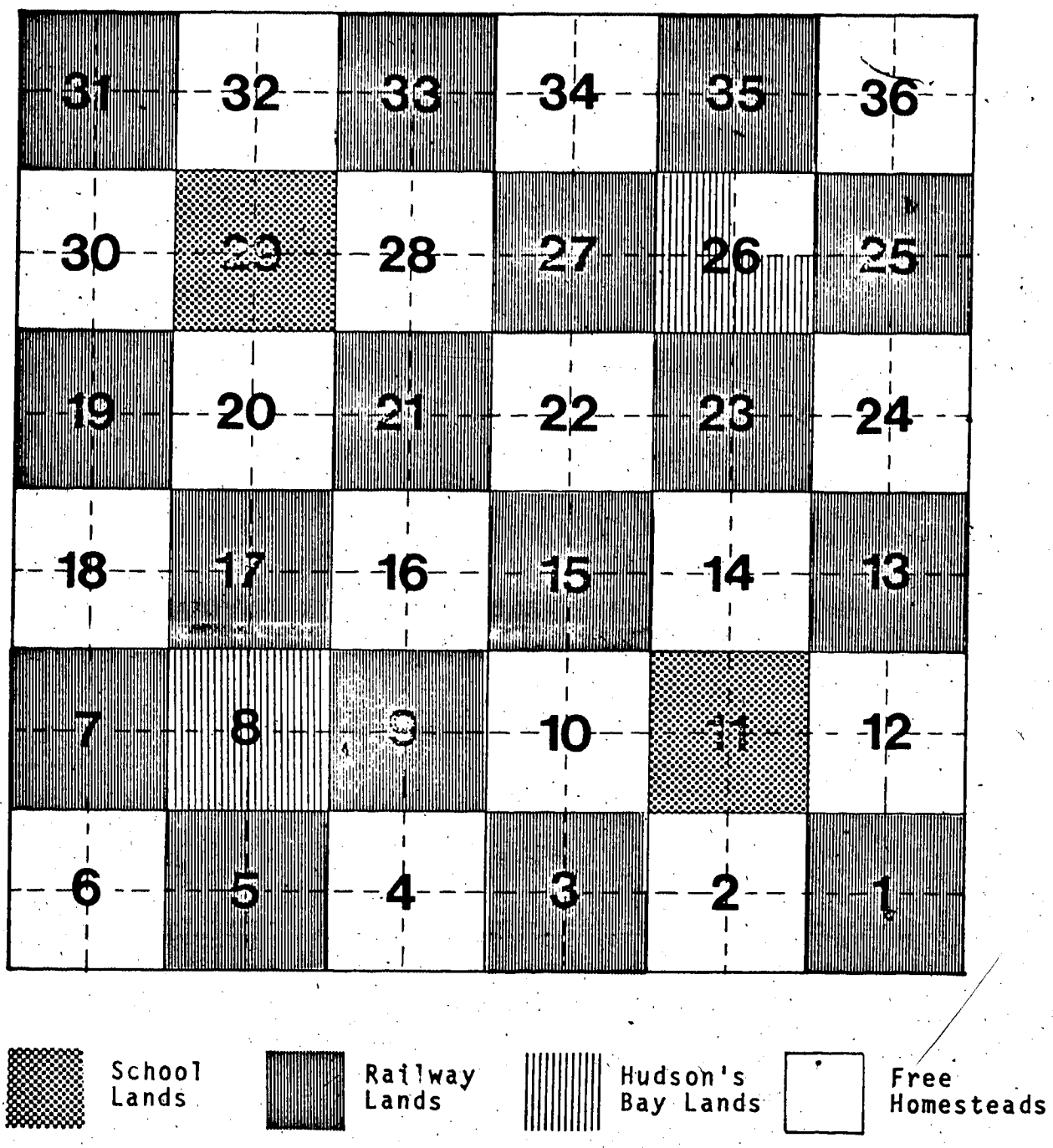

Figure 2.1

Survey Plan of Township

of the Soldier Settlement Act.[1]

In 1955, the Homestead Lease Loan Act was introduced. The original act established a fund of $1 million out of which a loan not exceeding $1,000 was granted to any one borrower for clearing and breaking lands held under homestead lease.[2] The interest rate on the loan was 3.5 percent payable annually on current installments and 4.5 percent on overdue installments. Loans were for any period not longer than ten years. After many revisions the Act authorized loans not exceeding $2,000 for the same purpose.[3] Such loans were payable in ten years with interest not exceeding 6 percent.

The Prairie Farm Rehabilitation Act was introduced in 1935 to provide for the rehabilitation of drought and soil drifting areas in the Provinces of Manitoba, Saskatchewan and Alberta.[4] Rehabilitation consisted of development and

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[1] Canada Department of Agriculture, Economics Branch, Federal Agriculture Legislation, Canada, 1969, Publication No. 69/19 (Ottawa: C.D.A., 1969).

[2] Statutes of Alberta, Homestead Lease Loan Act, S.A. 1955, C. 142.

[3] Canada Department of Agriculture, Provincial Agricultural Legislation in Western Canada, 1971, Publication No. 72/8 (Regina: Economics Branch, Canada Department of Agriculture, 1971), p. 8.

[4] H. Buckley and E. Tihanyi, Canadian Politics for Rural Adjustment: A Study of the Economic Impact of A.R.D.A., P.F.R.A. and M.M.R.A. (Queen's Printer, 1967), pp. 55-56, 71-73. Also: Canada Department of Agriculture, Economics Branch (1969), op. cit., pp. 37-40.

promotion of systems of farm practice, tree culture, water supply, irrigation, and land utilization and settlement. In Alberta, the programme led to greater improvement in the irrigation facilities provided through the St. Mary River Project and the Bow River Project in 1938 and 1943, respectively.

In order to operate Canadian land policy, surveys were necessary. American westward expansion had been piecemeal due to a variety of baselines and numerous meridians upon which surveys were based, but Canada had the advantage of undertaking an integrated survey. A section of land was fixed at 640 acres and a township at 36 sections by an Order-in-Council on April 25, 1971.[1] The Canadian system numbered the townships north from the international boundary as a base line running the ranges of townships East and West (Figure 2.1).[2] Thus the system started numbering from the lower right-hand (Southeastern) corner of the township. With approval from both levels of government, special systems to conform to topographical or climatic conditions were devised for the C.P.R.'s irrigation lands.[3]

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[1] C. Martin, op. cit., p. 17.

[2] Ibid., pp. 18-19.

[3] Ibid., p. 19.

The Canadian Pacific Railway Land Grants and Policies

The Canadian Pacific Railway was built under the terms of an agreement signed on October 21, 1880. The Syndicate Contract, as it was known, received Parliamentary approval in February, 1881.[1] The company received the railway lines built by the government, a subsidy of $25 million and a land grant of 25 million acres for building 2,000 miles of railway. The company was allowed freedom from rate regulation until the annual return on capital expended in the construction of the railway reached 10 percent. The government exempted the company from tariff duties on construction materials, from taxes on unsold lands in the Northwest for twenty years and from Dominion or Provincial taxation of the railway and railway property as well as capital stock of the company forever. To guarantee against encroachment by rivals, no competitive lines connecting with the Western United States were to be charted for a period of twenty years.

The company's land grant entitlement was the alternate odd-numbered sections within 24 miles on either side

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[1] J.B. Hedges, op. cit., pp. 24-36. Also see: George A. Walker, "Canadian Pacific Land Grants" in Canadian Pacific, Facts and Figures, Edited by the General Publicity Department (Montreal: Canadian Pacific Foundation Library, 1939), p. 147; and Canadian Pacific Railway, "Confederation and the Canadian Pacific," pp. 37-40.

of the railway. The land subsidy had to be "fairly fit for settlement", otherwise the company was not obligated to receive it as part of the grant. On the prairie, land shortages due to limited alternate sections adjoining the mainline were to be made up from other prairie lands between the 49th and 57th parallels. With the consent of the government, the company could select lands in the alternate sections extending back 24 miles on each side of any branch line or lines of railway to be located by the company.

In July 1894, Parliament recognized that irrigation was necessary for utilization of lands in Southern Alberta. Parliament also recognized that to induce land and irrigation development, it was necessary to grant lands en bloc between Medicine Hat and Crowfoot Crossing.[1] On August 22, 1903, 2,900,000 acres was granted in a compact block as the Irrigation Block of the Canadian Pacific Railway by an Order-in-Council (Figure 2.2).

The C.P.R. adopted policies to help in the disposal of its land grants to permanent settlers.[2] They tried to sell to settlers who were willing to cultivate and otherwise improve the land. In September 1881, their sale price

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[1] J.B. Hedges, op. cit., pp. 51-58.

[2] Ibid., Chapters VIII and IX. These references discuss colonization policy and the activities of the Department of Natural Resources

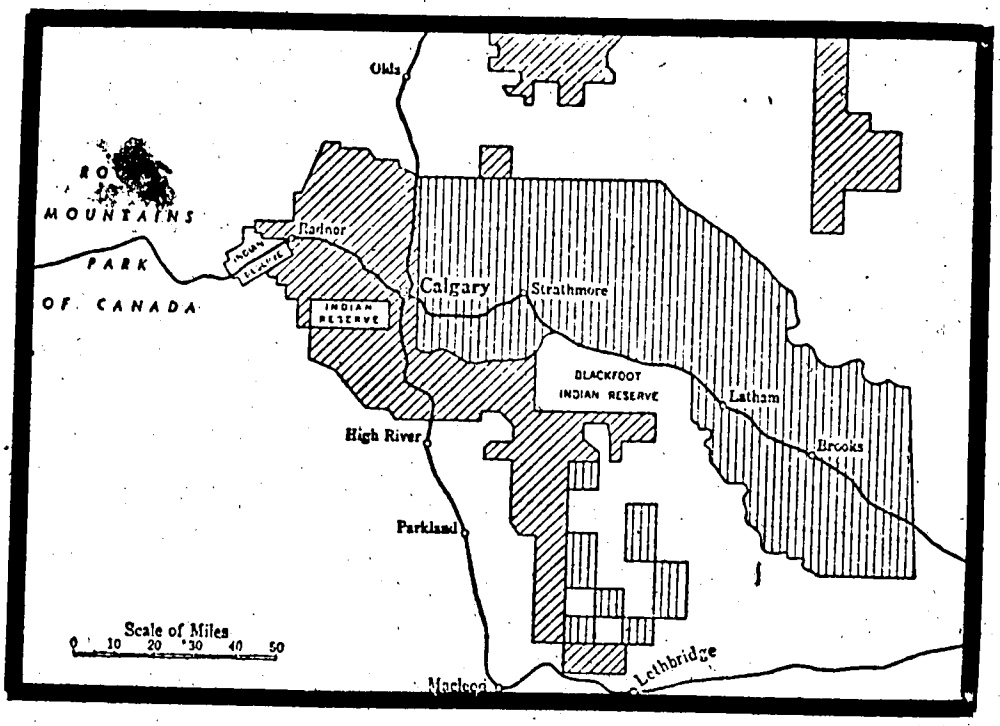

Figure 2.2

Canadian Pacific Lands in Southern Alberta

Note: The diagonally-hatched areas are those in which the Railway, for the most part, owned the alternate sections. In the vertically-hatched areas, the Railways for the most part owned both the odd- and even-numbered sections. The large area thus hatched is the Irrigation Block.

SOURCE: J.B. Hedges, Building the Canadian West: The Land and Colonization Policies of the Canadian Pacific Railway (New York: Russell and Russell, 1971), p. 170.

was $2.50 per acre regardless of quality or location.[1] Their sale contracts required payment of one-sixth of the purchase price in cash, with the remainder in five equal installments. It was required of the purchaser to cultivate, sow and harvest a crop on three-fourths of the land within four years. If a purchaser erected an approved type of building on the land, his cultivation requirement was reduced to one-half of the area purchased. To attract settlers the company allowed a rebate of $1.25 per acre for each acre cultivated within the four year period. In the event of non-compliance of the contract, a forfeiture clause permitted the company to cancel the agreement and retain the land in the name of the company.

The C.P.R. impressed upon its agents that:

> ...the goal of the company was the most complete agricultural development of the irrigation block, with the density of traffic which, it was hoped, that would produce.[2]

To fulfill this ambition the company tried several policies to attract settlers. Moreover, as the largest private owner of lands in the West, the company felt obliged to take a lead in the promotion of immigration to the prairies.[3] They

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[1] Ibid., pp. 67-68.

[2] Ibid., p. 199.

[3] Ibid., pp. 94-125. This reference contains details of how the C.P.R. advertised the West. Other advertisements directed to C.P.R. agents and prospective settlers were printed in various C.P.R. publications.

began their advertising campaigns in 1881. Attractive publications and magnificient displays of prairie products were employed in the campaigns. Figures 2.3, 2.4 and 2.5 are examples of these advertisements.

Canada was advertised as the bread basket of the world. By 1883, their London (England) office advertised regularly in 167 journals in Great Britain and 147 continental papers. They organized special lectures aided by lantern slides. Between 1883 and 1884, they supplied stands of produce from the Northwest to thirty leading exhibitions and agricultural shows. In 1886, the company started promoting immigration by organizing testimonials by settlers in the West. Also, they encouraged clergymen and other notables to visit Canada compliments of Canadian Pacific so that they could be used as professional lecturers. Faith in Canada was propagated in schools by offering prizes in the form of bound literature, "unseen readers". By 1894 the Travelling Exhibition Van had for some years carried Canada to the remotest corners of the British Isles. Railway Exhibition cars had become popular by the mid-eighties in Eastern Canada. The C.P.R. undertook at its own expense to bring delegates of prospective settlers to Western Canada in order that they might return home and report their impressions to friends and neighbours. In addition, in 1891, the C.P.R. organized a "return men" experiment and sent 17 settlers to London (England) at company expense to share their experiences with prospective immigrants. The

LANDS.

The Canadian Pacific Railway has for sale 5,500,000 acres of choice farm lands in Manitoba, Saskatchewan, and Alberta.

Prices range from $8.00 to $25.00 per acre for lands suitable for mixed farming and grain growing, according to quality and location.

160 acres, or one quarter section of land at $10.00 per acre may be obtained for settlement upon making a cash payment of $239.70. Interest only on the outstanding purchase money is payable at the end of the first year. The balance of purchase money is payable in nine equal annual instalments of $200.00 each, which include interest at 6 per cent. Purchasers who do not undertake to go into residence upon the land within one year from the date of purchase are required to pay not less than one-sixth of the purchase money down and the balance in five equal annual instalments with interest at the rate of six per cent. per annum.

The valuable lands allotted to the Canada North-West Land Co., Ltd., are for sale at the office of the Land Dept.

For detailed prices, maps, and full particulars, apply to

F. T. GRIFFIN,
C.P.R. Land Commissioner, Winnipeg, Man.

ALBERTA LANDS.

This company is developing by means of irrigation three million acres in the Bow River Valley of Sunny Southern Alberta. Combination farms are there obtainable upon terms within the reach of all: the irrigated portions raising small fruits, alfalfa, and all grain, root and fodder crops; the non-irrigated lands producing winter wheat, cereals, etc., besides providing the world's finest pasture. Splendid yields, good markets, low taxation, cheap living, abundance of water, and the valley's unexcelled climate lead thousands to establish homes upon its fertile lands.

A further two million acres, the greater portion of which is situated in Central Alberta, is now being offered for sale at low prices and upon exceptionally advantageous terms.

For detailed information, maps, and prices, apply to

J. S. DENNIS,
Manager, C.P.R. Irrigation and Land Interests in Alberta and British Columbia,
Calgary, Alberta.

TELEGRAPHS.

The telegraph system of the C.P.R. not only extends along the entire length of the railway, but also reaches every point of importance off the lines of Railway in the Dominion of Canada.

The Commercial Cable Co. (Mackay-Bennett System) gives the C.P.R. the most direct connection with Europe, Asia, and Africa.

Also in direct connection with the British Pacific Cable to Australia, New Zealand, etc.; the Commercial Pacific Cable to the Hawaiian Islands, Philippine Islands, China, and Japan; and the Commercial Havana Cable to Havana, etc.

The Postal Telegraph Co. of New York and San Francisco enables the C.P.R. to reach all important points in the United States.

The Halifax-Bermuda & Direct West Indies Cable Co. gives connection with Bermuda, Jamaica, and points in the West Indies.

Direct connection with the Dominion Government Telegraph line to the Yukon and points in Alaska.

A tariff of charges for Telegrams is posted at all Telegraph Offices, and is kept by all Sleeping and Parlour Car Porters.

JAMES KENT,
Manager of Telegraphs.

Head Office, Montreal.

Figure 2.3

Canadian Pacific Advertisements

Note: Advertisements regarding lands in Western Canada, irrigated lands in Southern Alberta and telegraph facilities in Canada.

SOURCE: Canadian Pacific Railway, "An Annotated Time Table of the Transcontinental and Other Main Line Routes of the C.P.R." (1912), p. 104.

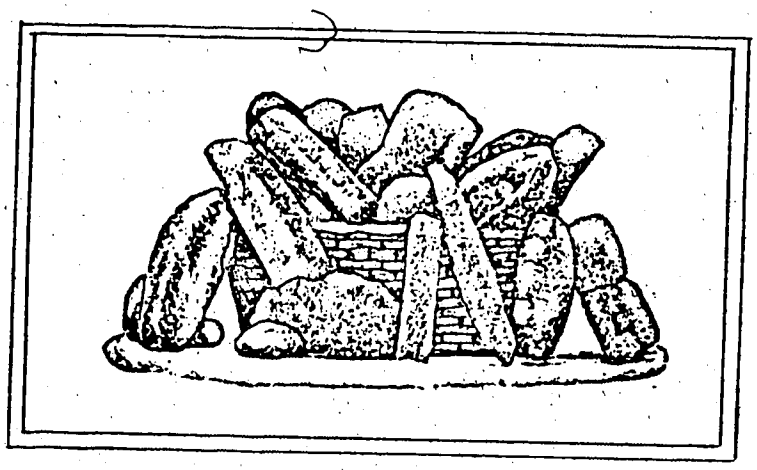

Figure 2.4

Come to the Land of Plenty

SOURCE: Canadian Pacific Railway, "Western Canada: Manitoba, Saskatchewan, Alberta: How to Reach It, How to Obtain Lands, How to Make a Home" (1906), p. 8.

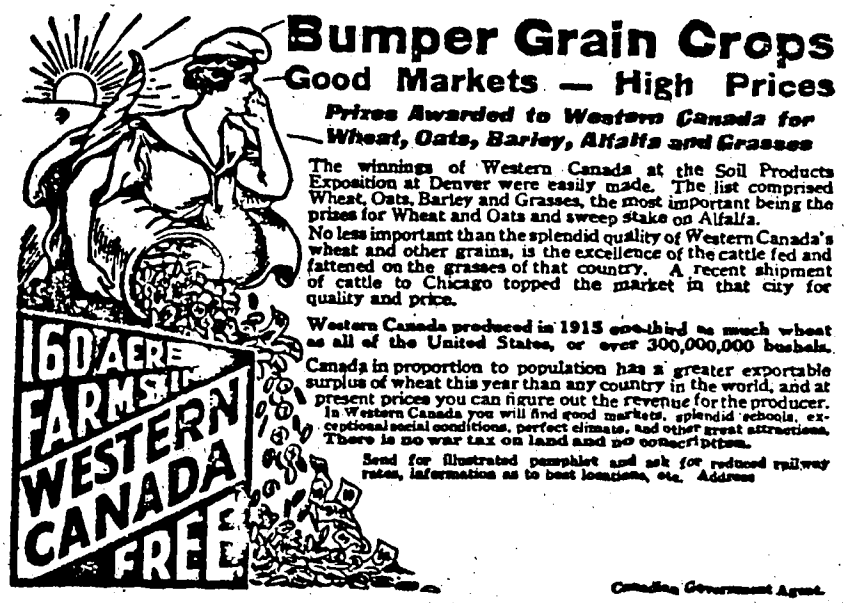

Figure 2.5

An Advertising Propaganda Circulated in the United States

SOURCE: Canada Department of the Interior, Annual Report 1915-1916, Sessional Paper No. 25, II (Ottawa: King's Printer, 1917), p. 75.

need for farm help prompted the company to start the "Harvesters Excursion" in 1891 to carry workers to the West without charge. "Home-seekers" and "land seekers" excursions were organized from 1887 as a means of educating Eastern farmers about the attractions of the West. Starting in 1895, the C.P.R. conducted Editors' Excursions through the Northwest at its own expense. Editorial Associations from Minnesota, Wisconsin, and Pennsylvania were on the excursion in 1898, 1899 and 1906, respectively. In 1899, the National Editorial Association of the U.S.A. took the trip. "The Canadian Land Seekers' Certificate" was introduced to ease the transportation problems of immigrants by granting them extremely low rates for moving themselves and their belongings West. Again for purposes of immigration promotion, the C.P.R. acquired the Elder Dempster fleet of fourteen vessels in 1903 to help transport immigrants from overseas.[1]

The company's policy of colonization was expressed through their Development Branch and also through the Department of Natural Resources.[2] The Development Branch undertook initial farming operations -- fencing, land preparation, and seeding -- for the settler in certain cases.

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[1] J.B. Hedges, op. cit., pp. 106-107.

[2] S.G. Porter, "The Department of Natural Resources," in Canadian Pacific, Facts and Figures, Edited by General Publicity Department (Montreal: Canadian Pacific Foundation Library, 1939), pp. 155-156.

They organized the Assisted Settlement Plan in its various forms -- ready made farms and loans to settlers.

The Department of Natural Resources was created in 1912 to administer the land resources of the C.P.R. District representatives were appointed to replace district agents when it was realized in 1913 that the agents were good at selling lands but not good at colonizing them.[1] The "Extension of Settlement Clubs" promoted by the C.P.R. were seen by the Department of Natural Resources as a way of encouraging settlement of unoccupied lands in the neighbourhood of settled areas. The crop payment plan was introduced to allow delivery of grain to the company to replace the payment of an installment, especially during periods of severe economic conditions. The company reviewed its repayment plan at various times, the most significant introductions being the 20-year payment plan and the 34-year amortization plan. The company had realized that agricultural development set the pace for industrial development so it actively promoted better agriculture by seeking to cooperate closely with all recognized agricultural institutions and organizations engaged in agricultural development. The company developed demonstration farms within the irrigation block. Of special significance was the one developed at Strathmore in 1905. It encouraged development of animal husbandry by importing high grade sires. It conveyed seed

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[1] J.B. Hedges, op. cit., p. 271.

wheat suited to the environment from Kansas City to Southern Alberta without charge to farmers.

Colonization and Land Companies

Apart from the government and the C.P.R., the Hudson's Bay Company was the most important among colonization companies in terms of land holdings. The Dominion Government's conviction that "the agricultural possibilities of the country were too great to admit of its being reserved any longer for the fur trade"[1] led to the Rupert's Land Act of 1868 which empowered the Dominion Government to purchase the territory of the Hudson's Bay Company.[2] By the terms of the surrender, the company could:

> ...claim in any township or district within the fertile belt in which land is set out for settlement, grants of land not exceeding one-twentieth of the land so set out.[3]

The Lands Act of 1872 allowed the company to receive Section 8 in each township, Section 26 in each township whose number was divisible by five and the southern half and northwest quarter of Section 26 in all other townships (Figure 2.1). On such terms, 6,313,900 acres passed to the company. Land grants were also given to other railway companies and land

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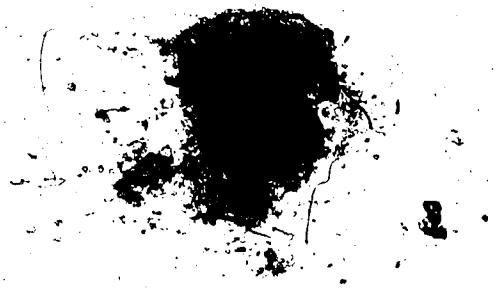
[1] Ibid., pp. 4-5; and V.C. Fowke, op. cit., p. 142.

[2] C. Martin, op. cit., pp. xix-xxiii, 1-6.

[3] J.B. Hedges, op. cit., p. 9.

and colonization companies were allowed to purchase lands as investments.[1]

This chapter has provided the historical background necessary for the understanding of the economic and social structure upon which the analytical part of the study is based.



[1] Ibid., p. 70.

CHAPTER III

ECONOMIC ANALYSIS OF IRRIGATION

In a study such as this, the rationale for water and land development schemes must be understood. In an attempt to provide such a background, this chapter explains the nature of water as a resource, presents views on the objectives of irrigation schemes, and discusses economic efficiency of development projects. In this way, concepts and procedures used in the analyses of water projects and unresolved difficulties associated with them are reviewed.

Water as a Resource

The institutional and legal frameworks of society provide the basis for discussion concerning the utilization of water as a resource. Water laws developed in an arid region should be expected to differ from those evolved in humid regions because of the need to solve the complicated problem of conflicting claims to a limited supply of water.[1]

Water attracts great concern because at times it is destructive and sometimes it is beneficial.[2] The functions

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[1] R.T. Ely and G.S. Wehrwein, Land Economics (Madison, Wisconsin: University of Wisconsin Press, 1964), p. 351.

[2] Ibid.

of water in plant growth, irrigation, domestic, industrial and urban utilization (all of which reduce the volume or alter the nature of the water), and its use for fisheries, navigation, water power and recreation (which do not consume or change to any appreciable extent the substance of water), are all beneficial aspects. Most of these uses conflict where water is relatively scarce. Domestic and municipal uses usually take precedence over irrigation. Irrigation may deprive cities of water for industrial purposes, and it may reduce stream levels sufficiently to hamper navigation. It is for the resolution of such conflicts that laws and institutions governing irrigation practices and other water resources laws have developed.

One characteristic of water resources is their great mobility. The processes of evaporation, transpiration and precipitation link the various forms of water -- rivers, lakes, ground water and soil moisture -- in the hydrologic cycle. Water alternates between liquid and vapour phases but is not destroyed thus making it a resource that is continuously being replenished. Each form of water use affects the other uses. This calls for a comprehensive approach to research planning and the actual use of water resources.

Kuznetsov and Lvovich state that water resources are related to elements of the environment like climate, soil,

vegetation and bedrock.[1] The state and volume of water is affected by climate mainly through such natural intermediaries as soil and vegetation. Conclusions to be drawn from this are that (1) planning the use of water requires consideration of other natural elements and (2) these elements can be used to influence the condition and volume of water.

An assessment of Canada's water resources based on estimation of precipitation and run-off was undertaken by Cass-Beggs.[2] The study made projections of annual water consumption for principal regions of Canada for 1956 and at five-year intervals from 1960 to 1990. For the various categories of use, projections for farm and irrigation use were highest in the Prairie Provinces.

In another study, an estimate was made that out of the current agricultural water withdrawals of 1,527.9 million gallons per day (mgd) for 1973, 1,231.7 mgd were used for irrigation in Canada.[3] The Prairie Provinces'

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[1] N.A. Kuznetsov and M.I. Lvovich, "Multiple Use and Conservation of Water Resources," Natural Resources of the Soviet Union: Their Use and Renewal, Edited by W.A.D. Jackson (San Francisco: W.H. Freeman Company, 1971), Chapter 2, p. 71.

[2] D. Cass-Beggs, "Water as a Basic Resource," Regional and Resource Planning in Canada, Edited by R.R. Krueger, J.O. Sargent, R. de Vos and N. Pearson (Toronto: Holt, Rinehart & Winston of Canada Ltd., 1970), p. 176.

[3] Canada Department of the Environment, Canada Water Year Book 1975 (Ottawa: Hignell Printing Ltd., 1975), p. 118.

share of irrigation water was 930.1 mgd in 1973. In 1971, 1,251,019 acre-feet of water were withdrawn to irrigate 622,140 acres in the Prairie Provinces. In that year, Alberta alone irrigated 573,321 acres which was more than 50 percent of Canada's total irrigated acreage of 1,041,160 acres. Water withdrawals for irrigation in Alberta thus constitute a substantial proportion of national withdrawals yet the estimate of the former study indicated the least supply potential for the Prairie Provinces.[1]

Water was once regarded as a free good. There is no impending danger of running out of water. But the situation of having enough water at all times and for all conceivable uses no longer exists. The importance of water to an economy is appreciated better in inverse relation to its availability, quality and quantity.[2] As the demand for the products of watersheds -- power, water, irrigation, and recreation -- increases over time, varied pollution effects are created and problems of water quality management become important. Water quality problems become more common as industrial and urban developed proceed. Water, as a resource, is moving into the realm of economic goods like most other natural resources. One could therefore assume

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[1] D. Cass-Beggs, op. cit., p. 185.

[2] J.E. Menzies, "Water Pollution in Canada by Drainage Basins," in Water: Selected Readings, Edited by J.G. Nelson and M.J. Chambers (Toronto: Methuen Publications, 1969), Chapter 12, pp. 213-233.

that principles of planning and evaluation applicable to other natural resources can be applied to water without modification. Unfortunately this is not the case since water possesses unique characteristics which pose special problems and make unusual demands upon the tools and skills of analysis in all professions concerned with water development and use.[1]

The peculiar nature of water calls for large investments with long gestation periods that public rather than private agencies are usually able to undertake.[2] The theory of value assumes that under pure competition all consumers and producers try to maximize their own economic benefit. Each consumer spends on a particular good until the last dollar of outlay yields exactly the same satisfaction as the last dollar spent on any other good. Likewise, each producer hires productive factors until the last dollar spent yields exactly a dollar's worth of output. The element of "time", or the cost of waiting, plays an important role in investment decisions. The long period between costs and returns gives rise to some problems. The

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[1] A.V. Kneese and K.C. Noble, "The Role of Economic Evaluation in Planning for Water Resource Development," Natural Resources Journal, Vol. 2 (December, 1962), pp. 446-447.

[2] I. Burton, "Investment Choices in Public Resource Development," in Water: Selected Readings, Edited by J.G. Nelson and M.J. Chambers (Toronto: Methuen Publications, 1969), Chapter 18, p. 296.

problem of financing creates the need to evaluate the cost of credit from different sources for different durations. Also the problem of relative profitability of alternative investments characterized by streams of varying cash outlays and receipts over time exists. In view of these problems, private producers shun an industry where production would be socially desirable because conditions of cost and demand are such that they cannot recover the full cost of production. They regard production of large-scale output such as irrigation development undesirable because consumers' overall willingness to pay is less than the cost of production. The foregoing reasons compel governments or quasi-government institutions to undertake large investment projects. The social desirability of large projects led Rogers and Manning to recommend the allocation of capital costs of irrigation in the Eastern Irrigation District on the basis of distribution of net benefits -- irrigation farmers, 11 percent; local area, 22 percent; Alberta, 32 percent; and Canada, 35 percent.[1]

Objectives of Irrigation Schemes

Irrigation projects are implemented on some occasions

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[1] W.B. Rogers and T.W. Manning, The Economic Benefits and Costs of Irrigation in the Eastern Irrigation District of Alberta, Alberta Irrigation Studies Volume V (Edmonton: Agricultural Economics Department, University of Alberta, 1966).

to deal with short-run policy issues like providing food in wartime, assisting resettlement of returned servicemen or solving unemployment problems. Irrigation schemes and other water resource projects are as a rule appraised administratively and from physical and engineering points of view without adequate reference to economic analysis.[1] Attention is paid to the details of construction without carefully considering all phases of the development. To define realistic objectives, all relevant disciplines need to be integrated. Although the prime purpose of providing irrigation is to increase production, the objectives of a sector should be guided by national goals. The Economic Council of Canada has set out the following national economic objectives:

1. Full employment;
2. High rate of economic growth;
3. Reasonable stability of prices;
4. Viable balance of payments; and
5. Equitable distribution of rising incomes.[2]

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[1] A.R. Prest and R. Turvey, "Cost-Benefit Analysis: A Survey," The Economic Journal, Vol. LXXV, No. 300 (December, 1965), p. 683. See also: J.C. Flinn, "Estimating the Demand for Water in Commercial Agriculture," Canadian Journal of Agricultural Economics, Vol. 19, No. 3 (November, 1971), p. 114; and R.J. Hammond, Benefit-Cost Analysis and Water Pollution Control (Stanford: Food Research Institute, Stanford University Press, 1960), p. 3f.

[2] Economic Council of Canada, First Annual Review: Economic Goals for Canada to 1970 (Ottawa: Queen's Printer, 1964), p. 1.

Manning has observed that due to diversity of interest within groups in agriculture, within other groups associated with agriculture and among the various groups, it is difficult to identify goals for agriculture that are different from the national goals.[1] The objectives of watershed policy cannot be divorced from those of other economic policies.[2] The Federal Task Force for Agriculture highlighted the importance of some basic national objectives in defining economic goals for Canadian agriculture and reframed these as:

1. Higher national incomes per capita, and
2. That all Canadians should have at least a minimum (or specified) standard of living.[3]

Such expressions of objectives are not different from Flinn's documentation that:

> Justification for the public investment in water resources is often argued in terms of stimulating

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[1] T.W. Manning, "Economic Guidelines for Land and Water Resource Use in Agriculture," Canadian Journal of Agricultural Economics, Vol. XVII, No. 3 (1969), p. 1.

[2] S.V. Ciriacy-Wantrup, "Philosophy and Objectives of Watershed Policy," in Economics of Watershed Planning, Edited by S.G. Tolley and F.E. Riggs (Ames: Iowa State University Press, 1961), Chapter 1, p. 4.

[3] Canada Department of Agriculture, "Economic Goals for Agriculture," Proceedings of the Canadian Agricultural Congress (Ottawa, March 24-27, 1969), pp. 8-11. This is the view expressed by the Task Force position paper which later appeared in Federal Task Force on Agriculture, "Goals," in Canadian Agriculture in the Seventies (Ottawa: Queen's Printer, December, 1969), Chapter 3, pp. 28-32.

> or maintaining economic growth, providing a means of income redistribution, efficiency objectives and/or political motivations.[1]

Phillips and Schultz convey the same idea in their statement that objectives are expressed in terms of maximizing some quantity or value, usually national income or social welfare.[2] Ciriacy-Wantrup stated that "optimizing is not and cannot be an actual policy objective" and that the "actual objective of policy decisions involves successive incremental improvements of the existing state of welfare."[3] Arrow has also indicated that a unique social welfare function is an unlikely occurrence.[4] Operationally, therefore, in dealing with public natural resource development and management, economists attempt to maximize net social benefits.[5]

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[1] J.C. Flinn, op. cit., p. 113.

[2] W.E. Phillips and W.M. Schultz, "Public Decision Guides for Water Resource Development in Western Canada" (Paper Presented to the Canadian Agricultural Economics Society, Lethbridge, Alberta, July, 1971).

[3] S.V. Ciriacy-Wantrup, op. cit., pp. 4-5.

[4] K.J. Arrow, Social Choice and Individual Values (New York: John Wiley & Sons, Inc., 1963), pp. 31f, 81f.

[5] Jan Tinbergen, Shaping the World Economy: Suggestions for an International Economic Policy (New York: Twentieth Century Fund, 1962), p. 133. See also: S.V. Ciriacy-Wantrup, Resource Conservation: Economics and Policies (Berkeley: University of California, Division of Agricultural Sciences, Agricultural Experiment Station, 1968), p. 230f.
Chapter 17 treats the problem exhaustively in terms of conservation and distinguishes between theoretical refinement of the formal definition of social optimum -- "The state which social net revenues are maximized over time" -- and practical goals which gives rise to the practical criterion of increase in present total social net revenues.

This is a workable procedure if a single-valued objective (e.g., maximization of aggregate net farm income) is adopted with restricted conditions outlined.[1] Phillips and Schultz also recommend the identification of sub-objectives as the operational way of achieving optimality through sub-optimization.[2] This approach may have its limitations but at present there is no clear cut way to quantify non-pecuniary utility.

It will be difficult to determine an optimal level of water resource development due to complex problems unresolved by economists.[3] However, both Ciriacy-Wantrup and Manning are of the opinion that more limited objectives like the feasibility of individual water resource schemes lend themselves to economic analysis.[4] Marglin accepts that the prime objective of public water resource development is the maximization of national welfare, however, he agrees its operational value is difficult to assess.[5] He recognizes

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[1] T.W. Manning, op. cit., p. 6.

[2] W.E. Phillips and W.M. Schultz, op. cit., p. 69.

[3] T.W. Manning, op. cit., p. 7.

[4] S.V. Ciriacy-Wantrup, op. cit., p. 5. See also: T.W. Manning, op. cit., p. 7.

[5] S.A. Marglin, "Objectives of Water-Resource Development: A General Statement," in Design of Water-Resource Systems: New Technique for Relating Economic Objectives, Engineering Analysis and Government Planning, Edited by Arthur Mass, et al. (Cambridge: Harvard University Press, 1962), Chapter 2, p. 17.

the possibility of defining national welfare as national income. In such a situation the objective of a river development system then becomes maximization of the contribution of the system to national income. While this is quantifiable, the implication conveyed in the idea is unacceptable as a complete expression of the broad objectives. In the context of such a definition, non-economic aspects of welfare are not only excluded, but the definition also conveys the idea that society is indifferent as to the recipient of the income generated by river development systems or that a desirable distribution of gains will be made by measures unrelated to the manner in which the system is designed. Assumption of social indifference embodies an opinion that the marginal social significance of income is the same regardless of who receives it. But few would share such opinion. Should the sole design criterion be the maximization of national income, then, a socially optimal redistribution of systems-generated income will take place through taxation and subsidies that redistribute income directly from one group to another.[1]

National welfare is not only the size of economic benefits but also accounts for how the benefits are to be shared and the method of sharing. Marglin reiterates that a single objective cannot be useful in view of the three-dimensional nature of national welfare and suggests alterna-

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[1] Ibid.

tive objectives which should be adopted. These are: (1) efficiency that expresses the objective of maximization of the economic benefit -- "efficiency net benefits" -- and (2) an income redistribution method of sharing that satisfies the values of society -- "redistribution net benefits."[1]

Economic Efficiency of Development Projects

Micro- and macroeconomic considerations apply to irrigation activity related to either a farming unit or a region. Under microeconomic considerations, two types of procedures may be involved in marginal theory.

Unconstrained Maximization

Unconstrained maximization involves a situation with unlimited capital for investment in irrigation equipment and other resources necessary for its use, e.g., water, labour, electricity and fuel. Assuming unlimited funding, which is very rare, investment in irrigation equipment should continue to the point where the last dollar expended results in a dollar return of output. An underlying assumption is that the same condition is simultaneously true for

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[1] Ibid., p. 18. See also: S.A. Marglin, Discussion on "Economics of Water Resource Use," Seventy-fourth Annual Meeting of the American Economic Association, New York, December 27-29, 1961, The American Economic Review, Vol. LII, No. 2 (May, 1962), p. 469.

for each of the other variable resources. In this case, diminishing returns to a variable resource is the determining factor. The cut-off point is where the associated marginal value products are equal to the prices of the resources.

Constrained Maximization

Constrained maximization represents a situation where limited capital is available for investment in an irrigation system. The criterion in this case gives full recognition to other investment opportunities on the farm. It implies that investment in irrigation equipment and associated inputs will be made only when its earning ability is greater than that of alternative opportunities. In such a framework, limited capital should be allocated to an irrigation system in such a way that equal returns -- marginal value products -- are obtained from each of the last dollar expenditures in irrigation resource categories. In this case, the opportunity cost principle is used to allocate investment to the highest earning opportunities on the farm so that equal marginal value productivities for resources per unit of marginal cost outlay will be obtained.

Benefit-cost analysis is also often used as an efficiency criterion for project feasibility. Economic analysis of a project is composed of the cost of investment and the

internal rate of return.[1] Phillips and Schultz observe the recognition given to internal rate of return, which is a measure of the relative "amplifying power" of a project, as the most general measure of economic efficiency to be used for the ranking of projects with any kind of time distribution of inputs and outputs.[2] It can be used to rank alternatives in the order of their dollar "amplifying power".

Investment decisions may achieve the net benefit objective of maximizing economic growth by use of the internal rate of return criterion. Prest and Turvey present a survey of cost-benefit analysis and cite guidelines on the measurement of benefits and costs.[3] The guidelines attempt to make operational microeconomic decision criteria like the rate of return, to offer measures of macroeconomic impact and to make evident non-market components of public

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[1] The decision criterion compares the internal rate of return with the cost of capital-interest rate. The internal rate of return is defined as the rate of discount which makes the present value of the stream of net benefits equal to zero. See: O.C. Herfindahl and A.V. Knesse, Economic Theory of Natural Resources (Columbus, Ohio: Charles E. Merrill Publishing Company, A Bell and Howell Company, 1974), p. 198.

[2] W.E. Phillips and W.M. Schultz, op. cit., p. 73. See also: O.C. Herfindahl and A.V. Knesse, op. cit., p. 198.

[3] A.R. Prest and R. Turvey, op. cit., pp. 687-703. Some relevant considerations under the main question are: (a) Enumeration of Costs and Benefits; (b) Valuation of Costs and Benefits; (c) Choice of Interest Rate; (d) Relevant Constraints.

interest.[1] Limitations exist in the use of the price system to provide adequate quantitative measures of many social benefits and costs. In an attempt to overcome some of these problems, Ciriacy-Wantrup discusses the issues and classifies them as follows.[2]

1. Price Signals Do Not Exist

Price signals do not exist when considering extra-market benefits and costs. Collective items not divisible in consumption (like scenic values and flood control) and marketable items divisible in consumption (like recreation facilities offered by public reservoirs and public hunting and fishing) are traditionally provided free or nearly so. There is a need to direct attention towards a meaningful procedure of evaluating extra-market benefits and costs. Indirect use of market values through analysis of data on fees, leases and real estate transactions and utilization of data in physical units like man-days and questionnaire investigations to obtain values of traditional units of use may yield useful results.[3]

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[1] W.E. Phillips and W.M. Schultz, op. cit., p. 74.

[2] S.V. Ciriacy-Wantrup (1961), op. cit., p. 5f.

[3] Some studies in this direction have been pursued in Alberta: G.B. Parlby, Gull Lake Project: An Economic Feasibility Study (Edmonton: Economics Division, Alberta Department of Agriculture, 1970), p. 64 and Appendices; and W.E. Phillips and W.S. Pattison, "Moose Hunting Activity in Alberta Big Game Zone I: An Economic Study of Wildlife Management," Agriculture Bulletin (Edmonton: The University of Alberta, Fall, 1970), pp. 12-16.

2. Price Signals Not Received by Decision Makers but by Others -- Externalities

This aspect of the malfunctioning of the price system relates to the class of costs and benefits which accrue to persons other than the planning agent responsible for a decision. In the absence of regulations, a planning agent is only interested in revenues that accrue to him and costs which he must bear. He fails to account for others affected by his decisions. This leads to externalities or spill-over effects. Therefore, the issue is the degree of accountability the sponsors are prepared to accept. In water resource economics it may be better discussed as "off-site" and "indirect" benefits and costs. Ciriacy-Wantrup expresses the opinion that the origin and incidence of "off-site" benefits and costs can be influenced through property institutions like resource law and taxation.[1] McKean proposes that originators of public investment projects should account for external effects of their actions where they alter the physical production possibilities of other producers or the satisfaction that consumers can get from given resources.[2] The price system does not fully account for the relations between upstream and downstream interests in watershed planning such as the construction

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[1] S.V. Ciriacy-Wantrup (1961), op. cit., p. 8.

[2] R.N. McKean, Efficiency in Government through Systems Analysis (New York: John Wiley & Sons, 1958), Chapter 8, p. 135.

of a reservoir upstream. Neither are upland and bottom-land farmers adequately considered in land use planning. But Ciriacy-Wantrup contends that transfer items are to be considered in benefit-cost analysis since they are relevant to project repayment which implies cost-sharing and financing.[1] Spill-overs arising from upstream and downstream resource utilization may be corrected by internalizing the effects if the spill-over is concerned with a single agency or otherwise providing compensation.[2]

3. Distortions of the Price System

The price system is considered distorted when market prices do not correspond to social values. Social institutions affect market prices through income distribution and market organization. When income distribution that results in market prices diverges from income distribution considered as the "ideal", the situation is a departure from the Pareto optimum. The effects of monopoly, duopoly, oligopoly and other divergencies from pure competition are regarded as impediments to the necessary conditions which steer the economy towards a welfare optimum.[3] As an example, in sugar beet production, which enjoys government subsidy

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[1] S.V. Ciriacy-Wantrup (1961), op. cit., p. 8.

[2] A.R. Prest and R. Turvey, op. cit., p. 689.

[3] S.V. Ciriacy-Wantrup (1961), op. cit., p. 8f.

and depends upon irrigation such as occurs in Southern Alberta, farmers' demand for irrigation water will not be a sufficient indication of the merits of the irrigation project.[1] Additionally, the farm gate price for sugar beets cannot be used to determine part of the social benefits of additional irrigation development without subtracting the social cost of the subsidy in order to remove the distortion.[2] In terms of pricing, a perfectly competitive state of affairs is the ideal. However, in the real world situation, many types of distortions, like over-pricing of labour during periods of unemployment, make the achievement of perfect competition impractical. Economists must take cognizance of such distortions by adjusting the prices to more accurately reflect social values where possible. In more difficult cases, reliance on existing prices should be rejected and the values should be treated as extra-market.[3]

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[1] A.R. Prest and R. Turvey, op. cit., p. 692.

[2] W.E. Phillips and W.M. Schultz, op. cit., p. 75.

[3] Ibid.

CHAPTER IV

METHOD OF ANALYSIS

Introduction

The purpose of encouraging settlement in the sparsely populated areas of Southern Alberta at the turn of the century could be related to the political and general economic conditions in Canada at that time. Politically, Canada wanted to establish a permanent link between the East and the West. Also, Canada wanted to establish its sovereignty along the Canada-United States border. National policy at that time was directed towards encouraging emigration to Canada, particularly Western Canada. Wheat had been established as an important crop and its price at that time was encouraging enough to expand production across the prairies. In addition, a transcontinental railway was built not only because of economic necessity, but also to help unify the East and the West.

In the main, the purpose of settlement in Southern Alberta was to take advantage of the production potential and ensure a well developed agriculture with a stable population. The expectation was to achieve agricultural development through the provision of infrastructure that would induce settlement. Therefore, in analysing the factors affecting

settlement in Southern Alberta, it is necessary to understand the role played by agriculture in the development process.

Economic development is defined by Meier as the process whereby the real per capita income of a country increases over a long period of time.[1] It involves the "upward movement of the entire social system". It is also the fulfillment of "ideals of modernization". It implies growth and change in a particular social system. Economic development, however, is not total development but a component of national development.

Agriculture's contribution to national development in the early stages of development is well documented.[2] This may be summarized as: provision of increased food supplies and raw materials, agricultural export earnings, release of labour to industry, contribution towards capital formation, and increased rural net cash income which acts as a stimulus towards industrialization by providing markets for off-farm inputs and consumer goods.[3]

There is need for the provision of some basic necessities to ensure that agriculture performs its multifarious

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[1] G.M. Meier, Leading Issues in Economic Development (Oxford: Oxford University Press, 1971), pp. 5-9.

[2] J.W. Mellor, The Economics of Agricultureal Development (New York: Cornell University Press, 1966); and H.M. Southworth and Bruce F. Johnston, Agricultural Development and Economic Growth (New York: Cornell University Press, 1967), Chapter 2.

[3] G.M. Meier, op. cit., pp. 412-418.

functions during the process of economic development. The characteristics of the environment mainly dictate what these necessities should be.

Hayami and Ruttan stress that the capacity of farmers to respond to the technical and economic opportunities available to them depends significantly on the [illegible] of both physical infrastructure and organizational or institutional infrastructure.[1] They reiterate that "investments in transportation, communication, power, irrigation and related activities are a necessary precondition for economic growth."[2] Unless these facilities are provided to a "critical minimum" level, the return to private economic activity will be insufficient to induce the investment necessary for sustained growth. Recent empirical research has demonstrated that human capital and technical inputs were dominant sources of growth in agricultural output in developed countries.[3]

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[1] Y. Hayami and V.W. Ruttan, Agricultural Development: An International Perspective (Baltimore, Maryland: The Johns Hopkins Press, 1971), p. 274. Physical infrastructure refers to roads, rural electrification, and irrigation works. Organizational or institutional infrastructures are extension education systems, disease and pest control organizations, or quality control and/or certification activities.

[2] Ibid., p. 279.

[3] Ibid., pp. 86, 242. Sources of productivity growth were categorized as: (a) Resource endowments -- include original land resource endowments and internal capital accumulation like land reclamation and development, livestock inventories, etc.; (b) Technical inputs -- the mechanical devices and the biological and chemical materials purchased from the industrial sector; (c) Human capital -- broadly includes the education, skill, knowledge, and capacity embodied in a country's population.

In this study, due to limited data, development was quantified by studying settlement. For purposes of analysis it was hypothesized that irrigation development and railway construction in Southern Alberta promoted settlement in that region. The model for this thesis quantified human capital in terms of population growth. Technical inputs were represented by irrigated acreage and railway track mileage.

The writer has taken the position that in Alberta, and Southern Alberta in particular, various government policies and those of various colonization companies were instrumental in establishing the level of settlement and agricultural productivity presently attainable. Examination of these policies indicate that not only was rapid settlement of prime importance but also that both levels of government and colonization companies were determined to build a prosperous community in Southern Alberta.

Development of the Analytical Model

Important factors that influenced agricultural expansion in Southern Alberta had started to emerge by the turn of the century. Firstly, railway transportation started in the 1880's and continued to expand for several years. A feature of the Canadian Pacific Railway's transcontinental line was its location through Southern Alberta. The railway tracks of the Alberta Railway and Irrigation Company

were also located in Southern Alberta.

Secondly, the railway infrastructure helped to promote another physical infrastructure in the form of irrigation facilities. Moderate acreages were being irrigated by the turn of the century. There were wide variations in irrigated acreages depending on year to year rainfall and soil moisture conditions.

Thirdly, a steady flow of immigrants was encouraged by the government and supported by various organizations notably, the Canadian Pacific Railway Company. They were the main source of Canadian labour supply and formed the human resource aspect of the country's development. For frontier development, persons with agricultural experience were preferable but those with substantial capital were also encouraged to homestead.[1] Most of the immigrants easily adapted to their new environment and they adjusted to changing conditions over time.

Some factors which can be subjected to economic analysis can be isolated from the physical and socio-economic information presented in this study. They are as follows.

Factors Influencing Settlement in Southern Alberta

Population

The benefits generated during the development process

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[1] J.B. Hedges, op. cit., p. 316.

accrue to the population. The direct benefits are enjoyed by the local population while the indirect benefits are shared with the population in the district, region, province, and country. The provision of infrastructure at a place which hitherto was sparsely populated tends to attract population. The role played by population growth in the development process may be conflicting since it can serve both as a stimulus and as an impediment.[1] In Southern Alberta it served the former role by contributing to market expansion, allowing specialization, economies of scale and the establishment of new economic activities. Such a favourable outcome was possible because of rising economic opportunity in Canada as a whole, and expansion of settlement in the prairie regions.[2]

[redacted]ulation variable was derived from the popula-t[redacted]ns of the relevant Census Divisions as discussed in Chapter I. Although the variable is referred to in the analysis as representing Southern Alberta, it is actually the population of the irrigation block minus the population of Census Division 6. This procedure was adopted since agriculture has not been the most important factor influencing settlement in Census Division 6.

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[1] A.P. Thirlwall, Growth and Development (London: Macmillan Press, 1972), pp. 128-133.

[2] W.T. Easterbrook and M.H. Watkins, editors, Approaches to Canadian Economic History (Toronto: McClelland and Stewart Ltd., 1967), pp. 4, 170-173.

Population in Southern Alberta increased steadily up to 1922 and then declined between 1923 and 1926. For the remainder of the study period, the population of the region increased steadily.

Irrigated Acreage

Irrigated acreage denotes the acreage that is actually irrigated within the irrigable acreage. Initially, year to year variation in irrigated acreage mainly depends upon the size of irrigable acreage made ready to receive water. However, when a project is fully completed, farmer decision dictates the size of irrigated acreage except in extreme situations where reservoir recharge is not sufficient to supply all the water needed. Observation over the study period shows a steady increase in the area irrigated.

Irrigation made greater settlement possible. As more farm lands were occupied in Alberta there was increased pressure to settle on lands in Southern Alberta although these lands could not be farmed properly unless irrigated. Therefore, as more irrigable lands were occupied, irrigated acreage increased.

The development of irrigation in Alberta is restricted to the Irrigation Districts in the South Saskatchewan River Basin (Figure 1.2). The establishment of the Irrigation Districts took more than fifty years. St. Mary and Milk River Development was the first to be established in 1899. The Bow River Development (Provincial) and the Ross Creek

Irrigation District were the last to be established in 1961 and 1949, respectively. Dates of establishment of other important districts are: Taber Irrigation District, 1915; Eastern Irrigation District, 1904; and Lethbridge Northern Irrigation District, 1920.

The total acreage irrigated annually grew from 500 acres in 1911 to 637,000 acres in 1964. The acreage irrigated in 1940 was 395,000. Before then, the largest acreage irrigated was 415,000 in 1937. In 1974, the acreage irrigated was 606,649.

Crop requirement, rainfall and soil moisture greatly influence the acreage irrigated. Detailed information on the grouping of Irrigation Districts on the basis of land use of the irrigated land is provided by Elgaard.[1] Due to the fact that a substantial portion of the land area in the irrigation block is used for dryland farming there is great diversity of crop and livestock enterprises in the region. Grain, forages, oilseeds and specialty crops are the main cropping activities. Beef production, dairying, swine and poultry production are the major livestock enterprises. Sheep production occurs on a limited scale.

Irrigation affects agricultural production potential in the sense that it allows the introduction of crops which

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[1] K. Elgaard, "Present Status and Development of Irrigation Agriculture in Alberta," in Proceedings of Irrigation Economics Conference, Edited by T.W. Manning (Edmonton: University of Alberta, June, 1964), pp. 15-21.

cannot be grown without irrigation. Introduction of irrigation introduces a change in the cropping season by lengthening the season to allow summer vegetables and potatoes to be introduced. Irrigation has the advantage of increasing yield and also creating the possibility of double cropping. The total effect of irrigation, therefore, is to increase agricultural production. The benefit of increased agricultural production is the ability to support a bigger population. So the viability of irrigation in Southern Alberta is seen as a means of supporting a larger population than can naturally be possible.

Railway Track Mileage

The invention of the steam locomotive in 1829 made cheap transportation possible and helped to establish the economic life of the nineteenth and twentieth centuries.[1] The marketing of goods and services greatly depends upon a good transportation network. Through the transfer of goods from place to place, a network of transportation systems makes possible the establishment of central markets and commodity prices. An extensive transportation system permits the extension of the area of profitable production for a given market. By lowering the cost of production, an extensive transportation network helps to reduce the price

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[1] D. Philip Locklin, Economics of Transportation (Homewood, Illinois: Richard D. Irwin, Inc., 1972), pp. 1-9.

of goods. This is accomplished through reduction in the cost of getting goods from production centres to consumers, through reduction in the cost of assembling raw materials, and through the opportunity it creates for geographical division of labour. A good system of transportation also encourages large-scale production. The economies associated with large-scale production result in lower prices.

The development of large inland cities is dependent on a good transportation network. Without such systems of transportation it would be difficult to supply food, especially perishable products, to large cities. Through large-scale production, territorial division of labour, and the resulting exchange of commodities, a reliable system of transportation serves as a stimulus to urbanization.

The development of a transportation system has been found to be essential to the economic development of a country.[1] Because of this, it is not only governments who support the construction of transport facilities. It is observed that:

> Even where railways were built by private capital, investment was often motivated by expectations of indirect economic gains -- appreciation of land values, greater profitability of agriculture and other enterprises -- rather than profits of railway operation.[2]

The Western Canadian situation was no different. With

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[1] Ibid., p. 16.

[2] Ibid.

respect to Canada, Currie notes that:

> Throughout our transportation history we have not been able permanently to resolve the conflict between preserving private enterprise and using public funds to carry out national objectives. Yet we have always been supplied with safe, efficient and low cost service.[1]

It is realized from this observation that a good system of transportation has been an important factor in the economic life of Canada. Railway construction formed an integral part of the Confederation scheme of 1867.[2] It was found that cheap, reliable, year-round transportation was essential if the colonies in British North America were to be effectively bound together socially, politically, and economically.

The existing network of railway lines (Figure 1.1) was started in the early 1880's.[3] The transcontinental railway, C.P.R., reached Medicine Hat in 1882. Construction was completed in 1885. The Northwest Coal and Navigation Company built a railway line on behalf of the Alberta Railway and Coal Company in 1885. This railroad connected Medicine Hat to Lethbridge. In December, 1890, the Alberta

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[1] A.W. Currie, Economics of Canadian Transportation (Toronto: University of Toronto Press, 1954), p. 27.

[2] Ibid., p. 4.

[3] Alberta Bureau of Statistics, op. cit. (1954), pp. 252-253; and Alberta Bureau of Statistics, Alberta Industry and Resources (Edmonton: Government Printer, 1964), pp. 110-113.

Railway and Coal Company opened a railway line between Lethbridge and Coutts. Calgary was served with railway facilities in 1883 and in 1891 the C.P.R. extended its railway system to Edmonton.

The development of railway track mileage in Alberta is shown in Appendix A, Table A.1. This appendix shows annual increments of railway track mileage in Alberta as a whole. For purposes of this study, the annual increments of railway track mileage in the study area were compiled (Appendix A, Table A.2). The cumulative mileage resulting from this compilation was used as the variable for railway track mileage. All the lines in the study area are owned by the C.P.R. either through original construction or acquisition from other companies.

The relationship between railways and settlement is highlighted by Professor Chester Martin:

> The place of railways in the settlement of Western Canada is axiomatic.... While it would seem at first sight, as Dr. Mackintosh has observed, that the railways 'followed the settler rather than preceeded him', it is more than likely that 'in reality the settler for the most part, merely anticipated the railway already projected or under construction'. In any event, whatever the temporary relationship [redacted]en the frontiersman and the railway, the per- relationship between the railway and sound [redacted]ic settlement is scarcely to be gainsaid.[1]

According to Hedges:

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[1] C. Martin, op. cit., pp. 73-74.

> It was assumed that the settlement and development of the country which had awaited the coming of the railway, would now go forward with a rush.[1]

Therefore he implies that the railway had a leading influence in settlement and subsequent development. The researcher's view in choosing the railway track mileage as a variable is that substantial land occupation occurred after the building of the railways but not before.

The railway track mileage exhibits two distinctive patterns. After the turn of the century, it was characterized by two periods of growth, 1908 to 1914 and 1925 to 1930, and two periods of stagnation, viz. 1915 to 1924 and 1931 to 1940. The First World War and the Depression of the 1930's might have diverted investment away from railway construction.

On the assumption that after construction of the railway lines in Southern Alberta there was delayed response in settlement, the railway track mileage variable was lagged for varying periods.

Other Variables

The other variables used in the analysis were non-quantifiable. These qualitative variables were categorized according to their years of effectiveness. Thus, with respect to governmental and colonization company policies, the

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[1] J.B. Hedges, op. cit., p. 71.

entire period of analysis was relevant. The effective period for the rest of the dummy variables are: Canadian Pacific Railway policies, 1911-1937; and the Prairie Farm Rehabilitation Act, 1935-1940.

Expected Interrelationships

Increased demand for land and the government's desire to settle lands closer to the American border necessitated settlement of the semi-arid regions in Southern Alberta. Such settlement could not have taken place without the provision of irrigation. In making greater settlement possible, irrigation activities helped to increase the population. Therefore increases in irrigated acreage ultimately increased population. A positive relationship therefore exists between the two variables.

For effective consideration of railway mileage, it must be considered in terms of its entire length between two points. For this reason, mileages have been computed to Calgary which serves as the northern link with the irrigation block (Figure 1.1). When passing through a semi-arid area, the railway rendered those lands accessible thereby increasing their economic potential. The location of the rail lines therefore tended to increase irrigated acreage.

The expansion of railway track mileage rendered many places accessible, ensured communication over a wider area, and facilitated marketing of agricultural products and farm inputs. It was expected that land acquisition would increase

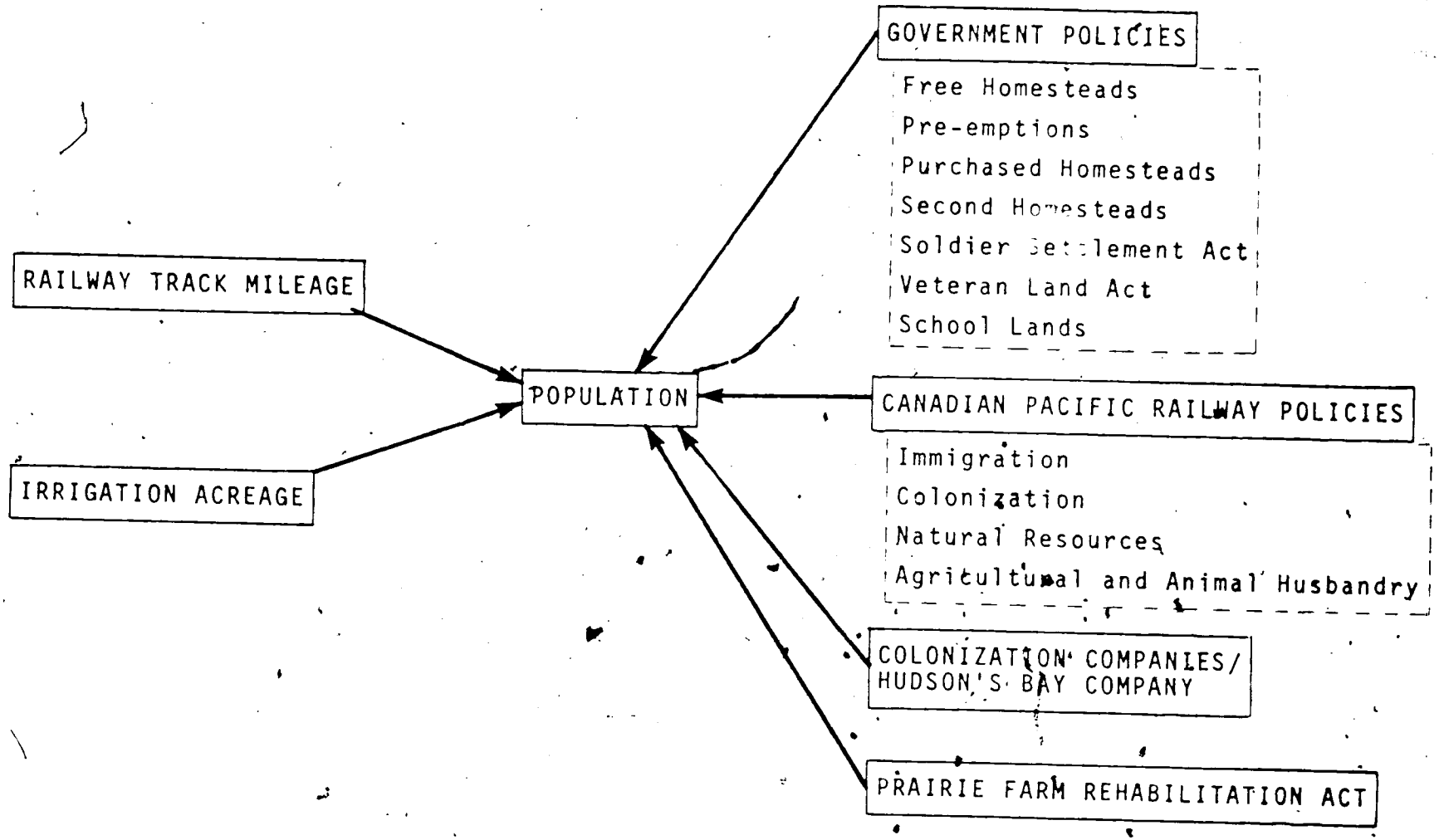
in the neighbourhood of railway lines. Homesteading resulting from this would eventually lead to increased population. A positive relationship therefore exists between railway track mileage and population. As a result, an increase in railway track mileage will be associated with an increase in population.

The Model

The background information presented enables the formulation of a model in terms of settlement relationship with irrigated acreage and railway track mileage. Four additional variables in the form of dummy variables were also considered simultaneously with the quantitative variables. These variables are: various government policies, various Canadian Pacific Railway Company policies, the policies of the Hudson Bay Company and other colonization companies, and the Prairie Farm Rehabilitation Act. The relationship is diagramatically represented by Figure 4.1. Prairie Farm Rehabilitation Act has been categorized separately from government policies because items listed under government policies were mainly for land disposal while the Prairie Farm Rehabilitation Act sponsored programmes that were principally for rehabilitation and readjustment.

In an attempt to test whether the factors mentioned influenced settlement, regression models were developed. A simple correlation matrix was used to provide a guide in

Figure 4.1. Diagramatic Representation of Factors Influencing Settlement in Southern Alberta



the model specification. Since it is necessary to have a settled community before development can proceed, the model considered the influence of various factors on the settlement of Southern Alberta.

$$Y_{1t} = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \beta_4 X_{4t} + U_t$$

$$Y_{2t} = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t+n} + \beta_3 X_{3t} + \beta_4 X_{4t} + U_t$$

$$n = 2, 3, 4, 5 \text{ or } 6.$$

where Y_{1t} = population,

Y_{2t} = population,

t = time,

n = effective lagging period (in years),

X_1 = irrigated acreage,

X_2 = railway track mileage,

X_3 = Canadian Pacific Railway policies,

X_4 = Prairie Farm Rehabilitation Act.

Data were collected for a 64 year period, 1911-1974. But to make a rational analysis, the period of study was restricted to 30 years, 1911-1940. The purpose of the restriction was to eliminate the effects of possible influ-

ences not considered in this study.[1]

Problems of indeterminateness arise in the use of models containing dummy variables. Solution of such estimation problems requires the elimination of some variables, the objective being the removal of perfect intercorrelation among the variables.[2] In this analysis, therefore, government policies and colonization companies' policies were eliminated to make the solution determinate. The theory supporting the models specified above is reviewed for clarification.

Theoretical Premises of the Analytical Model

A variable that moves in an orderly fashion with respect to another variable may often be decomposed into (1) a systematic part, which is some function of the latter variable, and (2) a random part, the behavior of which is unpredictable. The model of normal linear regression has often been used in the measurement of economic relationships. A simple linear regression model may be represented as:

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[1] The discovery of oil in the late 1940's resulted in increased explorations in Alberta and by the 1960's, oil and gas influenced the economy of the Province more than any other economic activity.

[2] D.B. Suits, "Use of Dummy Variables in Regression Equations," Journal of American Statistical Association (December, 1957), p. 548; and W.G. Tomek, "Using Zero-One Variables with Time Series Data in Regression Equations," Journal of Farm Economics (November, 1963), pp. 818-819.

$$Y = \alpha + \beta X + U^{1}$$

where Y = the dependent variable,

α = unknown constant term (intercept),

β = unknown constant (slope),

X = the independent variable,

U = the unknown residual or error term.

The variable Y may thus be decomposed into $(\alpha + \beta X)$, the systematic part, and, U, its random part.

In most real life situations, a dependent variable may be related to more than one independent variable. The multiple linear regression model which may be used in such cases can therefore be written as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots . \beta_k X_k + U^{2}$$

where Y = the independent variable or regressand,

X_i $(i=1,2,\ldots,k)$ = the k independent (or explanatory) variables or regressors,

β_0 = unknown constant (intercept),

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[1] J. Johnston, Econometric Methods (New York: McGraw-Hill, 1972), pp. 9-11.

[2] Ibid., p. 121; and also D.S. Huang, Regression and Econometric Methods (New York: John Wiley & Sons, 1970), p. 76; supplemented with W. Phillips, Lecture Notes, Ag. Ec. 416, University of Alberta, Edmonton, Fall, 1973.

β_i $(i=1,2,\ldots,k)$ = the unknown constants (slopes),

U = the unknown residual.

The β_i coefficients in the equation represent partial regression coefficients. Each coefficient shows the amount by which Y will change per unit change in X_i, all other things remaining constant. In this way, it is generally implied that the variation in Y is systematically explainable by the part of Y that is represented as $(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots. \beta_k X_k)$ and that the part of Y not explained by the X's is represented by U.

For a sample of n observations on the Y's and X's, we may write for k variables:

$$Y = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots. \beta_k X_{ki} + U_i$$

$$i = 1,2,\ldots,n.$$

A complete description of this equation results in a system of equations:[1]

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[1] J. Johnston, op. cit., p. 68.

$$Y_1 = \beta_0 + \beta_1 X_{11} + \beta_2 X_{12} + \ldots + \beta_k X_{1k} + U_1$$

$$Y_2 = \beta_0 + \beta_1 X_{21} + \beta_2 X_{22} + \ldots + \beta_k X_{2k} + U_2$$

$$\vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots$$

$$Y_n = \beta_0 + \beta_1 X_{n1} + \beta_2 X_{n2} + \ldots + \beta_k X_{nk} + U_n$$

The complete descriptive system may be represented compactly in matrix notation by the model:

$$y = X\beta + U^1$$

where X is a matrix of independent variables, y is a vector of dependent variables, β is a vector of parameters and U is a stochastic vector.

Estimation for the general linear model is based on the fundamental Gauss-Markov Theorem.[2] It states that if we have n observations, Y_i, which are equal to known linear functions of a number k, of unknown parameters, plus errors which are uncorrelated, have expectation zero, and have variance σ^2, then the best linear unbiased estimates (BLUE)

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[1] Ibid., p. 69.

[2] Ibid., p. 23.

of the parameters are given by the method of least squares and the expectation of the sum of squares of deviations from the regression divided by (n-k) is equal to σ^2.

Assumptions of the Classical Model

The crucial assumptions of the model are:[1]

1. There exists a linear functional relationship between the dependent and the independent variables. Also, the true values of Y, the dependent variable, and X_i, the independent variables, are not appreciably different from their observed values.
2. The error terms, U_i, are normally distributed variables with zero expectation, $E(U) = 0$, and constant variance σ^2. There is no interdependence of the random errors.
3. The independent variables, X_i, are composed of a set of fixed numbers. This means that in repeated sampling, U must be independent of X and the sole source of variation in the Y vector is variations in the U vector with the result that the properties of estimates and tests are conditional upon X. The X_i are not only independent of each other but also of α and β_i.

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[1] Ibid., pp. 122-123; also A.S. Goldberger, Econometric Theory (New York: Wiley & Sons, 1964), p. 162.

4. The number of observations exceeds the number of parameters to be estimated, i.e., X has rank $k < n$.

Mention has been made of the inclusion of dummy variables in the analytical model. At times it becomes necessary to introduce dummy variables in a regression model to capture the effects of qualitative attributes of an economic structure.

Dummy variables are useful when a researcher believes that the explanatory variable is a step function in form and the break points are known.[1] The dummy variable technique introduces into a regression analysis information contained in variables that are not conventionally quantifiable. When time series data are qualitative in nature and the original observations can be divided logically into two distinct classes, dummy variables can appropriately be applied in regression equations.[2] Such situations may arise from a distinct institutional or structural change such as introduction of a policy measure in one period and its withdrawal in another. The term "dummy variables" usually connotes "zero-one" variables where a criterion which is met is scored one and otherwise zero. An obvious but crucial point is that correct demarcation between the

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[1] A.S. Goldberger, op. cit., p. 218.

[2] W.G. Tomek, op. cit., p. 814.

mutually exclusive classes is of paramount importance.

In tribute to the use of dummy variables, Suits comments that:

> There is nothing artificial about such variables; indeed, in a fundamental sense they are more properly scaled than conventionally measured variables.[1]

The implication is that dummy variables are able to establish a better proportion between variables than quantitative variables. He points out that if regression analysis provides an estimate of a dependent variable, it must be noted that where a curvature occurs in estimation, linear regression results are biased. Under such situations, unbiased estimates are obtained by partitioning the scale of a conventionally measured variable into intervals and defining a set of dummy variables on them because the regression coefficients of the dummy variables conform to any curvature that is present.[2]

The dummy variable technique was used in this research to help evaluate the qualitative policy variables pertinent to this study.

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[1] D.B. Suits, op. cit., p. 551.

[2] Ibid.

CHAPTER V

RESULTS OF EMPIRICAL ANALYSIS

The factors affecting settlement in Southern Alberta have been discussed in preceding chapters. Empirical results of the analytical model formulated in Chapter IV are presented and discussed in this chapter.

In considering the settlement of Southern Alberta, population was selected as a measure of settlement. From the model, other factors that may relate to this measure of settlement are irrigated acreage, railway track mileage, Canadian Pacific Railway policies and the Prairie Farm Rehabilitation Act.

A simple correlation of factors influencing settlement in Southern Alberta is presented in Table 5.1. The correlation coefficient, r, for irrigated acreage was 0.908, while that for railway track mileage was 0.905. The variable for Prairie Farm Rehabilitation Act yielded a correlation coefficient of 0.559. The Canadian Pacific Railway policies variable showed a correlation coefficient of -0.39. The results indicate that there is some association between population and the independent variables mentioned here.

Testing the results with Fisher's Z-transformation indicated that when using population as a measure of settle-

TABLE 5.1

SIMPLE CORRELATION OF FACTORS INFLUENCING SETTLEMENT IN SOUTHERN ALBERTA

Factors	X_1	X_2	X_3	X_4	Y
X_1	1	.754	-.429	.649	.908***
X_2		1	-.293	.440	.905***
X_3			1	-.666	-.390**
X_4				1	.559***
Y					1

Y = Population.

X_1 = Irrigated acreage.

X_2 = Railway track mileage.

X_3 = Canadian Pacific Railway policies.

X_4 = Prairie Farm Rehabilitation Act.

In all cases in the tables, one asterisk (*) will imply significance at the 10 percent level, two asterisks (**) will show significance at the 5 percent level, and three asterisks (***) will indicate significance at the 1 percent level.

ment, all the independent variables, except Canadian Pacific Railway policies, were significant at the 99 percent level. The values of the correlation coefficient are too great to have come by chance from an uncorrelated population. The simple correlation results revealed that the dependent variable could be predicted by more than one independent variable. Multiple regression procedures are therefore employed in the analysis.

The purpose of the correlation matrix shown in Table 5.1 is twofold. Firstly, it helps in the selection of variables to be included in the models used for estimation. The variables most closely associated with the dependent variable are obviously selected. The second purpose of the correlation matrix is to make evident any trace of multicollinearity. Multicollinearity occurs when some or all the explanatory variables are highly collinear or perfectly collinear.[1] A consequence of multicollinearity is that it becomes difficult to disentangle the relative influences of the various independent variables. In the presence of high correlation between two independent variables, it is not advisable to use both variable in the same equation. One variable can serve as a substitute for the other.

Results of stepwise regression are shown in Table 5.2. The equation represents a situation where the model seeks

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[1] J. Johnston, op. cit., p. 160.

TABLE 5.2

ESTIMATED REGRESSION EQUATION

		R^2	F	Variation	D.W.
$Y = 62{,}044.627 + 0.04481^{***} X_1 + 38.939^{***} X_2$		93.81	204.45^{***}		1.462
(0.00625) (5.558)					
	X_1			82.55	
	X_2			11.26	

Y = Population.

X_1 = Irrigated acreage.

X_2 = Railway track mileage.

Standard errors of the coefficients are given in parentheses below the coefficients.

to explain settlement in Southern Alberta in terms of irrigated acreage and railway track mileage. The equation was the best, among several trials involving lagging railway track mileage to explain the relationship between the dependent variable and the independent variables. None of the lag models gave appreciably better results. The final selection was based on statistical criteria relating to the coefficient of determination (R^2), the F-ratio (F), the standard error of the regression coefficients, the Student-t distribution (t) and the Durbin-Watson statistic (DW).

The results presented in Table 5.2 show that in the model $Y_{1_t} = \beta_0 + \beta_1 X_{1_t} + \beta_2 X_{2_t} + U_t$, irrigated acreage ($X_1$) and railway track mileage (X_2) explained a high percentage of the variation in settlement. The value of the coefficient of determination (R^2) was 94 percent. Before the railway track mileage (X_2) was introduced into the stepwise regression, irrigated acreage (X_1) accounted for 83 percent of the variation in settlement. With the addition of railway track mileage (X_2) to the regression equation, 11 percent of the unexplained variation in settlement was explained by the railway track mileage variable. There was a high intercorrelation between irrigated acreage (X_1) and railway track mileage (X_2) as shown in Table 5.1. The correlation coefficients of these variables were almost equal, being 0.908 and 0.905, respectively. In simple regression analysis would be expected that the coeffi-

cients of determination for the two variables would not differ appreciably. The difference in the values of the coefficients of determination reported here resulted from the use of the stepwise regression procedure. Since the stepwise regression introduced the irrigated acreage (X_1) variable into the solution first, that variable was able to explain an appreciably higher proportion of the variation in the dependent variable than the other variable, railway track mileage (X_2). These results indicate that with population as a measure of settlement, irrigated acreage and railway track mileage jointly explained 94 percent of the variation in settlement in Southern Alberta.

R^2, the coefficient of determination, is a statistic that measures concomitant covariation between the dependent variable and the set of independent variables. The computed value of the R^2 was high which implies that a high proportion of the total variation in the dependent variable was statistically explained by the linear relation.

Further analysis was carried out by incorporating two dummy variables, Canadian Pacific Railway policies (X_3) and Prairie Farm Rehabilitation Act (X_4), into the equation. The resulting stepwise regression did not improve the coefficient of determination appreciably. While Canadian Pacific Railway policies (X_3) contributed only 0.03 percent to the explanation of the variation in settlement, Prairie Farm Rehabilitation Act (X_4) contributed 0.05 percent.

The F-test was applied to the results by comparing

the critical F-value with the calculated F-value for the various equations. The test showed the level of confidence that can be placed in the independent variables which seek to explain the variability of the dependent variable.[1] The null and the alternative hypotheses were tested:

H_0: $R^2 = 0$: That the model does not explain a significant amount of the variation in the dependent variable, or that the specified econometric model is not useful in representing the economic experience under consideration.

H_1: $R^2 \neq 0$: That the special model is somewhat useful in representing the variation in the dependent variable.

In all equations, the calculated F-value exceeded the critical F-value and the null hypothesis was rejected. The results are significant so the specified model is useful since it fits the data measuring the historical experience under consideration.

The legitimacy of including certain variables in the equation was confirmed through the t-test. The test indicates the level of significance of the individual regression coefficients in an equation. Stepwise regression results showed that in the equation reported here, the regression coefficients for irrigated acreage (X_1) and railway track mileage (X_2) were significant at the 99 percent confidence

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[1] J. Kmenta, Elements of Econometrics (New York: Macmillan Company, 1971), p. 367. The F-statistic is calculated from the ratio of the explained variance to the unexplained variance.

level. Their respective t-values were 7.17, and 7.00 while the critical t-value is $t(0.01; 27) = 2.473$ for one tail test. Thus evidence has been adduced to justify the inclusion of irrigated acreage and railway track mileage in the equation. In terms of the regression coefficients, it may be stated that a change of one in railway track mileage was associated with a change of 39 in population, and a change of 100 in irrigated acreage was associated with a change of 4.5 in population.

The extension of the analysis to include the dummy variables did not prove worthwhile. In this analysis the t-values for irrigated acreage (X_1), railway track mileage (X_2), Canadian Pacific Railway policies (X_3), and Prairie Farm Rehabilitation Act (X_4) were 5.94, 6.73 -0.53, and -0.43, respectively. Here again, the first two variables, X_1 and X_2, were significant at the 99 percent confidence level. The critical t-value is $t(0.01; 25) = 2.485$. The regression coefficients of the last two variables, X_3 and X_4, were not significant. This result does not support the inclusion of X_3 and X_4 in the equation. The implication of the result is that it is difficult in the long run to quantify policy measures deemed to have influenced settlement in Southern Alberta.

The signs of the regression coefficients for both irrigated acreage (X_1) and railway track mileage (X_2) were consistent with expected economic interpretation. A priori reasoning indicated that as settlement proceeded and popu-

lation increased demand for irrigated lands would increase and lead to further settlement. With respect to railway track mileage (X_2), the positive sign was expected since expansion of railway track mileage would render many places accessible, ensure communication over a wider radius and facilitate marketing of agricultural products and farm inputs. This should lead to greater land acquisition in the neighbourhood of railway lines. Settlement resulting from this will eventually lead to increased population.

The Durbin-Watson test was utilized to test whether or not the disturbances are significantly autocorrelated. Autocorrelation exists when the disturbance terms of different observations are dependent on each other. Such dependency may be reflected in the correlation of error terms with themselves in preceeding or subsequent observations.

The null hypothesis for the test is that the random errors of the explanatory variables are not correlated -- H_0: $Cov(\varepsilon_t \varepsilon_{t-1}) = 0$. The alternative hypothesis is that positive first order autocorrelation exists -- H_1: $Cov(\varepsilon_t \varepsilon_{t-1}) > 0$.

The calculated Durbin-Watson statistic was compared with the upper (d_u) and lower (d_L) critical values for d from the Durbin-Watson d-statistic table. Various authors have formulated a guide as to how conclusions could be arrived at using the Durbin-Watson test based on residuals

from regression analysis.[1]

Value of Calculated d	Conclusion
If $d < d_L$	Positive autocorrelation. Reject hypothesis of non-autocorrelated u; accept the alternate hypothesis.
If $d_L < d < d_u$ or $(4 - d_u) < d < (4 - d_L)$	Test is inconclusive.
If $d_u < d < (4 - d_u)$ or $d > d_u$	No autocorrelation. Accept null hypothesis.
If $d > (4 - d_L)$	Negative autocorrelation.

In the equation reported in Table 5.2, there was inconclusive evidence of autocorrelation at the 5 percent level. The critical values are $d_L = 1.28$ and $d_u = 1.57$. However, at the 1 percent level, negative autocorrelation exists, the critical values being 1.07 for d_L and 1.34 for d_u. This is further justification for the acceptance of the equation.

In conclusion, the multiple regression results show that irrigated acreage and railway track mileage help to explain variations in the settlement of Southern Alberta.

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[1] J. Johnston, op. cit., p. 252; and J.L. Murphy, Introductory Econometrics (Homewood, Illinois: Richard D. Irwin, Inc., 1973), p. 313.

On the premise that there was delayed response in settlement after railway lines were built in Southern Alberta, a sensitivity analysis was undertaken by lagging the railway track mileage variable, X_2, over two, three, four, five, and six years in various equations. The results of the analysis are shown in Appendix B, Table B.1. Results from this analysis did not improve the expectation appreciably. A discussion of the results relating to the lag model can be found in Appendix B.

CHAPTER VI

SUMMARY, CONCLUSIONS AND IMPLICATIONS

Summary and Conclusions

The research reported in this thesis traced the historical development of irrigation and its role in the settlement of Southern Alberta. Canadian land and water policies that influenced agricultural settlement in Southern Alberta were also examined. A regression model was developed to help identify the important variables that influenced settlement in Southern Alberta and made agricultural development possible.

The multiple linear regression technique was utilized to determine the relationship between the dependent variable settlement, as measured by population, and the independent variables which were irrigated acreage, Canadian Pacific Railway policies, Prairie Farm Rehabilitation Act and railway track mileage. For further analysis, the railway track mileage variable was lagged over two to six years on the assumption that there was delayed response in settlement after building railway lines in Southern Alberta.

Results of the analysis showed that the regression coefficients for irrigated acreage (X_1) and railway track mileage (X_2) were significantly different from zero at the

99 percent level of significance. On the other hand, when the analysis was extended to include the dummy variables Canadian Pacific Railway policies (X_3) and Prairie Farm Rehabilitation Act (X_4), the quantitative variables -- irrigated acreage and railway track mileage maintained their significance at the specified level of significance but the Canadian Pacific Railway and Prairie Farm Rehabilitation Act variables were not significant.

A conclusion which is drawn from this study is that irrigated acreage and railway track mileage were factors which contributed to settlement in Southern Alberta. Although the variable for Canadian Pacific Railway policies (X_3) was not found to be a statistically significant factor contributing towards settlement in Southern Alberta, the variables for irrigated acreage (X_1) and railway track mileage (X_2) were both quantifiable outcomes of Canadian Pacific Railway policies. Therefore, the importance accorded the Canadian Pacific Railway in earlier discussions of this study should not be negated.

The other dummy variable in the analysis, Prairie Farm Rehabilitation Act (X_4), was not statistically significant. It should be noted that the Prairie Farm Rehabilitation Act (X_4) was in effect only in the last six years of the study period. This short period could be the reason for not rendering the Prairie Farm Rehabilitation Act (X_4) variable significant. Government support for irrigation, which increased after the early thirties, and the Prairie

Farm Rehabilitation programmes, which started in the mid-thirties, should not be overlooked simply because the results from this analysis have failed to exhibit their importance. It is concluded that it is difficult to quantify qualitative variables that influenced settlement in Southern Alberta.

The government and other organizations charged with colonizing the West did not limit their planning horizon, as expressed through their policies, to short term decisions. The Canadian Pacific Railway, for example, expressed policy intentions which were in conformity with the general expression of objectives of welfare maximization.

The major conclusions of this study are that:

1. Agricultural settlement of Southern Alberta has been consistent with the proposition that entrepreneurial efforts in both private and public sectors with respect to the development of irrigation were directed towards the establishment of a stable population as a precondition for agricultural development.
2. Results of the regression analysis supported the hypothesis that irrigation played a major role in settlement of Southern Alberta. The irrigation variable explained 83 percent of the variation in settlement of the region.
3. The regression analysis was also consistent with the hypothesis that railway transportation influ-

enced settlement in Southern Alberta. The railway track mileage accounted for an additional 11 percent of the variation in settlement.

4. The hypothesis that Canadian land and water resource development policies aided settlement in Southern Alberta was rejected according to the results of the regression analysis.

Limitations of the Study

Although a useful model was developed, one of the limitations that constrained this study was lack of appropriate data. Also, lack of uniformity in statistical compilation for the various Irrigation Districts and the non-existence of data for some Districts did not permit the comparative analysis which this study initially sought to undertake.

Implications

The experience in Southern Alberta shows that there was justification in initiating water resource development because it helped stabilize people into settled communities thus creating opportunity for long term planning and development. The ranching economy of Southern Alberta was replaced by settled communities of irrigation farmers. These irrigators have transformed the agricultural economy

of the region into a viable mixed farming economy. The provision of irrigation facilities benefited the region directly through increased agricultural production. In addition, indirect benefits were realized. The additional net incomes accruing from processing and distribution of the immediate products are some of the indirect benefits stemming from the provision of irrigation. Another aspect of the indirect benefits induced by irrigation activities in Southern Alberta are those benefits accruing from the expenditures made by the irrigators which stimulated other economic activities like the manufacture of off-farm inputs. Two inducement mechanisms of direct productive activities, input utilization of forward linkage effects and input with a derived demand schedule or backward linkage effects, are identified in Southern Alberta as a result of irrigation.

Industrial activities resulting from irrigation are contributing substantially to the general welfare of Southern Alberta and the country as a whole. The main developments include sugar and canning factories where a variety of irrigated crops are processed. Packing plants for meat and poultry are also some of the major developments in the region. Seed cleaning plants and alfalfa mills are also operating in the region. Irrigation in Southern Alberta has created the possibility for employment and trade in materials used in agricultural production. Increased rural population as a result of irrigation has resulted in a much greater volume of business in the urban

areas which in turn has increased population and business in the province. Hence the introduction of irrigation does not only influence settlement, but as a modern input in agricultural production, irrigation can induce changes in other sectors of the economy.

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APPENDIX A

MILEAGE INCREMENTS OF RAILWAY TRACK

The information contained in Appendix A relates to annual increments in railway track mileage in Alberta. Analytical data for the railway track mileage variable (X_2) were derived from Table A.2.

TABLE A.1

MILEAGE INCREMENTS OF RAILWAY TRACKS IN ALBERTA

Origin and Destination of Rail Lines	Year of Operation	Mileage	Present Ownership of Rail Lines	Construction Charter Originally Granted To:
Stirling-Foremost-Gessday	1914	84.49	C.P.R.	
Stirling-Coutts	1912	47.05	C.P.R.	Alberta Railway and Coal Company
Stirling-Lethbridge	1890	23.84	C.P.R.	
Stirling-Cardston	1912	46.44	C.P.R.	St. Mary's Ri[illegible] Railway Compa[illegible]y
Lethbridge-Fort MacLeod-Peigan	1909	41.47	C.P.R.	
Peigan-Pincher-Crownest	1898	59.65	C.P.R.	
Fort MacLeod-Durward	1892	46.35	C.P.R.	
Durward-Aldersdye-Calgary	1891	60.92	C.P.R.	
Aldersdye-Eltham-Vulcan-Carmangay	1911	57.58	C.P.R.	
Lethbridge-Taber-Bow Island-Dunmore	1885	106.72	C.P.R.	Northwest Coal and Navigation Company
Dunmore-Walsh	1883	25.00	C.P.R.	

TABLE A.1 (CONTINUED)

Origin and Destination of Rail Lines	Year of Operation	Mileage	Present Ownership of Rail Lines	Construction Charter Originally Granted To:
Dunmore-Medicine Hat-Suffield-Brooks-Cassils-Bassano-Gleichen-Calgary	1883	175.82	C.P.R.	
Suffield-Vauxhall-Lomond	1914	83.98	C.P.R.	
Bassano-Rosemary-Patricia-Empress	1914	101.16	C.P.R.	
Shepard-Langdon-Strathmore-Gleichen	1883	45.82	C.P.R.	
Calgary-Norfolk	1913	13.2	C.N.R.	Alberta Midland Railway
Norfolk-Nightingale-Rosebud-Rosedale-Drumheller	1911	56.30	C.N.R.	Alberta Midland Railway
Nightingale-Standard	1911	19.10	C.P.R.	
Nightingale-Irricana	1911	17.49	C.P.R.	
Calgary-Irricana-Beiseker	1913	33.00	C.N.R.	Grand Trunk Pacific Railway
Beiseker-Acme	1909	8.27	C.P.R.	

TABLE A.1 (CONTINUED)

Origin and Destination of Rail Lines	Year of Operation	Mileage	Present Ownership of Rail Lines	Construction Charter Originally Granted To:
Langdon-Keoma-Irricana	1909	31.52	C.P.R.	
Beiseker-Three Hills-Elnora-Lousana	1912	55.5	C.N.R.	Grand Trunk Pacific Railway
Lousana-Heatburg	1911	21.3	C.N.R.	
Calgary-Crossfields-Innisfall-Red Deer	1890	93.49	C.P.R.	
Red Deer-Lacombe-Wetaskiwin-Edmonton	1891	99.15	C.P.R.	
Wetaskiwin-Camrose	1905	25.13	C.P.R.	
Camrose-Daysland	1905	26.16	C.P.R.	
Daysland-Sedgewick-Hardisty	1907	43.85	C.P.R.	
Hardisty-Provost-Hayter	1907	56.00	C.P.R.	
Camrose-Heisler-Galahad			C.N.R.	
Galahad-Alliance				

TABLE A.1 (CONTINUED)

Origin and Destination of Rail Lines	Year of Operation	Mileage	Present Ownership of Rail Lines	Construction Charter Originally Granted To:
Camrose-Ryley	1910		C.N.R.	Alberta Midland Railway
Ryley-Vegreville	1909		C.N.R.	
Camrose-New Norway	1910		C.N.R.	Grand Trunk Pacific Railway
Ferintosh-Alix-Heatburg	1910		C.N.R.	
Camrose-Edberg-Stettler-Warden	1910	58.0	C.N.R.	Alberta Midland Railway
Stettler-Munson	1910		C.N.R.	
Munson-Drumheller	1910	13.43	C.N.R.	
Munson-Michini	1912	9.58	C.N.R.	Canadian Northern Alberta Railway
Hanna-Watts-Michini	1912/3	30.73	C.N.R.	
Hanna-Sibbald	1912	84.98	C.N.R.	
Lacombe-Alix	1905	26.59	C.P.R.	
Alix-Stettler	1906	23.03	C.P.R.	
Stettler-Castor	1910	35.37	C.P.R.	

TABLE A.1 (CONTINUED)

Origin and Destination of Rail Lines	Year of Operation	Mileage	Present Ownership of Rail Lines	Construction Charter Originally Granted To:
Castor-Mile 105	1911	21.68	C.P.R.	
Mile 105-Coronation	1912		C.P.R.	
Coronation-Veteran-Consort-Compeer	1914	50.00	C.P.R.	
Red Deer-(Sylvan Lake)-Rocky Mountain House	1914	64.71	C.P.R.	Alberta Central Railway
Alix-South Junction	1921	0.54	C.N.R.	
Mile 0.54-Briggs	1911	44.87	C.N.R.	
Briggs-Otway	1912	45.71	C.N.R.	Canadian Northern Western Railway
Otway-Saunders	1913	42.60	C.N.R	
Saunders-Brazeau	1914	17.26	C.N.R.	
Edmonton-Ryley-Viking-Irma	1909	105.5	C.N.R.	
Irma-Wainwright-Chauvin	1908	18.00	C.N.R.	
Calgary-Cochrane-Canmore-Banff-Lake Louise-St. Stephen-Field	1883	136.61	C.P.R.	

TABLE A.1 (CONTINUED)

Origin and Destination of Rail Lines	Year of Operation	Mileage	Present Ownership of Rail Lines	Construction Charter Originally Granted To:
Brocket-Pecten	1927	21.36	C.P.R.	
Cardston-Glenwood	1927	27.68	C.P.R.	
Ryley-Woolford	1912	7.83	C.P.R.	
Woolford-Whisky Gap	1929	13.16	C.P.R.	
Kipp-Turin	1925	26.98	C.P.R.	
Eltham-Arrowood	1930	23.33	C.P.R.	
Arrowood-Lomond	1925	39.82	C.P.R.	
Cassils-Kitsim-Rainer-Scandia	1914	25.00	C.P.R.	
Standard-Bassano	1913	35.61	C.P.R.	
Collicutt-Cremona	1931	27.79	C.P.R.	
Acme-Sunny Slope-Torrington-Wimborne	1930	31.91	C.P.R.	
Acme-Kirkpatrick	1921	35.24	C.P.R.	
Kirkpatrick-Kneehill	1923	3.60	C.P.R.	

TABLE A.1 (CONTINUED)

Origin and Destination of Rail Lines	Year of Operation	Mileage	Present Ownership of Rail Lines	Construction Charter Originally Granted To:
Kneehill-East Coulee	1929	15.66	C.P.R.	
Rosemary-Mallow-Gem	1929	16.74	C.P.R.	
Rosemary-Control-Finnegan	1929	30.47	C.P.R.	
Bonar-Sheerness-Wardlow	1919	50.00	C.N.R.	
Hanna-Scepa-Hackett-Warden	1925	62.18	C.N.R.	
Scapa-Garden Plain-Spondin	1930	15.00	C.N.R.	
Hemaruka-Sedalia-Calthorpe	1925	50.3	C.N.R.	
Halkirk-Cordel	1911	13.60	C.P.R.	
Lacombe-Jackson-Breton	1921	69.82	C.P.R.	
Breton-Thorsby	1929	21.40	C.P.R.	
Thorsby-Leduc	1931	21.27	C.P.R.	
Willingdon-Gainer	1929	105.37	C.P.R.	
Clandonald-Willingdon	1928	52.91	C.P.R.	

TABLE A.1 (CONTINUED)

Origin and Destination of Rail Lines	Year of Operation	Mileage	Present Ownership of Rail Lines	Construction Charter Originally Granted To:
Lloydminster-Clandonald	1927	15.33	C.P.R.	
Vegreville-Willingdon	1930	24.60	C.P.R.	
Edmonton-Cannell-St. Albert	1906		C.N.R.	
Cannell-Stony Plain-Evansburg-Chip Lake	1909		C.N.R.	
Edmonton-Stony Plain	1907		C.N.R.	
Chip Lake-Edson-Hinton-Entrance	1910		C.N.R.	
Entrance-Miette-Decongne	1911		C.N.R.	
St. Albert-Off Onoway	1911		C.N.R.	
Off Onoway-Sangudo	1913		C.N.R.	
Sanguado-Off Sangudo	1915		C.N.R.	
Off Onoway-Leaman-Off Carrot Creek	1912		C.N.R.	

TABLE A.1 (CONTINUED)

Origin and Destination of Rail Lines	Year of Operation	Mileage	Present Ownership of Rail Lines	Construction Charter Originally Granted To:
Off Carrot Creek-Bickerdike	1913		C.N.R.	
Bikerdike-Robb	1911		C.N.R.	
Robb-Foothills	1912		C.N.R.	
Robb-Shaw-Mountain Park	1912		C.N.R.	
Bikerdike-Hinton-Jasper-Geikie	1913		C.N.R.	
Edmonton-Fort Saskatchewan-Bruderheim-Vermilion-Lloydminster	1905	126.5	C.N.R.	

SOURCES: Information supplied by the Corporate Archives, Canadian Pacific, Montreal, through the Public Relations and Advertising Department, Canadian Pacific, Calgary; Information supplied by the Canadian National Railway, Edmonton; and D.H. Brown, "Annual Increments of Railway Track, 1883-1915 - Province of Alberta" (Unpublished Map, University of Alberta Map Collection, Edmonton, 1975).

TABLE A.2

MILEAGE INCREMENTS OF RAILWAY TRACKS IN SOUTHERN ALBERTA

Origin and Destination of Rail Lines	Year of Operation	Mileage
Stirling-Foremost-Gessday	1914	84.49
Stirling-Coutts	1912	47.05
Stirling-Lethbridge	1890	23.84
Stirling-Cardston	1912	46.44
Cardston-Glenwood	1927	27.68
Raley-Woolford	1912	7.83
Woolford-Whisky Gap	1929	13.16
Lethbridge-Fort MacLeod-Peigan	1909	41.47
Peigan-Pincher-Crownest	1898	59.65
Brocket-Pecten	1927	21.36
Coalhurst-Turin	1925	26.98
Lethbridge-Taber-Bow Island-Dunmore	1885	106.72
Dunmore-Walsh	1883	25.00
Dunmore-Medicine Hat-Suffield-Brooks-Cassils-Bassano-Gleichen-Calgary	1883	175.82
Suffield-Vauxhall-Lomond	1914	83.98
Lomond-Queenstown-Arrowood	1925	39.82

TABLE A.2 (CONTINUED)

Origin and Destination of Rail Lines	Year of Operation	Mileage
Arrowood-Eltham	1930	23.33
Aldersyde-Eltham-Vulcan-Carmangay	1911	57.58
Carmangay-Kipp	1909	29.65
Kipp-Coalhurst	1926	5.00
Fort MacLeod-Durward	1892	46.35
Durward-Aldersyde-Calgary	1891	60.92
Standard-Bassano	1912	35.61
Bassano-Rosemary-Patricia-Empress	1914	101.16
Shepard-Langdon-Strathmore-Gleichen	1883	45.82
Bassano-Hussan	1912	20.78
Cassils-Kitsim-Rainer-Scandia	1914	25.00
Rosemary-Control-Finnegan	1929	30.47
Rosemary-Matziwin-Gem	1929	11.83

SOURCES: Information supplied by the Corporate Archives, Canadian Pacific, Montreal, through the Public Relations and Advertising Department, Canadian Pacific, Calgary; Information supplied by the Canadian National Railway, Edmonton; and D.H. Brown, "Annual Increments of Railway Track, 1883-1915 - Province of Alberta" (Unpublished Map, University of Alberta Map Collection, Edmonton, 1975).

APPENDIX B

RESULTS OF THE LAG MODEL

Analysis of the lag model based on the assumption that there was delayed response in settlement revealed in all equations that both railway track mileage (X_2) and irrigated acreage (X_1) explained variation in settlement, the greatest proportion of the variation being explained by railway track mileage. The coefficient of determination varied from 96.35 percent to 91.01 percent for the four variable cases. The percentage was highest in the two year lag and least in the six year lag. The level of confidence for the regression coefficients was 99 percent for both X_1 (irrigated acreage) and X_2 (railway track mileage) in the two year lag and three year lag cases. In the four, five, and six year lag cases, X_1 (irrigated acreage) was significant at the 95 percent level of confidence while X_2 (railway track mileage) was significant at the 99 percent level of confidence. Results are tabulated in Table B.1.

It is difficult to explain why railway track mileage should supercede irrigated acreage in explaining a higher proportion of the variation in settlement in the lag model. However, the diminishing levels of the other statistical criteria -- the F-ratio, the t-value, and the Durbin-Watson statistic -- and the increase in the values of the standard error of the regression coefficients make the lag model suspect.

The test related to the Durbin-Watson statistic showed that calculated d was smaller than the d-statistic in the four, five and six year lag model. It is a confirmation

that the U_i series are not random. This result violates the assumption that the random elements in successive observations are independent of one another. Some conditions under which this assumption is violated are when the model is incorrectly specified or when the variables which exert systematic influence on the dependent variable are omitted for convenience due to lack of data or because of inadequate knowledge of the structure.[1]

Fox points out that sample surveys and controlled experiments are designed to overcome the problem of autocorrelation but in a time series analysis like this study, the variables are uncontrollable.[2] He further explains that with economic time series, the original observations frequently show strong trends and cycles, so that successive observations exhibit high positive correlation. In another observation, Kmenta confirms that the assumption of non-autoregression is more often violated in relations dealing with time series data than in cases of cross-sectional data estimations.[3] In such situations he observes that the disturbances are a summary of a large number of random independent factors which enter into the relationship under study,

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[1] M. Dutta, Econometric Methods (Cincinnati: Southwester Publishing Co., 1975), p. 108.

[2] Karl A. Fox, Intermediate Economic Statistics (New York: John Wiley & Sons, Inc., 1968), p. 190.

[3] J. Kmenta, op. cit., p. 269.

but which are not measurable.

The assumption of mutual independence of error terms is the criterion which ensures the efficiency of the estimation. It helps to show that the least squares estimator is "best" in the sense that it has the least variance of the class of linear unbiased estimators. But the presence of autocorrelation makes the ordinary least squares estimators less efficient. Because the variance of the estimator is affected, the estimate of the confidence interval also becomes less reliable. However, autocorrelation does not affect the property of unbiasedness, neither does it affect the property of consistency.

TABLE B.1

MULTIPLE REGRESSION RESULTS WITH LAGGED VARIABLE OF TWO YEARS TO SIX YEARS

Variable	β-Coefficient	St. Error	t-Value	Variation
$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t+2} + U_i$				
X_1	0.03655***	0.00522	7.0	6.76
X_2	35.74475***	3.58496	9.97	89.51
X_0	= 69,189.917	R^2		= 96.27
F-Value =	348.7***	D.W. Statistic =		1.384
$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t+2} + \beta_3 X_{3t} + \beta_4 X_{4t} + U_i$				
X_1	0.03579***	0.00636	5.62	6.76
X_2	35.845***	3.72302	9.63	89.51
X_3	-1420.1071	2112.38879	-0.67	0.07
X_4	-348.7999	895.41520	-0.18	0
X_0	= 70,577.4054	R^2		= 96.35
F-Value	164.84***	D.W. Statistic =		1.368

TABLE B.1 (CONTINUED)

Variable	β-Coefficient	St. Error	t-Value	Variation
$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t+3} + U_i$				
X_1	0.03235***	0.00679	4.76	4.33
X_2	33.8612***	4.22119	8.02	90.51
X_0	= 73,061.82722	R^2		= 94.84
F-Value =	248.23***	D.W. Statistic =		1.306
$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t+3} + \beta_3 X_{3t} + \beta_4 X_{4t} + U_i$				
X_1	0.03009***	0.00827	3.64	4.33
X_2	34.2608***	4.41121	7.77	90.51
X_3	-1401.62233	2481.01839	-0.56	0.12
X_4	257.62725	2238.86055	0.12	0
X_0	= 74,286.05095	R^2		= 94.96
F-Value =	117.78***	D.W. Statistic =		1.266

TABLE B.1 (CONTINUED)

Variable	β-Coefficient	St. Error	t-Value	Variation
$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t+4} + \beta_3 X_{3t} + \beta_4 X_{4t} + U_i$				
X_1	0.0239**	0.01028	2.33	2.45
X_2	34.17863***	5.16531	6.62	91.13
X_3	-1381.71876	2763.2776	-0.5	0.15
X_4	615.70326	2506.3904	0.25	0.20
X_0 = 76,422.91538		R^2		= 93.75
F-Value = 93.73***		D.W. Statistic = 0.943		
$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t+5} + \beta_3 X_{3t} + \beta_4 X_{4t} + U_i$				
X_1	0.02422**	0.0151	2.1	2.0
X_2	32.31754***	5.56829	5.8	90.57
X_3	-1382.5845	2991.6325	0.46	0.1
X_4	64.41034	2701.63632	0.02	0
X_0 = 79,336.35709		R^2		= 92.67
F-Value = 79.05***		D.W. Statistic = 0.7		

TABLE B.1 (CONTINUED)

Variable	β-Coefficient	St. Error	t-Value	Variation
$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t+6} + \beta_3 X_{3t} + \beta_4 X_{4t} + U_i$				
X_1	0.02928**	0.01274	2.3	2.3
X_2	28.72138***	6.0136	4.78	88.57
X_3	-1169.2146	3315.2745	-0.35	0.03
X_4	-599.4024	2979.6145	-0.20	0.01
X_0	= 82,798.90513	R^2		= 91.01
F-Value =	63.25***	D.W. Statistic =		0.611

For all equations in the Appendix:

Y = Population.

X_1 = Irrigation.

X_2 = Railway track mileage (lagged).

X_3 = Canadian Pacific Railway policies.

X_4 = Prairie Farm Rehabilitation Act.

APPENDIX C

DATA FOR THE ANALYSIS

TABLE C.1

FACTORS INFLUENCING SETTLEMENT IN SOUTHERN ALBERTA

Year	Population (Nos.)	Irrigated Acreage (Acres)	Railway Track Mileage in Southern Alberta (Miles)
1905	--	--	544
1906	--	--	544
1907	--	--	544
1908	--	--	544
1909	--	--	615
1910	--	--	615
1911	91,222	500	673
1912	93,069	500	831
1913	94,916	2,600	831
1914	98,609	16,251	1,125
1915	102,303	8,318	1,125
1916	105,996	2,356	1,125
1917	107,521	13,262	1,125
1918	109,046	119,631	1,125
1919	112,095	147,818	1,125
1920	115,144	125,728	1,125
19[illegible]	118,193	210,819	1,125
19[illegible]	117,625	231,801	1,125
192[illegible]	117,058	121,971	1,125
1924	115,922	254,906	1,125
1925	114,787	257,432	1,192
1926	113,651	267,780	1,197
1927	115,716	66,266	1,246
1928	117,781	136,816	1,246
1929	121,910	130,817	1,301
1930	126,039	335,508	1,325
1931	130,168	351,282	1,325
1932	130,176	279,120	1,325
1933	130,183	338,509	1,325
1934	130,197	326,845	1,325
1935	130,211	382,659	1,325
1936	130,225	378,342	1,325
1937	130,579	415,416	1,325
1938	130,934	402,455	1,325
1939	131,642	368,923	1,325
19[illegible]	132,351	395,307	1,325

SOURCES: Turn overleaf for list of sources to Appendix C.

Sources to Appendix C

Variable Y_t (Population)

Dominion Bureau of Statistics, Census of Canada: Population - Urban and Rural Distributions, Cat. No. 92-709 (Ottawa: Queen's Printer, 1921-1941).

Variable X_1 (Irrigated Acreage)

Dominion Bureau of Statistics, The Canada Yearbook (Ottawa: Government Printer, 1925-1945).

Irrigation Districts, Annual Reports (Various Issues for all irrigation districts in Alberta).

Variable X_2 (Railway Track Mileage)

Alberta Bureau of Statistics, Department of Industries and Labour, Alberta Facts and Figures (Edmonton: Queen's Printer, 1954).

Alberta Department of Railways, Annual Report 1925, Sessional Paper No. 49 (Edmonton: King's Printer, 1926).

Canada Department of the Interior, Annual Report 1915-1916, Sessional Paper No. 25 (Ottawa: King's Printer, 1917).

APPENDIX D

POSSIBLE APPLICATION OF THE STUDY

A wider implication of the results of this study is the possibility of application of this experience as a strategy for agricultural development elsewhere. The writer is of course aware that in most cases, agricultural technology or information is location specific in character. Hayami and Ruttan have indicated that ecologically adapted and economically viable agricultural research and development are critical elements in the international transfer of agricultural technolgoy.[1] However, where similarities exist in physical structure in terms of environmental characteristics like lack of transportation, uncontrolled grazing, undeveloped water and land resources, and large expanse of unoccupied land, the findings of this study could be used for planning agricultural development.

The pattern of settlement in most of the Sahelian countries recently plagued by drought -- Chad, Mali, Mauritania, Niger, Senegal and Upper Volta -- has resulted in large areas being unsettled. These countries cover an area of 2,044,000 square miles with a combined population of 24.66 million.[2] Their total Gross National Product for 1972 was $2,921 million. In these countries, large expanses of land are used by nomadic herdsmen whose entire lives are

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[1] Y. Hayami and V.W. Ruttan, op. cit., p. 170.

[2] Jerry E. Rosenthal, "Survival in the Shael: One Year Later," War on Hunger, Vol. VIII, No. 8 (Washington: United States Agency for International Development, August, 1974), p. 36.

spent herding livestock.

The incidence of drought in the Sahelian zone during the late 1960's and early 1970's caused human and livestock deaths and starvation. The greatest impact of the drought was on livestock. Estimated losses of cattle, goats, sheep, camels, donkeys and horses in the six Sahelian countries ranged from a high of 80 percent in Mali to 33 percent in Chad and Niger.[1] Most of the Sahelian countries normally export livestock. As a result, the impact of the drought was also felt by livestock importing countries like Ghana and The Republic of Togo.

The dry Sahelian weather is associated with widespread deterioration of range as a result of uncontrolled grazing culminating in over-stocking. The lowering of the water table has also added to the dry conditions.

There are other countries in West Africa with large pockets of unoccupied land. Ghana is one such country.[2] Lack of water is among the common reasons for non-settlement of these areas. However, Ghana has rivers of moderate irrigation potential. The most important river passing through the uninhabited area is the River Volta. Some rivers with irrigation potential can be found in the Sahe-

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[1] Ibid., p. 4.

[2] The writer comes from Ghana. He is aware of the Damango Settlement Scheme which unsuccessfully tried to settle one such unoccupied area.

lian zone -- Niger River in Niger and Mali, Senegal River in Senegal and Lac due Guiers in Northern Senegal, River Chari and Lake Chad in Chad. These rivers unfortunately irrigate relatively little land; their waters are for the most part wasted.

Incidence of diseases such as onchocerciasis (river blindness) and tripanosomiasis (sleeping sickness) are other reasons why certain areas are uninhabited.

In order to promote agricultural development in the Sahelian zone and other countries where large pockets of land are unoccupied it is necessary to protect the natural resources of land and water as they are crucial to long-term agricultural development. There is no doubt that water for irrigation is the most important limiting factor in the agricultural development of such areas. Government policies should be directed towards developing the water resource potential of these areas, with initial attention directed towards irrigation.

Several factors or modifications of factors can be drawn from this study for use in policy formulation regarding settlement of these unoccupied areas. A variable that was not a decision variable in this study but that is important for these tropical countries is a programme to eradicate the tsetse fly and black fly in order to control sleeping sickness and river blindness. Such a programme will result in a healthy community of able bodied persons ready to accept the challenge of pioneer settlement and thus provide the basis for agricultural development.