A RECONNAISSANCE STUDY OF THE POTENTIAL FOR LARGE SCALE IRRIGATION OF THE CANADIAN PRAIRIES

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By

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SYNOPSIS

The results of a reconnaissance study into the feasibility and possible extent of large scale development of the irrigation potential of the Canadian Prairies are presented. The study examined the potentially irrigable areas, the expected benefits and costs of the on-farm irrigation development, the costs of the conveyance systems required to develop the proposed projects, and analyzed the overall economic worth of developing the irrigation potential of the prairies. A water balance model of the prairie river network developed to examine the flow allocations required for large scale irrigation of the prairies is also presented.

The study identified approximately 4,000,000 hectares of land as potentially irrigable, and examined 41 different irrigation projects. Based on the results of the economic analysis and the flow allocations determined from the water balance model, approximately 2,965,000 hectares could be irrigated for a total cost of $8.2 billion and would produce direct net on-farm benefits having a present worth of approximately $5.6 billion, for a benefit-cost ratio of 0.68. If indirect benefits are included, the total benefits could approach $14 billion. The overall irrigation system comprises 18 discrete projects which have direct benefit-cost ratios ranging from 1.16 to 0.30 at a real effective interest rate of 4.0 percent. The remaining projects were found to have rate of returns of less than 1.0 percent for their direct and indirect benefits under present conditions, and thus were deemed economically infeasible.

All of the projects deemed economically feasible by this study were supplied with water from the Saskatchewan-Nelson river basin. Should future conditions require additional irrigation development then inter-basin diversions of water from the Smokey, the Peace, or the Churchill rivers may be required to supply these additional developments.

Based on the analysis of the various projects examined, the study concluded that the irrigation potential of the prairies warrants further, more detailed examination than was possible in a study of this nature. In comparison with the potential benefits, the expected cost of such a study would be insignificant.

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CHAPTER 1 INTRODUCTION TO THE STUDY

1.1 BACKGROUND TO THE PROBLEM

There are several factors which presently justify an examination of the large scale irrigation potential of the Canadian prairies. These factors include the recent estimates [1,2] of growing global food demand, the recurring droughts which so seriously affect the agricultural production of the prairies, the ever increasing losses of productive prairie farmland to salinization and both water and wind erosion, and the current debate over possible long term global climatic changes and their possible effects in Western Canada. A recent seminar by the Science Council of Canada concluded that "a return to more variable conditions, characteristic of much of North American climate in earlier decades and centuries, would undoubtedly produce far greater year to year fluctuations in our agricultural outputs than those to which we have become accustomed (and have taken for granted in our national and international planning)" [3].

Based on recent Agriculture Canada and Canadian Wheat Board forecasts [1,2], the prairies must increase its agricultural production by 50 percent above its 1978 level to meet the long term forecast grain export demands of 36 million tonnes. These forecasts may be extremely optimistic given the current grain export environment, which has depressed the price of wheat and cereals to their lowest levels in many years. It must be emphasized that while artificial market influences such as the export subsidies currently being offered by the United States of America and the European Economic Community can drastically affect the price and available market for Canada's agricultural production, it is impossible to forecast the long term extent and scope of these market forces [4].

Should these export forecasts prove accurate in the long term, then continued production increases can only come from increasing intensification of the prairie farm practices in conjunction with snow management and/or irrigation, since virtually all of the agriculturally suitable arable land is already in production [5].

1.2 PURPOSE OF THE STUDY

This study attempts to investigate the present and future feasibility and extent of large scale irrigation development on the Canadian prairies. The study examined the economic feasibility of irrigation development under various scenarios, as well as the physical limits of irrigation development given the natural resource limits of the prairies. In addition to the inherent physical constraints of the prairies, the study also briefly examined the external constraints of the political and environmental aspects of water resource development on the prairies. The intent was not to catalogue each and every impact the irrigation water allocation systems would have on the prairies, but merely to determine to what extent the system was shaped and restricted by these constraints.

The specific intent of the study was to :

- assess and identify areas which appear suitable for irrigation

- determine the change in net farm income based on the present and potential input costs, market prices, and production for both dryland and irrigated farming

- identify potential irrigated crops and their expected yields under current and potential conditions

- determine the amount of water required by each proposed area based on expected water deficits and the water requirements of the crops selected

- determine the water available for irrigation and the works required to convey the water from the source to the farmer

- briefly discuss the political and environmental constraints on the water resources of the prairies, and the impact of the proposed water allocation systems.

- estimate the on-farm supply, drainage, and distribution costs, as well as the reservoir, canal, and diversion costs of the water supply system required.

- based on the direct and indirect benefits and costs of the various components of the irrigation system, determine the rate of return, the benefit-cost ratio, and the total net benefits for the different projects.

When reviewing the results and conclusions of this study, it should be realized that to facilitate the analysis many simplifying assumptions were made. This work is not intended to be the definitive study upon the subject, but merely attempts to determine if further, more comprehensive studies of the areas identified as irrigable are warranted. As will be discussed in Chapters 2 through 6, there are many areas of this study that warrant examination in considerably more detail than was permitted by the nature of this study.

1.3 STUDY AREA and TOPOGRAPHY

The area examined in this study (see Figure 1 on page 5) is almost entirely contained within the Saskatchewan-Nelson river drainage basin, and contains approximately 750,000 square kilometres of land. The boundaries of the study area were the United States-Canadian border on the south, the Manitoba-Ontario border on the east, the Rocky Mountain foothills on the west, and the northern limit of prairie agriculture which presently occurs at approximately 55 degrees Latitude North. The enclosed area roughly corresponds to the present areas of agriculture production on the prairies. In general the topography of the study area consists of relatively flat rolling plains which slope in a east to north-easterly direction. The elevations range from a high of 1160 m in southern Alberta down to a low of 240 m in Manitoba. The flat and rolling plains characteristic of the prairies are a result of the numerous glaciations the region has experienced, the last of which occurred about 15,000 years ago. The thick layers of lacustrine soils now found on the prairies were formed through sedimentation in the large lakes produced by the meltwater of the final glaciation period. As this glaciation receded numerous meltwater channels were created which today provide good potential sites for water storage reservoirs on the prairies.

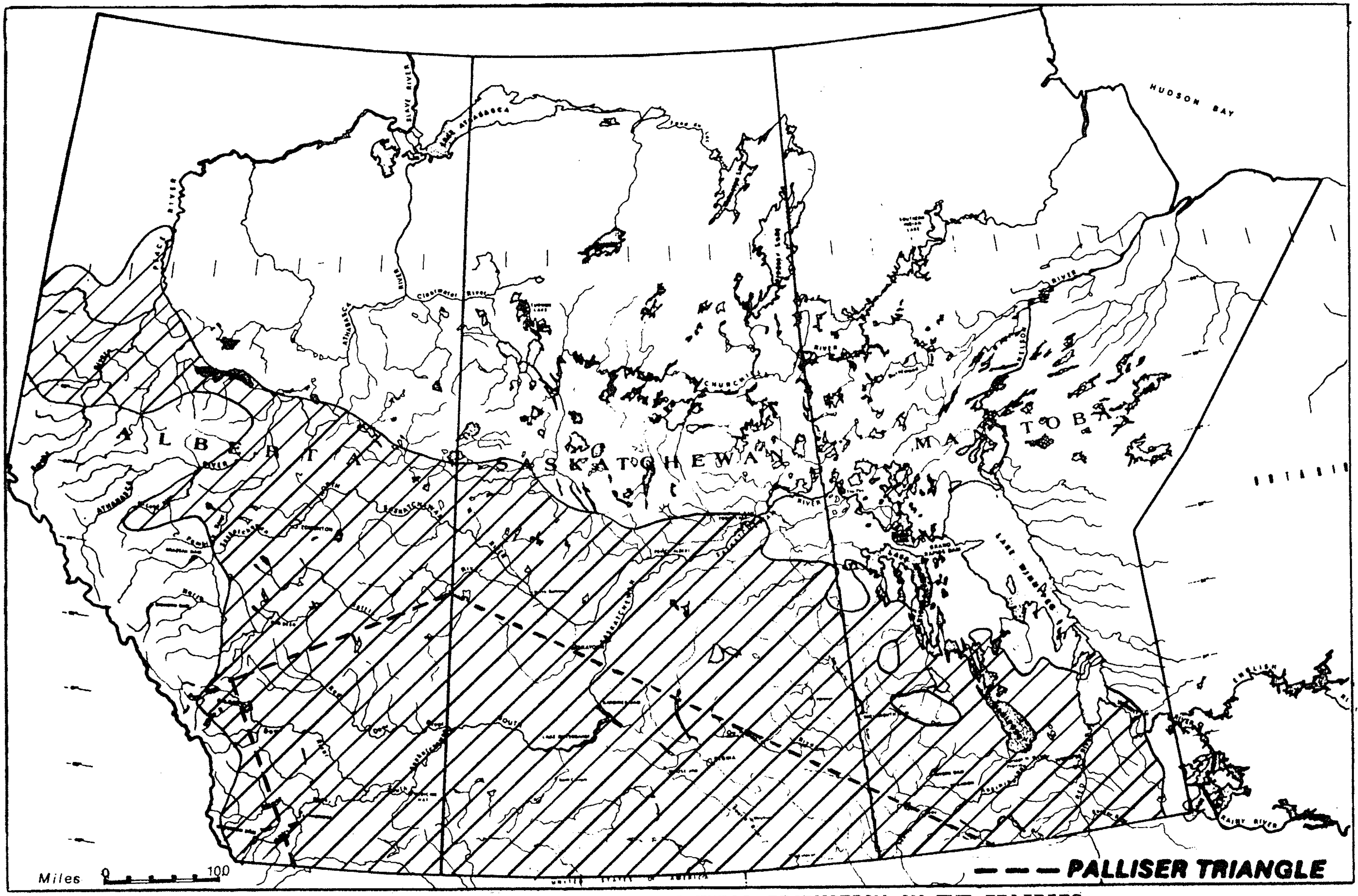

Figure 1 PRESENT AREAS OF AGRICULTURAL PRODUCTION ON THE PRAIRIES

There are three general topographical levels on the prairies, with the lowest of these being the flat featureless plains of Manitoba, which are the remains of the bottom of the former glacier-fed Lake Agassiz. This area is bounded on the west by the Duck, the Porcupine, and the Riding Mountains which comprise the Manitoba Escarpment, and are located on the western boundary of the province. The second topographic level of the prairies lies westward of the Manitoba Escarpment and consists of the gentle rolling prairies of Saskatchewan. The last of the three topographic levels lies west of the Missouri Cotteau Escarpment which cuts across central Saskatchewan in a generally north-westerly direction. This third level has quite irregular relief due to the erosion of its original glacier-planed flat surface, and contains many closed drainage basins.

1.4 CLIMATE and HYDROLOGIC CONDITIONS ON THE PRAIRIES

There is a considerable range in precipitation across the prairies, with the southern region of Alberta receiving an average of just 280 mm per year, while eastern Manitoba receives 560 mm per year, and the Rocky Mountain Foothills receive an average of 640 mm per year [6]. The average net evaporation on the prairies ranges from 130 to 640 mm [7]. Based on its average annual precipitation and evaporation values, the overall prairie climate is classified as semi-arid. If it were not for the "cold lows" rain storms which generally occur in the spring and fall seasons the prairies would resemble a barren desert much like the Chinese Gobi or the African Sahara. The importance of these storms to prairie agriculture was amply demonstrated during the "dirty thirties" drought when above average spring temperatures prevented these storms from occurring. The lack of these storms also greatly contributed to the recent droughts of 1977, 1981, 1984, and 1985. The delicate hydrologic balance between precipitation and evaporation frequently creates critical moisture deficits in the soils throughout the prairies. These droughts tend to be cyclical in occurrence, and droughts lasting 5 to 10 years have been observed.

The majority of the flow in the Saskatchewan-Nelson River basin is derived from the 1780 mm of precipitation which the eastern slopes of the Rocky Mountains receive on average each year. Because of the many closed basins on the prairies and the rate of evaporation, it has been estimated that all of the prairie lands contribute only 8 percent of the total annual runoff of the Saskatchewan-Nelson basin [6], although they constitute approximately 90 percent of the total drainage area of the basin.

1.5 SOILS of the PRAIRIES

The soils of the prairies can be classified into four broad soils groups consisting of the Brown, Dark Brown, Black, and Grey soil zones, the names of which arise from the dominant color of the topsoil. Like all soils, their properties are influenced by the parent materials from which their components were eroded, the method of deposition, the vegetation they've supported, the weathering they have undergone, their drainage, and the topography. The colors of the four soil zones correspond to the different types of vegetative cover and the climate which the soils developed in (see Figure 2 on page 8). The Brown soils correspond to dry grasslands, the Dark Brown soils were grasslands moister than the Browns, the Black soils were grass and treed parklands,

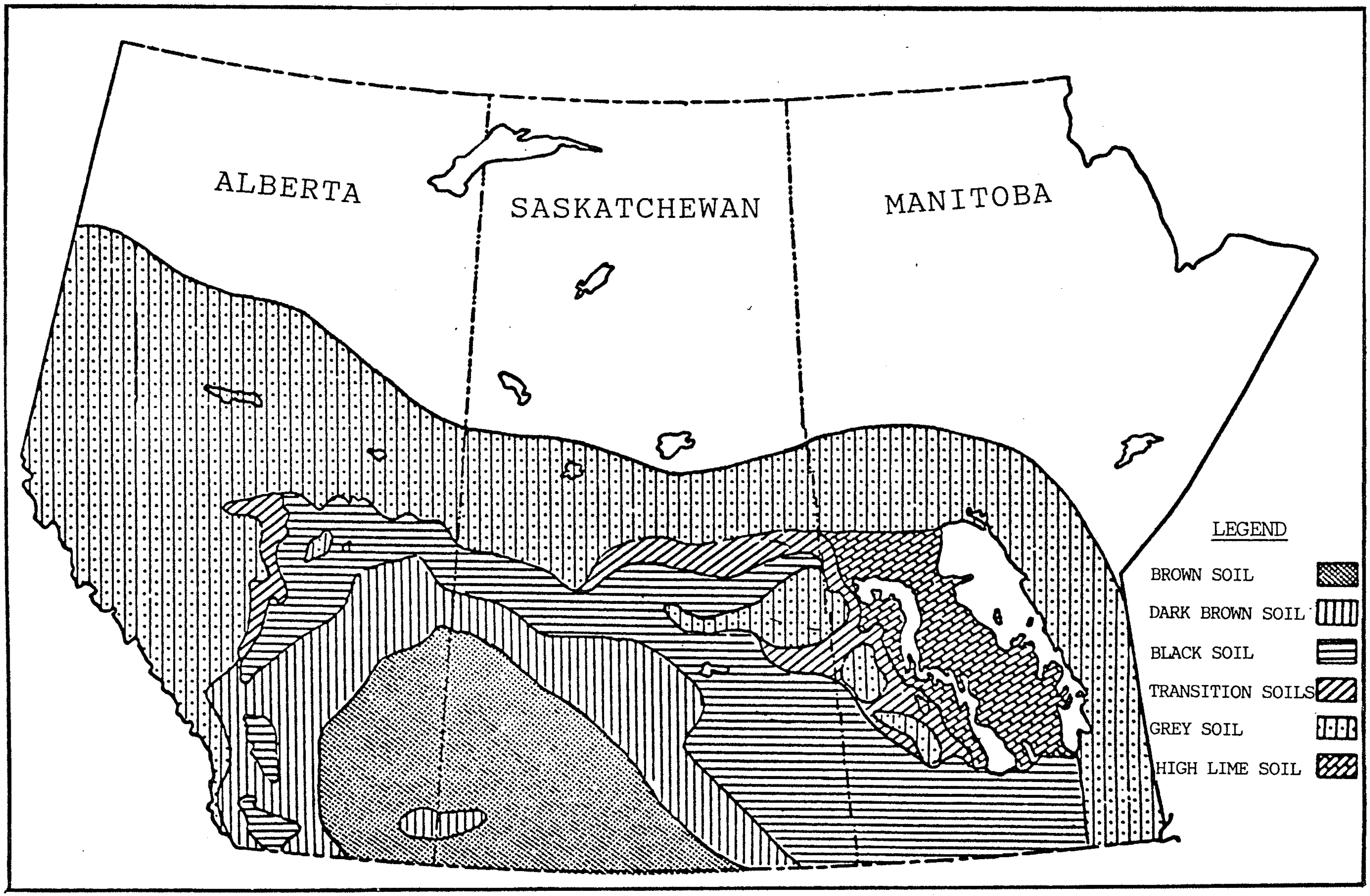

Figure 2 MAJOR SOIL ZONES ON THE PRAIRIES

and the Grey soils were boreal forest. This development pattern produced soils in which moisture, nitrogen content, and organic matter increase as one proceeds from a Brown to Dark Brown to Black or Grey soils. The crop production on most of the soils of the prairies is currently limited by the soil moisture available to the crop, but under irrigation the limiting factors would be the plant nutrients and minerals provided by the soil.

1.6 HISTORY of IRRIGATION of the PRAIRIES

The practice of providing supplemental water to croplands has been well documented throughout the written history of mankind [8]. The countries of Babylon, Egypt, Syria, Persia, India, China, Italy, and Peru have records and evidence of irrigation developments dating back as far as 2200 B.C. As an example of the quality of these early works, the famous Tu Kiang Dam in China presently irrigates 200,000 hectares of rice, yet was built by a man named Li and his son in 200 B.C. In comparison to these irrigation developments, the irrigation of the Canadian prairies is very young, with the first small developments occurring around 1880.

The development of dryland and irrigated agriculture on the Canadian prairies was greatly influenced by both political and economic motives. The Dominion of Canada obtained the Hudson's Bay Company's entitlement to Rupert's Land, as Manitoba, Saskatchewan, and Aberta were then known, in 1870. To promote rapid settlement and establish a sense of national identity in these newly acquired regions, the government encouraged construction of railroads by granting large blocks of land in the region to the railway companies. In 1880, the Canadian Pacific Railway consortium agreed to link Montreal to the Pacific coast with a railway for a payment of $25 million in cash and 10.1 million hectares of land "fairly fit for settlement"[6].

Following the completion of the railroad in 1885, the prairie settlement boom began. In the early 1890's a prolonged drought threatened to drive these early settlers off their homesteads. This confirmed an earlier assessment of the region by Captain John Palliser, a British explorer who in 1857 identified a large portion of the southern Canadian prairies as being too dry to support agriculture. This area is now known as the "Palliser Triangle" (see Figure 1 on page 5) and closely corresponds to the lands which would be nearly devastated in the drought of the 1930's.

In response to the 1890's drought, in 1894 the Canadian government passed the Northwest Irrigation Act in which all riparian rights to streams were revoked and the water was declared the property of the crown. The right to use the water for perpetuity could then be granted to users from the crown, providing the user did not abandon nor waste the water rights. To assess the availability of water on the prairies, the act also created the Irrigation Branch to inventory all usable water supplies in the west, and to identify all lands in the Dominion territories which would benefit from irrigation.

The first diversions and distribution of irrigation water on a significant scale were undertaken by private entrepreneurs and railway companies attempting to increase the value of their land holdings while also increasing the economic output and freight activity of the regions. In most cases these developments were quickly found to be money losing ventures, and the provincial governments were forced to legislate the