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THE UNIVERSITY OF ALBERTA

AN ANALYSIS OF SOME FACTORS AFFECTING THE AREAL VARIABILITY OF FARM SIZE IN ALBERTA

by

© AUSTIN A. LUPTON

A THESIS

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FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled An Analysis of Some Factors Affecting the Areal Variability of Farm Size in Alberta. submitted by Austin A. Lupton in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

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FOREWORD

During the course of constructing maps for the Agricultural Section of the Atlas of Alberta the author gained an insight into the areal patterns of agricultural activity in the Province of Alberta. Spatial relationships at a particular reference point in the evolving history of agriculture also became evident as the Agricultural Section progressed. Consequently the theme of the author's thesis research shifted gradually from a regional treatment of agriculture to a systematic but exploratory approach to the relationship of farm size and certain other variables that seemed to be logically related in terms of the existing theory in Economic Geography. Many of the observations expressed in this thesis concerning agricultural patterns as they existed in 1961 are based then on this experience with the Atlas of Alberta. It is suggested therefore that the reader will gain a fuller understanding of this thesis if he consults the aforementioned work.

FOREWORD

During the course of constructing maps for the Agricultural Section of the <u>Atlas of Alberta</u> the author gained an insight into the areal patterns of agricultural activity in the Province of Alberta. Spatial relationships at a particular reference point in the evolving history of agriculture also became evident as the Agricultural Section progressed. Consequently the theme of the author's thesis research shifted gradually from a regional treatment of agriculture to a systematic but exploratory approach to the relationship of farm size and certain other variables that seemed to be logically related in terms of the existing theory in Economic Geography. Many of the observations expressed in this thesis concerning agricultural patterns as they existed in 1961 are based then on this experience with the <u>Atlas of Alberta</u>. It is suggested therefore that the reader will gain a fuller understanding of this thesis if he consults the aforementioned work.

ABSTRACT

The thesis problem was expressed in the following form. Average farm size in each municipality in Alberta in 1961 is a function of variation in environmental quality, farm types, size of farm business and indirectly the influence of major cities. The results of simple and multiple correlation tests and a multiple step-wise regression analysis suggest that the quality of the physical site, within the economic and cultural parameters in existence in Alberta at this date, is probably one of the most important factors affecting the areal variability of farm size. Farm type appears to be poorly related to farm size because the farm type classification used in this study includes within a single category many commodities which may be grown under different levels of intensity. It was suggested therefore that a classification be established which stressed the intensity of farming. The utility of one classification technique, utilizing livestock farming as an example was demonstrated in a further analysis of average farm size and type.

The data for the various tests undertaken were obtained from the Dominion Bureau of Statistics. For the most part these data were abstractions from areal units, such as census divisions and the smaller municipalities. Special frequency distribution tabulations obtained directly from Ottawa were also used however to substantiate the observations based on the averages developed for each census unit. These data posed interesting problems when used as input for inductive parametric and non-parametric statistical tests.

The problem undertaken was largely an exploratory one. Consequently those areas of research that yielded few positive results other than the observation that answers were difficult to ascertain using a specified methodology and the census data supply were also included as valid findings.

ACKNOWLEDGEMENTS

The writer realizes that in many ways research represents one focal point in human relationships. Even though he may claim authorship for the ideas expressed here he at the same time recognizes that his right to this claim lies only in the fact that he has undertaken their formal expression and consequently the ultimate responsibility for defending them. In reality however his ability to explore a given subject area or theme and to present it in its final written form depended in large measure upon the knowledge, patience and good will of the larger academic and non-academic community. It is difficult therefore to single out individuals and to say, that person made this research possible. Instead one must in retrospect recollect that over the years men such as R.E. English, of the Farm Economics Branch, Alberta Department of Agriculture, Doctors Love and Manning of the Department of Agricultural Economics, R. Ellis of the Dominion Bureau of Statistics, A. Buse of the Department of Economics, Doctor K. Smillie of the Department of Computing Science and Doctors Laycock and Sitwell of the Department of Geography, freely offered facts, systems of analysis and a particular viewpoint of reality. It was out of this amalgam of ideas that the author synthesized his own thesis concerning the relationship of certain aspects of the agricultural sector of human activity.

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INTRODUCTION

Although there is considerable current literature[1] on the effect of farm size on income and production costs, the geography of, or, stated another way, the areal variation in farm size has received very little attention, particularly on the Canadian Prairies. A notable exception to this general statement is David Grigg's preliminary survey on a world scale of the geography of farm size.[2] In this work Grigg gave some indication of both the world pattern of average size of land holding and the factors affecting the variation in the areal dimensions of these holdings. He did not, however, systematically examine the effect of these variables on the areal size of farms for any particular geographic region but rather cited the findings of others in an attempt to demonstrate the range of possible responses to specific types of variables. It is clear from his analysis that the underlying causes of variation in farm size are exceedingly complex and that even after some of the relevant variables influencing farm size have been isolated, their full significance cannot be appreciated without some reference to historical antecedents. In his own words " ... whilst an examination of the present pattern of farm sizes will suggest some possible explanations, further study immediately indicates the need for an historical investigation. Many of the causes of present farm sizes lie in the past".[3] Consequently, although factors which seem to affect

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[1] See for example: <u>World Agricultural Economics and Rural Sociology Abstracts</u>, Amsterdam, 1959- to date.

[2] D. Grigg, "The Geography of Farm Size: A Preliminary Survey", <u>Econ. Geogr.</u>, Vol. 42, No. 3 July, 1966, pp. 205-235.

[3] <u>Ibid.</u>, p. 288.

present day patterns of farm size in Alberta will be emphasized in this study there will be some reference to historical trends in the regional growth of farm holdings and to the underlying causes for any differences in growth rates.

Objectives of the Study

This study was undertaken with the objective of isolating some of the more important factors affecting the variation in farm size from place to place in Alberta. It should not be understood from this statement that the size of the farm business was examined. It was not, except as one of the independent variables influencing the distribution of the areal size of farms. Consequently in any future discussion it should be remembered that differences in the areal size of farms do not by any means necessarily imply concomitant differences in the size of the business or, stated another way, variations in farm size are not necessarily proportional to variations in the value of production.

The above statement is not meant to convey the impression that this study concerned itself only with isolating variables which influence farm size because the basic goal of Geography has always been to describe and explain the locations of phenomena.[4] It is this emphasis on the "where?" and "why there?" that distinguishes Geography from regional economics or other regional science and this difference in approach was preserved in the hope that it would cast some light on the regional character of agriculture in Alberta. Therefore in addition to examining the relationship between farm size and factors which affect its areal variation through space some attempt has been made at examining the areal variation in the quality of each variable used in this study.

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4 H.H. McCarty and J.B. Lindberg, A Preface to Economic Geography, Prentice-Hall, Englewood Cliffs, N.J., 1966, p. 3. Italics in the book.

This is perhaps an appropriate point at which to stress that in this study no pretense was made at testing major economic theory but rather there is an examination of how economic forces as well as physical variables indirectly influence the areal variation in farm size. Nor was it possible to give much direct consideration to the actual or theoretical implications of transportation costs on the distribution of the intensity of agricultural activity.

Merely to describe the association of phenomena in space without reference to theory would yield few fruitful conclusions on which further research might be based. For example, McCarty and Lindberg have stressed the importance of theory to Geography and have suggested that

> ... there is very little virtue in learning verbatim the characteristics and arrangement of forces that explain the location of a particular set of economic activities, since that situation is quite unlikely to reappear in the future. As a consequence, we must focus attention on the <u>elements</u> in locational situations so that we may be able to rearrange those elements to fit new situations that appear as problems in our daily lives.[5]

In short we must be cognisant of the theoretical relationships of the elements in locational situations so that we may distinguish those areal associations which are meaningfully related from those which are not.

<u>Method</u>

Geography, like Sociology, for example, is in part an observational rather than an experimental science, in that it is extremely difficult, if at all possible, to control the factors affecting the distribution of the studied phenomenon. Scientists in the Physical Sciences, including some aspects of geography, can isolate and control their variables, introducing them one by one with a view to ascertaining the nature of their relationship with the dependent variable but an economic

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5 <u>Ibid.</u>, p. 10

geographer has little hope of imposing control on his data. He must attempt to explain complex situations or phenomena largely in the way they occur. One way in which he can reduce the complexity of his problem is to view his data systematically, that is, to abandon his regional approach and to examine only one type of phenomenon.

The new analytical techniques which have become available recently to geographers offer a promising avenue in this approach, particularly when they are related to theory and the development of normative models. Their use entails certain assumptions about the statistical data however and for the most part a geographer must exercise a degree of ingenuity in utilizing the traditional data sources such as the decennial agricultural census. Even then he must still acknowledge that the numbers of factors affecting his study remain very large and consequently a complete solution to the problem cannot be attained or, at least, is not worth the effort.

The present study has been conducted along the following lines. Size of farm was the major variable examined. All other variables studied were considered as having some degree of effect, either directly or indirectly, on the variation of farm size and consequently, were studied only in so far as to determine how they affected it.

The initial problem was, to develop the relevant hypotheses in which a formal statement concerning the relationship between the dependent and independent variables might be made. To achieve this end agricultural data associated with size of farm in Alberta were plotted on a series of maps and the resulting patterns were then examined with a view to establishing visual relationships between one or more sets of datum. Although, as H. McCarty and N. Salisbury have demonstrated experimentally,[6] it was difficult to discern with any degree of accuracy the precise way in which the mapped data covaried it was, nevertheless, possible to observe the patterns portrayed and to arrive at some tentative conclusions concerning their comparability. Often other variables, of which the investigator was aware, suggested themselves during this phase of the analysis because their pattern of occurrence was similar to those already mapped. An example will serve to illustrate this point. After the spatial distribution of farm size was mapped it was noticed that it varied in a manner that was consistent with the writer's knowledge of the physical resources of the province. It was also observed that there were regional variations in the concentration of specific types of farm that, in turn, were consistent with the previously observed variation in farm size. At this point the body of theory in Economic Geography was consulted to ascertain if there was any reason to suspect a logical connection between the variables mapped. In this manner, hypotheses concerning the relationships between the dependent variable, farm size, and the independent variables examined were developed and refined and finally tested with the aid of analytical statistics. The actual test of the hypotheses, of course, is the degree to which they suggest or predict the patterns which in fact exist in the area of study.

<u>Summary</u>

In summary, the major objective of this study was to examine systematically the variation in the average size of farm throughout Alberta and the underlying reasons for this variation. The study should

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[6] H.H. McCarty and N.E. Salisbury, <u>Visual Comparison of Isopleth Maps as a Means of Determining Correlations Between Spatially Distributed Phenomena</u>, Studies in Geography of the Dept. of Geography, Iowa State University, No. 3, Iowa City, 1961, 81 pp.

therefore be viewed more as an exploratory one in which the major causes of variation in farm size in Alberta were examined and their influence measured with the use of analytical statistics. The utility of census data in their traditional form was also assessed, albeit indirectly, and this constituted an important aspect of the exploratory nature of the study.

The method used to study these differences in farm size, and to ascertain the major reasons for different farm sizes occurring at different places in the province, falls under the heading of Systematic Geography. This approach was employed because it offered greater scope for the application of the methodology of Economic Geography, in which the need for hypotheses derived from theory and tested with precise measuring tools is stressed.[7]

The hypotheses examined here were largely derived from an examination of the mapped distribution of agricultural phenomena, such as agricultural land use and value of lands and buildings per acre, but always with the theory of Economic Geography in mind. The major hypothesis to be formally examined was expressed in the following manner: Average farm size per municipality in Alberta is a function of environmental conditions, type of farm, size of the farm business and the influence of major cities.

Before the influence of each of these variables upon the dependent variable could be assessed, other questions had to be asked so that a better grasp of the locational aspects of the problem could be obtained. The first question, normally posed by geographers, "Where are the study variables located?", was answered by mapping the data and observing the resultant patterns of areal variation. The second question, "How is the dependent variable, farm size, related to other

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[7] See for example H.H. McCarty and J.B. Lindberg, op. cit.

phenomena?", was answered primarily through the use of regression and correlation analysis. At the end of this stage of the analysis, the question of causality was explored in an attempt to explain how the variables were meaningfully linked. This part of the study proved most difficult because the reasons for the association of the variables were multitudinous and often lay in the past.

CHAPTER I

THE STUDY VARIABLES

AVERAGE FARM SIZE: THE DEPENDENT VARIABLE

A farm in Canada has been operationally defined[1] by the Dominion Bureau of the Census, as a holding one or more acres in size with sales of agricultural products during the twelve months preceding the census of fifty dollars or more.[2] Except for a slight modification in 1951 and 1956, this definition has been in existence in Alberta since 1901. There is, in addition to this definition, a further classification based on value of agricultural sales which divides farms into commercial and non-commercial, but this practice came into being only in 1961 and the definition has since been revised for the 1966 census, ruling out any possibility of studies of changes through time. For the purposes of this study the older and broader definition has been used because, although it encompasses small holdings which really are not farms in a commercial sense, it nevertheless is useful in providing long term data which indicate regional variations in farm size.

General Characteristics of Farm Size in Canada

A comparison of farm size, both spatially and temporally, seems appropriate at this point because it places the study in a contextual

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[1] An operational definition can be considered as a detailed set of instructions enabling one to classify individuals unambiguously. See H.M. Blalock, Social Statistics, McGraw-Hill, New York, 1960, p. 9.

[2] Canada, Dominion Bureau of Statistics, Census of Canada, vol. 5, pt. 3, no.3, Agriculture: Alberta, Ottawa, 1961, p.vii.

framework and it suggests some of the more important regional variations in farm size both current and historical.

A general analysis of the regional variation in farm size in Canada, as shown in Table I, indicates that the largest farms in terms of areal extent occur on the Canadian Prairies and the smallest in Eastern Canada. If, however, gross income had been used in this study

Table I Variation in Farm Size in Canada

Region	Average Size (Acres) 1961	1966	Percentage Change in Average Size	Income in Dollars per Acre -1961	Gross Income per Farm 1961
Atlantic Provinces	165	182	+ 10.3	15.00	2,410
Central Canada	150	161	+ 7.3	30.50	4,605
Prairies	584	650	+ 11.3	7.60	4,660
West Coast	226	277	+ 22.0	19.00	4,300
Canada	359	404	+ 12.5	12.50	4,500

Source: Canada. Dept. of Agriculture. Economics Branch. Current Review of Agricultural Conditions in Canada, Vol. 24, No. 1, January 1963.
Canada. Dept. of Agriculture. Economics Branch. Canadian Farm Economics, Vol 2, No. 4, October 1967.

as a measure of farm size, or more specifically, the size of the farm as an economic venture, then the largest and smallest farms would have been located on the Prairies and in the Maritime Provinces respectively. One of the reasons for this disparity in areal size is the differing rates of productivity per unit of land from place to place in Canada. Farmers in Eastern Canada obtained on the average a gross return of $30.50 per acre in 1961 whereas their counterparts on the

Prairies received only $7.60 per acre for the same period. It is obvious that this kind of comparison of the relative productivity of farms is not valid for all years because annual agricultural income on the Prairies varies markedly in response to climatic setbacks or fluctuation in international demand for farm products. Nevertheless the relative economic positions of farms in each region is accurately portrayed for the longer term in Table I.

Differences in the areal size of farms cannot be attributed alone to physical factors, such as soil and climatic conditions, because the same crop grown in different regions of Canada could not in itself account for the regional variation in gross income per unit of land. In the case of wheat, for example, if Ontario farmers attempted to compete with farmers in the west the average Ontario farm would have produced only approximately 4,106 bushels in 1966 (average yield of 25.5 bushels times average size of farm or 161 acres: assuming the whole farm was used for this purpose) whereas 10,660 bushels would have been produced under the same conditions on the Prairies.[3] This will be recognized as a very crude comparison because, for one thing, a farmer in the major wheat producing sections of the Prairie has traditionally maintained a large proportion of his farm in fallow in an effort to supplement the moisture available atmospherically in any crop year, and for another, the wheat produced in one region is not comparable in type: it is hard in the west and soft in the east; or price: it is cheaper in the east because of the emphasis on soft wheat. The comparison nevertheless, suggests that, in spite of the higher transportation costs of getting the western crop to market, in this

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[3] The values for this example were obtained from R.E. English, Statistician, Farm Economics Branch, Alberta Dept. of Agriculture.

case the lakehead ports of Port Arthur - Fort William, the ratio of gross income per acre for Ontario farmers when compared to those on the Prairies would be much lower if the farmers grew wheat than is the case now. In fact, rather than a ratio of four to one it would be more like a ratio of two to one assuming that production costs and the price received per bushel were equal. How then can the actual differences that currently exist in gross productivity be accounted for? It would appear that the physical environment plays some part because its quality varies regionally giving rise to areal variation in yields per acre, but it is equally apparent, if the above example of regional variation in wheat production is true, that we must look elsewhere to get a fuller explanation of the actual differences.

The key to this conundrum seems to lie in a regional specialization based on comparative advantage. Eastern Canadian farmers produce over thirty dollars gross income per acre simply because they do not try to compete in the production of a commodity that can be grown cheaply on a large scale in Western Canada. Instead, they have responded to increased market demands by intensifying their operation and producing high value per unit products such as milk, fruits and recently, corn fed meats. But, although this intensification in production has likely come about in response to market demands, it nevertheless has also been made possible because of the physical qualities of the environment. In Eastern Canada farmers can grow a wider range of crops than western farmers because frost free seasons are longer, more heat units are available per growing season and precipitation is more abundant and reliable. Consequently, as transportation and marketing systems have improved making a wider market easily available, Eastern farmers have specialized in commodities which can compete successfully with the produce of other agricultural regions.

Let us take another example with reference to Alberta. There is a demand for fresh produce in all major cities in Alberta, yet it is no longer met locally even though an agricultural economy exists around each city. The reason for the apparent anomaly lies, at least partially, in the fact that as average incomes have risen in Alberta consumers have demanded a high quality of fresh produce all year and these demands cannot be met locally without massive inputs of capital for structures and equipment to nullify the effect of a physical environment which essentially is not suited to this type of production. These capital expenditures could be made and the structures could be put in place because it is technically possible to produce for the local market, but they are not because it is not economically feasible as long as produce from more favoured areas can move unimpeded over provincial and international boundaries and as long as the marketing and transportation structures exist to make the produce cheaply and reliably available.

It appears then that farms differ regionally in areal size in Canada partly because the size of the farm business varies (see for example the Maritimes in Table I) but primarily because of the differences in the intensity with which agricultural land is used. The reasons for these differences are not immediately obvious but part of the variation in intensity seems linked both directly and indirectly, through economic pressures to the physical conditions in existence in each region. Yet one can immediately think of examples where this stated relationship breaks down, particularly if the scale of the study is shifted from a national level to a larger scale regional study.

Milk sheds are excellent examples of how high transportation costs, for example, can influence the location of dairy farms, often in spite of local physical conditions. Von Thunen, of course, developed a complete thesis on the effects of transportation costs on the intensity and concomitantly, the type of agricultural production surrounding urban places. But when examples such as these are introduced to argue against the above stated relationship between intensity of production and the physical resources, what really is being debated is the economic feasibility of substituting one factor, transportation costs, for another, lower priced land at a less accessible site.

With increasingly improved transportation systems it would appear that the costs of moving agricultural commodities are becoming less important relative to the advantages of the agricultural site. McCarty and Lindberg suggest that the relative importance of these factors seems to be shifting towards the latter. They state ...

> Improvements in transportation have tended to lessen the advantages of sites located near markets and have increased the advantage of locations that are favoured in terms of production costs. These advantages may arise from seasonal climatic superiorities, or from a combination of fertile soil and low cost irrigation water. They may arise from the economics of large scale production and marketing, or from an important production linkage with another commodity.[4]

These ideas appear very relevant to Alberta because most crops grown in this province are exported to distant extraterritorial markets. As a result, a shift in location of one or even two hundred miles within the provincial boundaries will add relatively little to the total transportation costs but may have a profound impact on the physical conditions encountered for the growth of a specific crop. It seems therefore reasonable to expect that under these conditions patterns of regional specialities will be clearly defined and consequently that the areal size of farm will vary markedly from place to place.

General Characteristics of Farm Size in Alberta

Average size of farm in Alberta, as shown by Fig. 1, has been

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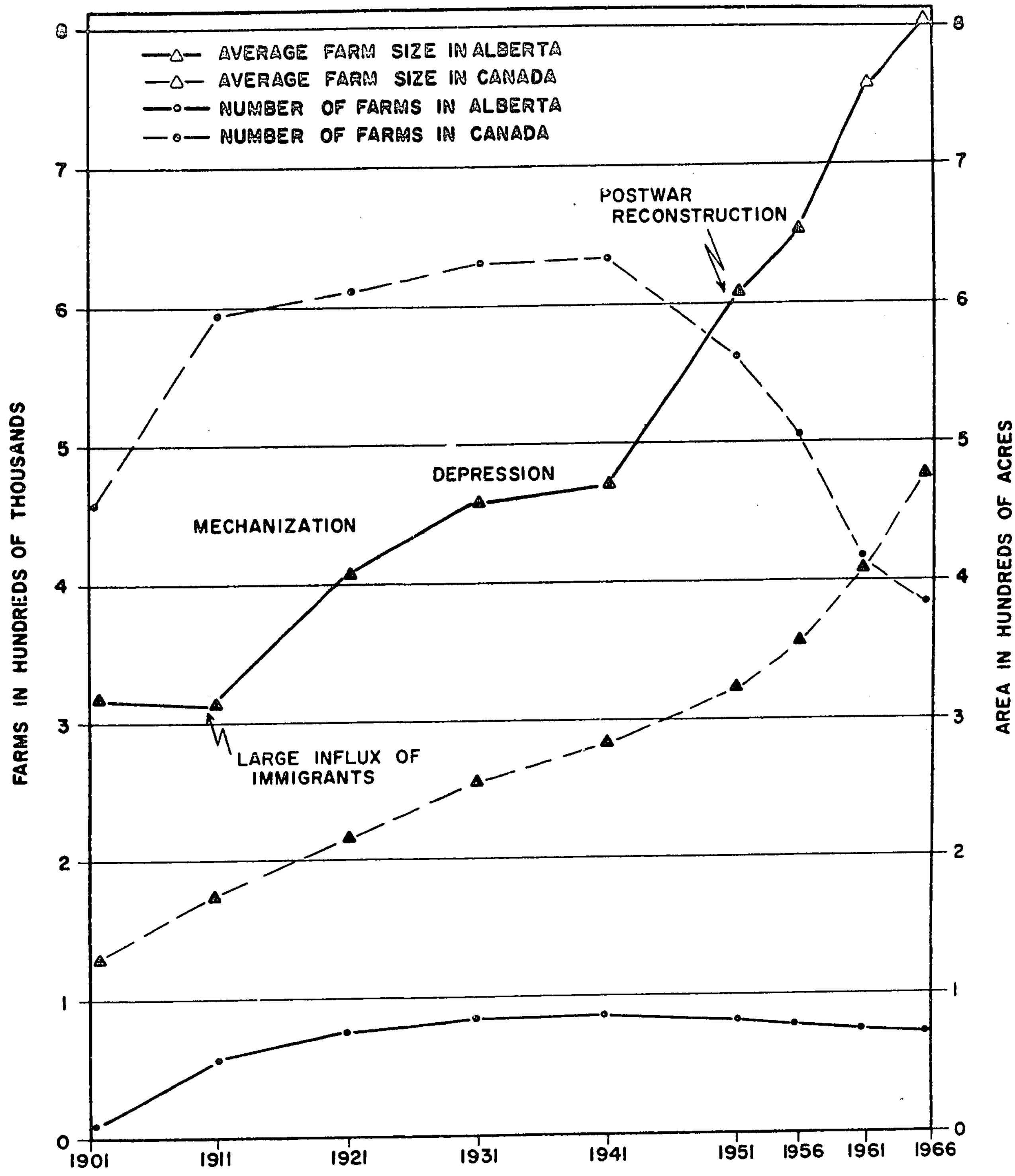
[4] H.H. McCarty & J.B. Lindberg, A Preface to Economic Geography, Prentice-Hall, Englewood Cliffs, N.J., 1966, p. 224.

Fig. 1

CHANGES IN SIZE AND NUMBER OF FARMS FROM 1901 TO 1966



SOURCE - DOMINION BUREAU OF STATISTICS, 1961, CENSUS OF CANADA, AGRICULTURE. CANADIAN FARM ECONOMICS, VOL. 2, NUMBER 4, OCTOBER 1967, PAGE 22.

consistently larger than the Canadian average throughout the history of the province. In 1901 the average size of farm in Alberta was almost 290 acres whereas the Canadian average was roughly 125 acres. The reason for this disparity was not, of course, that the settlers in this part of Canada were any more prosperous or long established than farmers elsewhere but simply because the Canadian government had recognized the relative disadvantages of the physical environment in Alberta for agriculture compared to Ontario and had made at least 160 acres of land per farm available under the terms of its Homestead Act.

The average farm size in Alberta dropped slightly from 1901 to 1911 partly because a considerable number of immigrants who came in response to the settlement policies of the Liberal government under Laurier[5] were Eastern Europeans without capital. Settlers such as these could only obtain the minimum holding allowable under the terms of the Homestead Act. Another important cause may have been related to the physical quality of the area being settled at this time. Whereas the stress had been in southern Alberta to this point settlers were now shifting into the more humid parts of central Alberta. The result was that the previous figure was diluted and reduced. Average farm size recovered quickly, however, and then began to rise even more rapidly than did the Canadian average. The two major causes of this increased growth rate in the average size of farm were associated with the economic and technological conditions existent at that time. The post World War One expansion of agricultural markets provided the economic stimulation to consolidate and expand farm size and the mechanization of Prairie agriculture made it possible. Although the rate of expansion began to decline the influence of mechanization in

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[5] J.J. Talman, Basic Documents in Canadian History, Van Nostrand, Toronto, 1959, pp. 122-123.

all likelihood extended into the next decade at least, partly because of the serious dislocations in agriculture which took place in southern Alberta in response to severe drought. Nevertheless it was still more rapid than in the rest of Canada. While the economic depression of the next decade did not completely stem the trend towards creating larger businesses by adding additional land it certainly severely curtailed this tendency. From the evidence offered in Fig. 1 its effect appeared to be uniform on the Alberta and Canadian means in terms of rate of increase in farm size, but rapid growth in Alberta was not long in coming again.

The new forces at work in the Canadian economy because of, first, war, then, reconstruction of the post war economy, were reflected in a sharp rise in the rate of farm consolidation and growth in Alberta. Average farm size rose dramatically from 432 to 528 acres in the 1941 to 1951 decade, but these changes in the national economy were not reflected in the Canadian average farm size until 1956. Generally the effect of these forces was to provide alternate well paid employment in the industrial and service section of the economy so that farmers with small holdings could either get capital from non-farm sources to expand their holdings or get out of farming completely, making their land available for their neighbour's expansion. Yet if these forces for expansion did emanate from a burgeoning economy then it may be difficult to understand why they first manifested themselves in Alberta, which up to that time was heavily dependent upon an agricultural economy.

Part of the answer seems to lie in the expansion of the western oil industry which took place after the 1947 Leduc discoveries and the role that Edmonton was playing at the same time as a supply centre for both this industry and northern development. Edmonton had previously enjoyed a boom during the Second World War and had consequently acted like a magnet drawing rural population from the rest of the province but with the oil boom the rates of population increase jumped from 3 per cent in 1947 and 1948 to over 8 percent for the remainder of this decade and on into the next.[6] These growth rates were so high in fact, that Calgary and Edmonton were among the most rapidly growing communities in Canada at that time (as they still are). Admittedly not all of this increase may be attributed to local population movements, but there is no doubt that rural depopulation played some part. In 1941, for example, the population on all census farms in Alberta was roughly 384,000. By 1951 it had dropped 11 per cent to 343,000.[7] Only the attraction of the urban labour market for farmers has been stressed in these examples but it should be emphasized that the oil industry provided the needed capital for farm expansion by also providing employment for farmers in its enormous exploration and drilling programmes.

The increased tempo of farm consolidation in Canada and Alberta has continued to the present for roughly the same general reasons. The abundance of alternate employment opportunities, for example, made the transition from country to urban place easier for members of the rural community who lacked the desire or capital to establish viable farm businesses, while at the same time the recent grain exports from western Canada to Communist markets have provided yet additional capital for farm expansion in Alberta and the other Prairie Provinces. The effect of these variables on average farm size is again illustrated

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[6] W.C. Wonders,"Edmonton, Alberta, Some Current Aspects of Its Urban Geography", Cdn. Geogr., no. 9, 1957, p. 13.

[7] Canada, Dominion Bureau of Statistics, Census of Canada, vol. 5, pt. 3, no.3, Agriculture: Alberta, Ottawa, 1961, Table 2.

in Fig. 1. Farm size in Canada increased more rapidly after 1956 than it had previously because of the increasingly favourable economic climate, but farm consolidation in Alberta proceeded at an even greater pace.

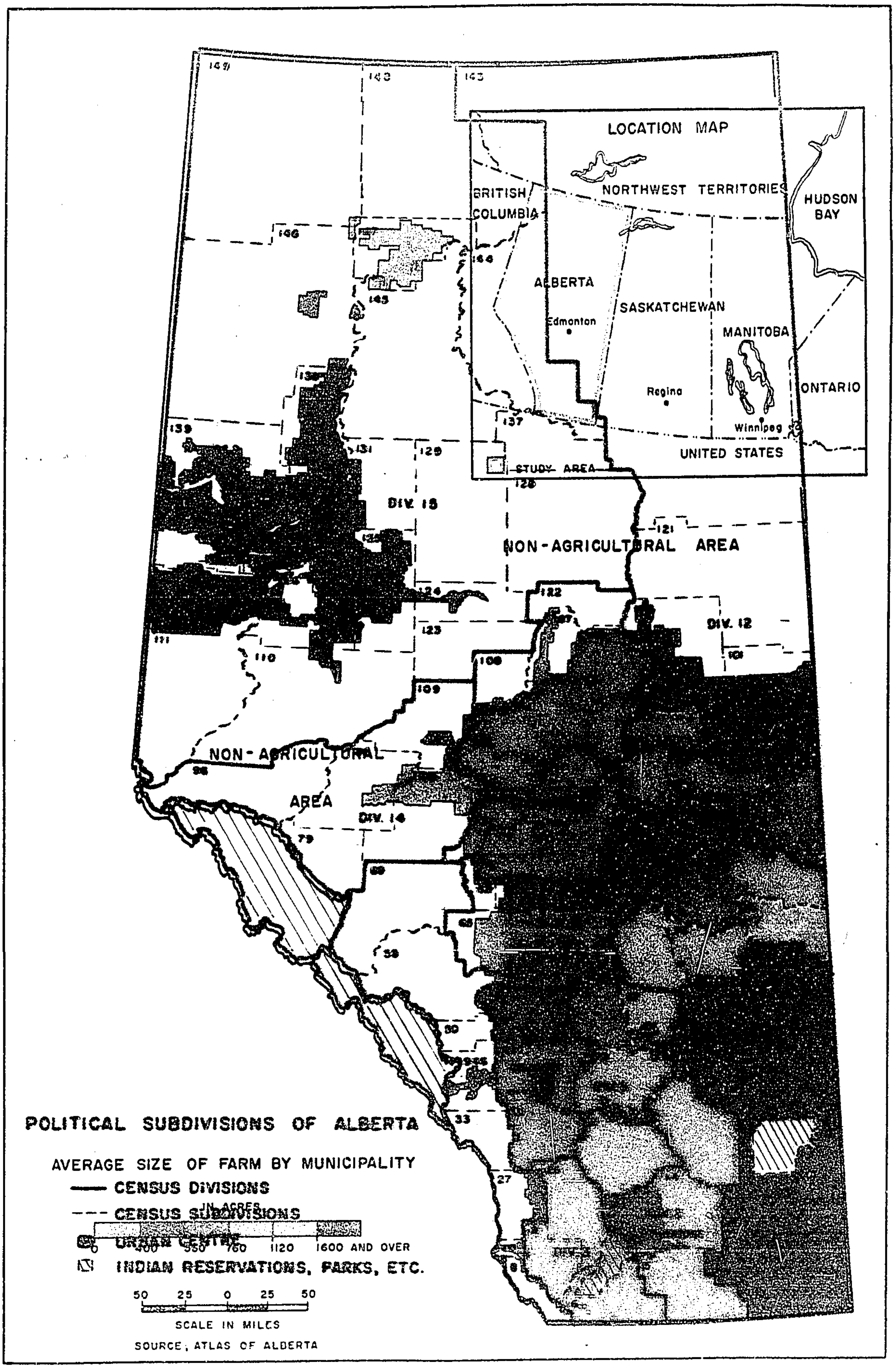
Although the foregoing general statements concerning the trends and underlying reasons for farm consolidation are valid at a national and provincial scale they cannot accurately portray the patterns of farm size for smaller political regions such as municipalities because they are merely summary statistics for broad and diverse areas. Also, when the scale of the study is changed local forces which modify or over-ride the factors acting at the larger scale are introduced and different regional patterns emerge. This background material still serves a useful purpose however, in that it provides a standard against which the local patterns and forces may be compared.

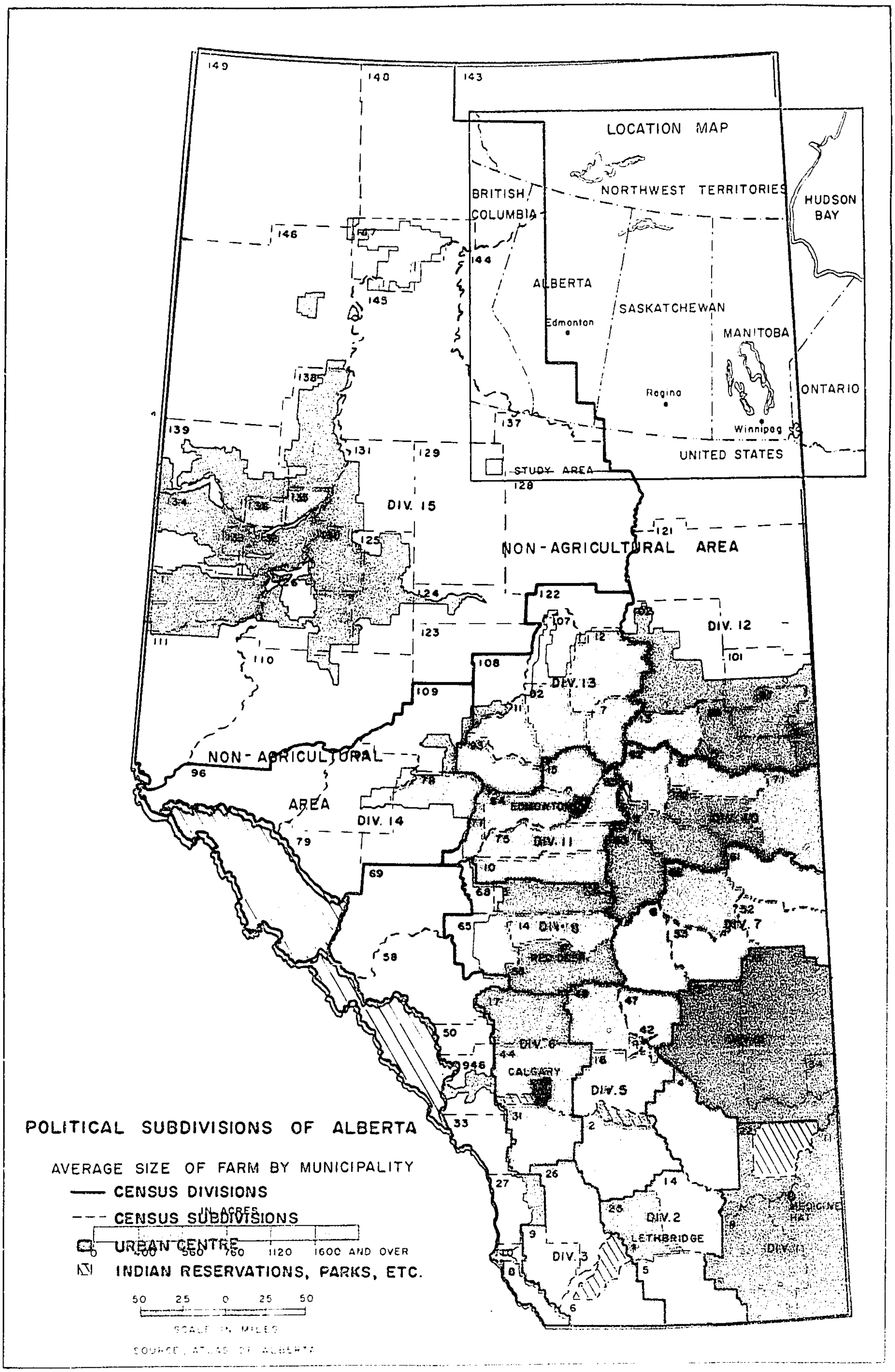
This study will now concern itself with an examination of the large scale patterns of farm size in Alberta which have developed in response to both national and local influences.

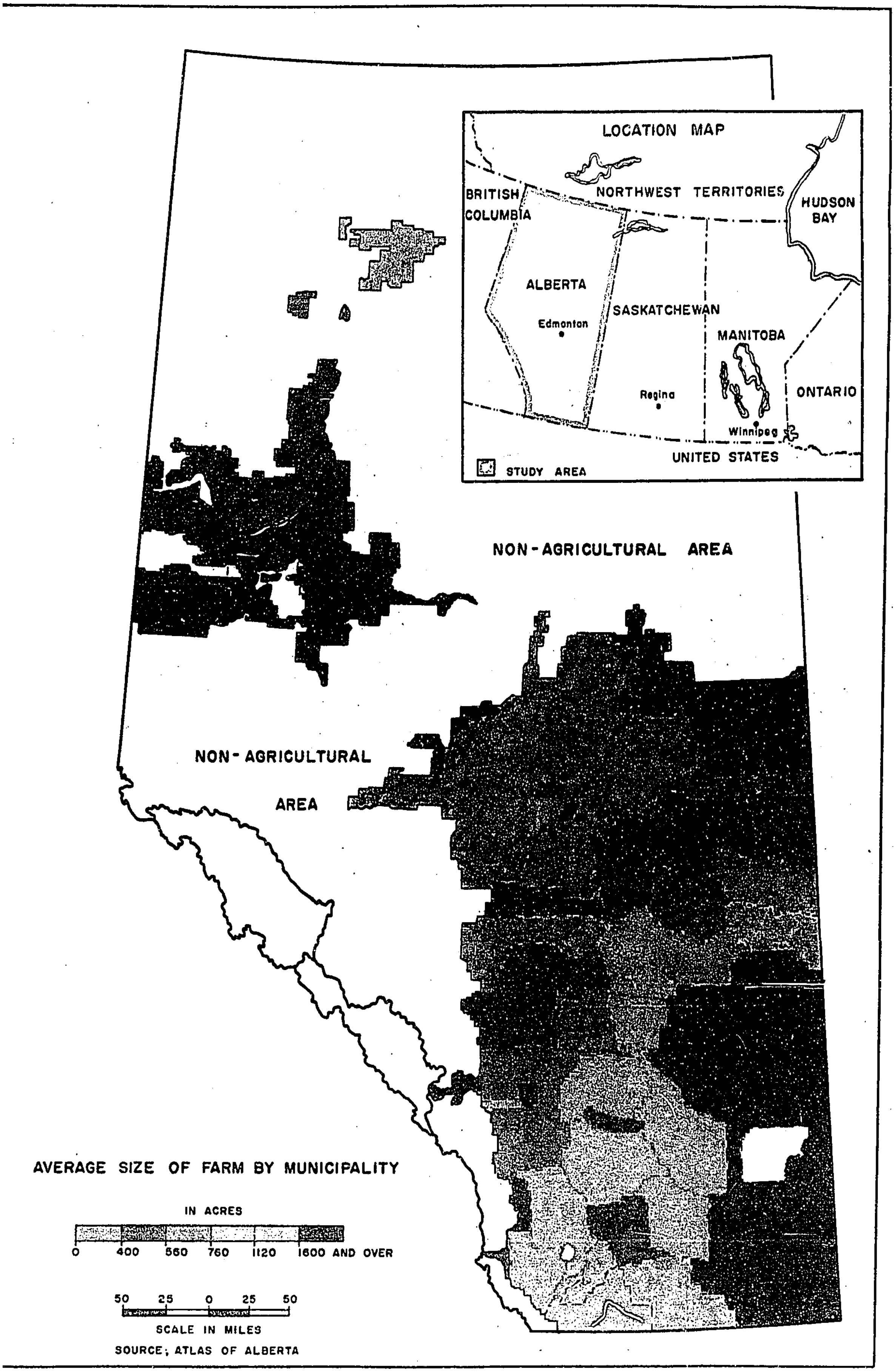
Average Farm Size in Alberta

The average size of farm for each municipality in Alberta was computed by dividing the area of all land in farms in the municipality whether improved, unimproved, owned or rented by the number of census farms. It was assumed that each farm is one holding and, although there are doubtless farms which are fragmented into two or more holdings some distance from one another, the trend in Alberta is for farmers to hold their land in a single block. If it could be demonstrated that holdings were fragmented in certain districts then this would indeed be a significant fact because there is a strong possibility that the intensity with which land is used would be affected. In this case the mean farm size would signify something somewhat different from a mean of similar value which had been computed for another municipality in which land holdings were not fragmented.

The regional pattern of average farm size per municipality is displayed in Map 1. It should be noted from the outset that average farm size has been divided into the same size categories used in the 1961 census of agriculture so that this map will be comparable with the next map which shows the frequency with which certain sizes of farm occur in each municipality. At this small scale it is apparent that there is a trend for farms to diminish in size in a northwesterly direction from the southeast corner of the province. This pattern is broken however in a number of ways that might become even more apparent if the values for average farm size had been broken into different size groups. The largest average size of farm occurs, for example, in the Foothills of the Rocky Mountains in municipality number 27, census division 9, not in municipality number 11, census division 1, in the southeast corner of the province. Furthermore, the average size of farm in the aforementioned southeast-northwest direction does not decrease uniformly because a broad area of larger farms exists to the north of municipality number 11, census division 1, in municipality number 22, census division 1, and the Special Areas in census division 4. Another outstanding deviation from this directional trend in average farm size exists in the Peace River district which lies as a detached region northwest of the main farming district of Alberta. Here average farm size ranges from 400 to 760 acres with farms in the largest category located in the north of the district in municipalities 135 and 136. Some other interesting but less obvious departures from the general pattern of average farm size occur in municipalities associated with some, but not all, of the larger urban places of Alberta. Municipality 25, census division 2, which contains


LOCATION MAP
BRITISH COLUMBIA
NORTHWEST TERRITORIES
HUDSON BAY
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
Edmonton
Regina
Winnipeg
UNITED STATES
STUDY AREA
DIV. 15
NON-AGRICULTURAL AREA
DIV. 12
NON-AGRICULTURAL AREA
DIV. 14
POLITICAL SUBDIVISIONS OF ALBERTA
AVERAGE SIZE OF FARM BY MUNICIPALITY
CENSUS DIVISIONS
CENSUS SUBDIVISIONS
IN ACRES
0 400 560 760 1120 1600 AND OVER
URBAN CENTRE
INDIAN RESERVATIONS, PARKS, ETC.
50 25 0 25 50
SCALE IN MILES
SOURCE; ATLAS OF ALBERTA


LOCATION MAP
NORTHWEST TERRITORIES
BRITISH COLUMBIA
HUDSON BAY
ALBERTA
SASKATCHEWAN
Edmonton
MANITOBA
Regina
ONTARIO
Winnipeg
UNITED STATES
STUDY AREA
DIV. 15
NON-AGRICULTURAL AREA
DIV. 12
DIV. 13
NON-AGRICULTURAL AREA
DIV. 14
EDMONTON
DIV. 11
DIV. 7
DIV. 8
RED DEER
DIV. 6
CALGARY
DIV. 5
DIV. 2
LETHBRIDGE
DIV. 3
MEDICINE HAT
DIV. 1
POLITICAL SUBDIVISIONS OF ALBERTA
AVERAGE SIZE OF FARM BY MUNICIPALITY
IN ACRES
0 400 560 760 1120 1600 AND OVER
CENSUS DIVISIONS
CENSUS SUBDIVISIONS
URBAN CENTRE
INDIAN RESERVATIONS, PARKS, ETC.
50 25 0 25 50
SCALE IN MILES
SOURCE: ATLAS OF ALBERTA


LOCATION MAP
BRITISH COLUMBIA
NORTHWEST TERRITORIES
HUDSON BAY
ALBERTA
Edmonton
SASKATCHEWAN
MANITOBA
Regina
ONTARIO
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UNITED STATES
STUDY AREA
NON-AGRICULTURAL AREA
NON-AGRICULTURAL AREA
AVERAGE SIZE OF FARM BY MUNICIPALITY
IN ACRES
0 400 560 760 1120 1600 AND OVER
50 25 0 25 50
SCALE IN MILES
SOURCE; ATLAS OF ALBERTA

Lethbridge, and municipalities 75 and 83, census division 11, which are in close geographic proximity to Edmonton are cases in point. Each of these municipalities stands in sharp contrast to its neighbours either on Map 1 or in the data used to compile this map. Additional anomalies also exist in municipalities in which Indian reservations or metis colonies predominate. Two of the most evident examples are the Blood Indian reservation in census division 3 and the metis colony in municipality 85 in census division 12.

Even though there are obvious exceptions to the general pattern of average farm size, the original description of the areal distribution of farm size still appears to be valid, but if each of the municipalities had been originally computed in such a way that their areas were smaller, then interesting modifications in the basic pattern would again become apparent. Field observations suggest that farm size would show some tendency to increase again from east to west in all the municipalities of census divisions 3 and 6 because farmers have responded to the increasing steepness and elevation of the Foothills by decreasing the intensity with which they utilize their land. Farther north however, in census divisions 8 and 11 the opposite trend would occur. Farm sizes are inclined to be smaller on the Grey Wooded soils in the western portion of these census units.

From the foregoing discussion it is evident that interpretations and even descriptions of the patterns of the average size of farm are dependent both on the size of the interval used in classifying farm sizes by groups and the size of the areal units or, municipalities in this case, from which the means are abstracted. Questions immediately arise as to how the data might have appeared if they were collected and grouped on a different scale, or even more important, what the means signify at this scale. The first problem, although interesting, is not germane to this study because the data provided by the

Dominion Bureau of Statistics are available only in these class intervals and only at this scale, but the second problem is highly relevant, particularly when it is the writer's intention to use the mean farm size values as basic data in a statistical analysis.

J.C. Weaver investigated the drawbacks inherent in the use of mean values as descriptive measures for counties in the American Midwest in his discussion of, "The County as a Spatial Average in Agricultural Geography."[8] He concluded that, "These averages are defensible generalizations that have real utility, but they are synthetic creations, and they mask a succession of distinctive and variable realities."[9] What he appears to have meant by this statement is that while means are useful for summarizing trends through space their value is merely a statistical abstract which is influenced by the degree of variability within each summary unit, in his case, counties. For example, it is easy to unthinkingly accept an average value as indicative of the conditions most commonly encountered in the municipality from which the figure was drawn, when in reality the mean value does not even exist. It may well be just the result of combining two distinct populations composed of small and large numbers. There are other measures to be sure, the median and the mode, that can be employed to check the validity of the mean as a valid measure of the general conditions existent in each census unit. Unfortunately these summary statistics lack the necessary qualities for further statistical analysis because although the median and the mode are excellent descriptive statistics, it is the mean which provides the

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[8] J.C. Weaver, "The County as a Spatial Average in Agricultural Geography", Geogr. Review, Vol. 46, no.4, Oct. 1956, pp. 536-565.

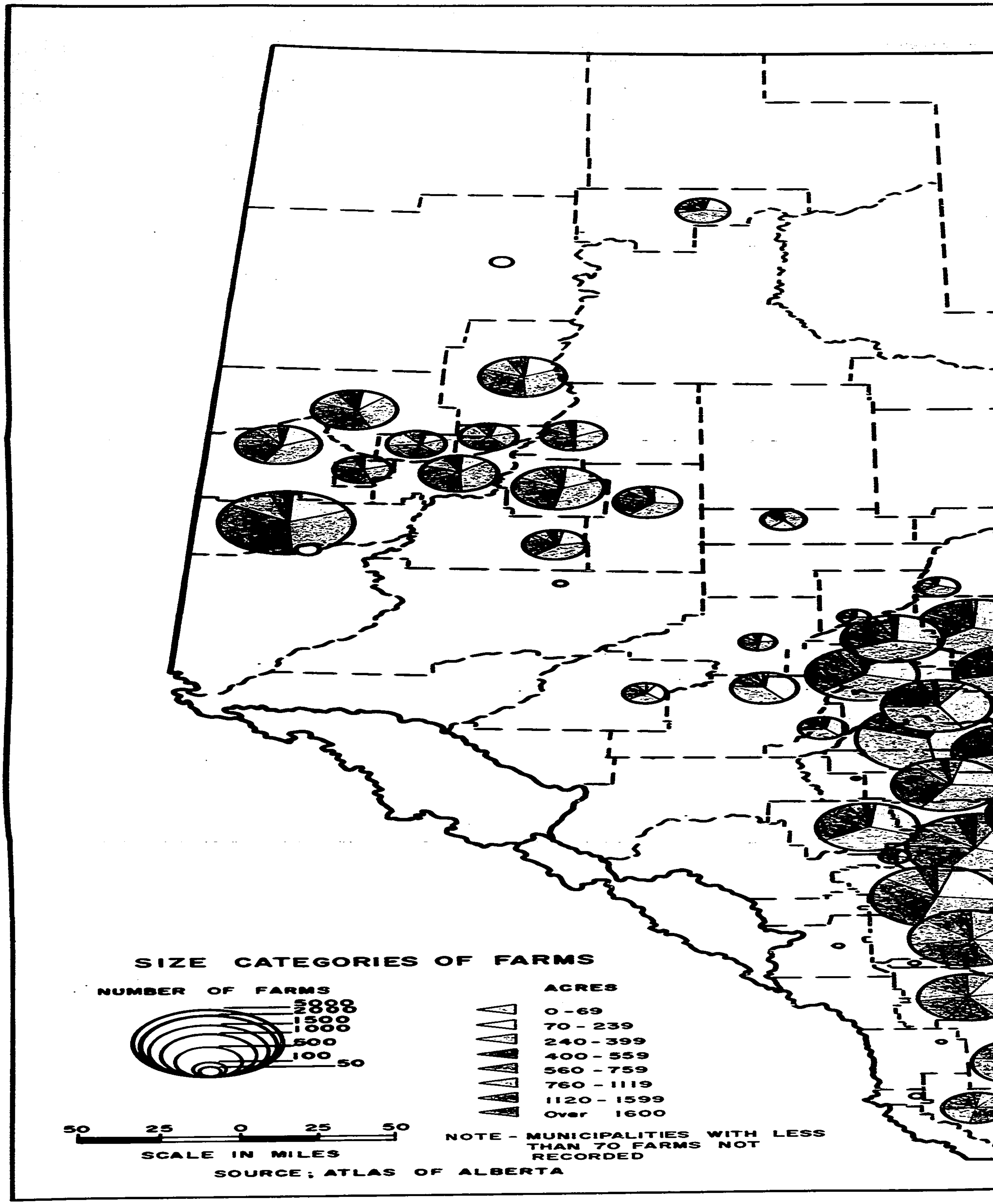
[9] Ibid, p. 536.

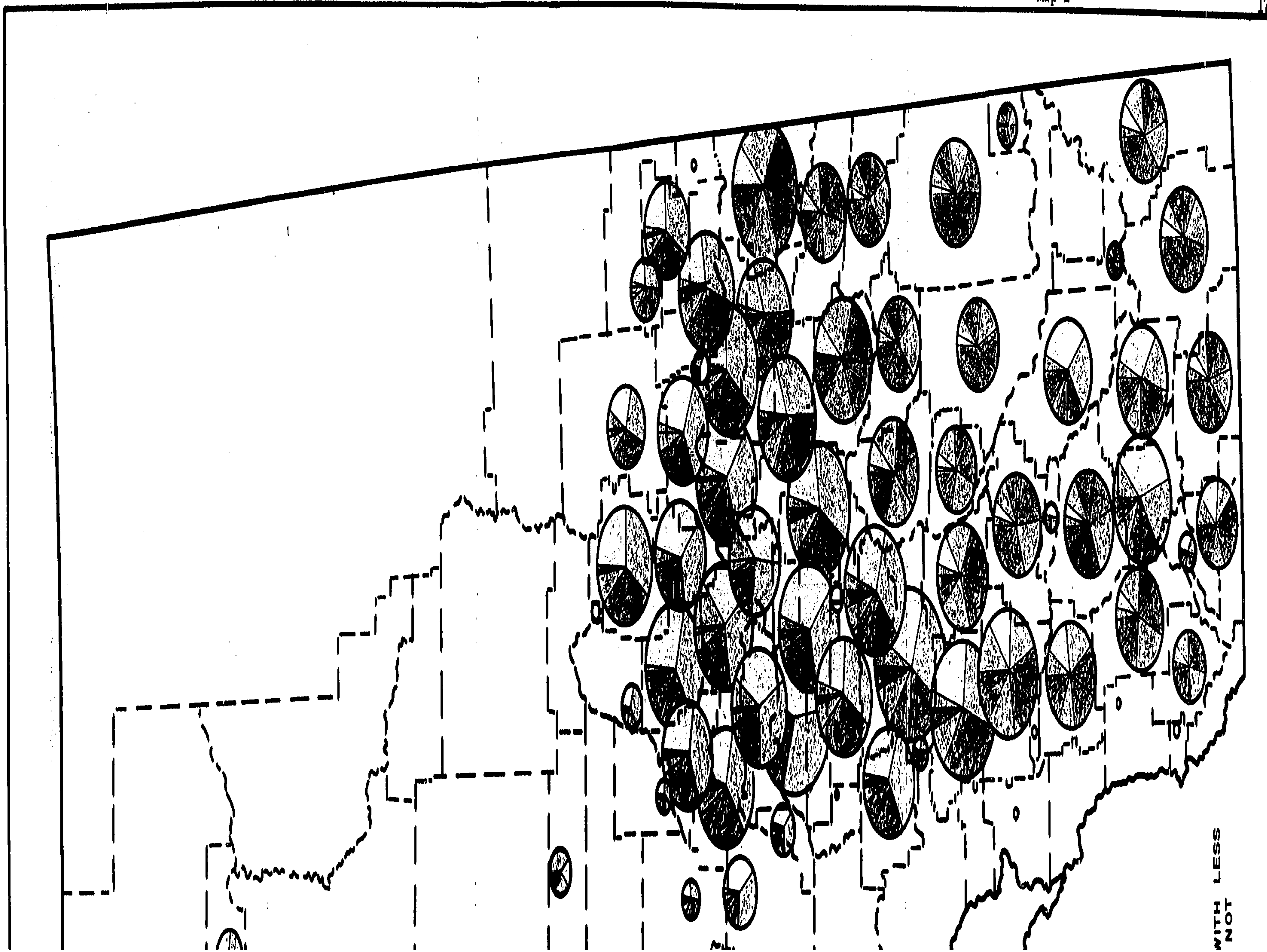
basis for computing the smallest possible value for the variance and associated standard deviation. This is important because this is one of the important characteristics upon which the theory of inductive statistics is founded. Therefore, even though the mean has characteristics which detract from its value as a general statement of average conditions, its use is still warranted when the data are ultimately going to be examined with the use of inductive statistics.

The Variability of Average Farm Size in Alberta

One way in which the significance of each mean value of farm size can be determined is to examine the range, the median, the mode and the variability of the data from which the value has been derived. A careful examination of Map 2 revealed that in almost every municipality farm sizes range from the smallest category of 1 to 69 acres to the largest of more than 1600 acres. This is generally true no matter where the municipality is located, be it subhumid southeastern Alberta or immediately adjacent to Edmonton on the fertile chernozem plain. Only in the Foothills in census division 9 is this not the case. Here farm sizes are distributed through only three or four size categories. It seems obvious then that an investigation of the range of farm sizes in each municipality will give little additional information concerning the significance of the mean farm size.

The median and the mode are the simplest techniques for determining how well the mean describes the general conditions of farm size in each municipality, but these measures also give no indication of the extent to which individual farm sizes are scattered about their individual means. They do, on the other hand, suggest immediately whether or not the distribution of farm size within each municipality is normally distributed. The possession of this piece of information is of importance because many tests in inductive


SIZE CATEGORIES OF FARMS
NUMBER OF FARMS
5000
2000
1500
1000
500
100
50
ACRES
0 - 69
70 - 239
240 - 399
400 - 559
560 - 759
760 - 1119
1120 - 1599
Over 1600
50 25 0 25 50
SCALE IN MILES
NOTE - MUNICIPALITIES WITH LESS THAN 70 FARMS NOT RECORDED
SOURCE; ATLAS OF ALBERTA


WITH LESS
NOT

statistics require normality in the distribution of data.

A quick perusal of these values for the province as a whole and for certain municipalities located in various parts of Alberta indicates that the mean value of farm size given for each political unit examined always overestimates the size of a majority of the farms in that unit. One of the conclusions which may be inferred from this finding is that the data are not normally distributed; rather they are skewed positively, that is, towards the lowest values in the distribution. If prediction of farm size were the stated aim of this study, this observation would strongly influence the direction of future research, but as it is not, the skewed condition of the data will be accepted as just one of the manifold problems inherent in research in the field of social science. It should be emphasised however, that because the data are skewed the mean gives an inaccurate impression of the typical size of farm in each municipality. The few very large farms in each municipality tend to pull the mean value in their direction so that farms appear larger than they are. Furthermore, this effect varies from place to place because the degree to which the data are skewed is not uniform for each municipality. Ultimately this will have important ramifications, when other variables are correlated with mean farm size, since it will increase the difficulty of determining whether correlations are low, because the relationship between the study variables is weak or because the data do not accurately portray average farm size.

Although each of the foregoing measures has yielded additional information about the distribution of the values from which each of the mean values of farm size, as shown on Map 1, has been computed, the amount by which individual farms vary from the computed mean is still not clear. Normally, when samples have been collected, the variability of the data around its computed mean is given by the standard deviation. In this case, however, this value is not available because the mean farm size for each municipality was derived from census returns which reported only the number of farms and the amount of agricultural land in each census area. If the standard deviation had been directly available then it would have been possible to compute a coefficient of variability for each mean. Attempts were made, however, to derive the standard deviation indirectly using the information exhibited in Map 2, so that this valuable coefficient could be constructed.

The major problem encountered in estimating the standard deviation from the categories of farm size depicted in Map 2 was how to determine the midpoint of the largest category since only the lower value of the size interval is given. When data are grouped into categories, it is normal practice to take the midpoint of each interval as the value which best represents all farms in that interval, but in this case it was obviously impossible. Attempts were next made to compute the midpoint of the last category by determining how much of the farm land in each municipality was accounted for by the previous categories and how much remained to be divided equally among the farms falling into the last category. This was done by multiplying the midpoint of each size interval by the frequency with which farms occurred in the interval and subtracting the result from the census value given for all land in farms. The remaining farm land was then divided by the number of farms in the last category to give the best estimate of the midpoint of the distribution. Once this value was established, it was possible to compute the standard deviation employing normal procedures.

Unfortunately this technique was valid only for southern Alberta where large farms constituted a major proportion of the total number of farms in each municipality. It failed when it was applied outside this area because all land was accounted for in the first step of the above method and consequently none remained from which the midpoint of the last interval could be computed. This suggests that the average farm size in each interval must in reality be smaller than the heretofore best estimate of farm size, the midpoint. In retrospect, this finding seems reasonable because, as was demonstrated earlier, the data in each municipality are skewed. It is highly likely then, that most of the individual farm values occur towards the low end of each size group with the result that the midpoint overestimates the average farm size in every interval. This point is neatly demonstrated by the data presented in Table II, which summarizes average farm size in each category for the province taken as a whole.

In a final attempt to ascertain the variability of the data associated with each municipal mean, J.C. Weaver's technique, for determining the best combination of numbers to describe specific numerical distributions, was employed.[10] This approach, which was developed to describe crop combinations in the American Middle West, utilizes a theoretical construct which allows an observer to objectively measure the degree to which land use values in a specific municipality fit a theoretical curve.[11] No data other than percentage values of the study variable are needed and consequently the method is ideally suited to the present problem.

First, the values in each size category, as shown on Map 2,[12] were

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[10] J.C. Weaver, "Crop-Combination Regions in the Middle West", Geog. Review, Vol. 44, No. 2, April 1954, pp. 175-200.

[11] See Appendix B.

[12] See Appendix A.

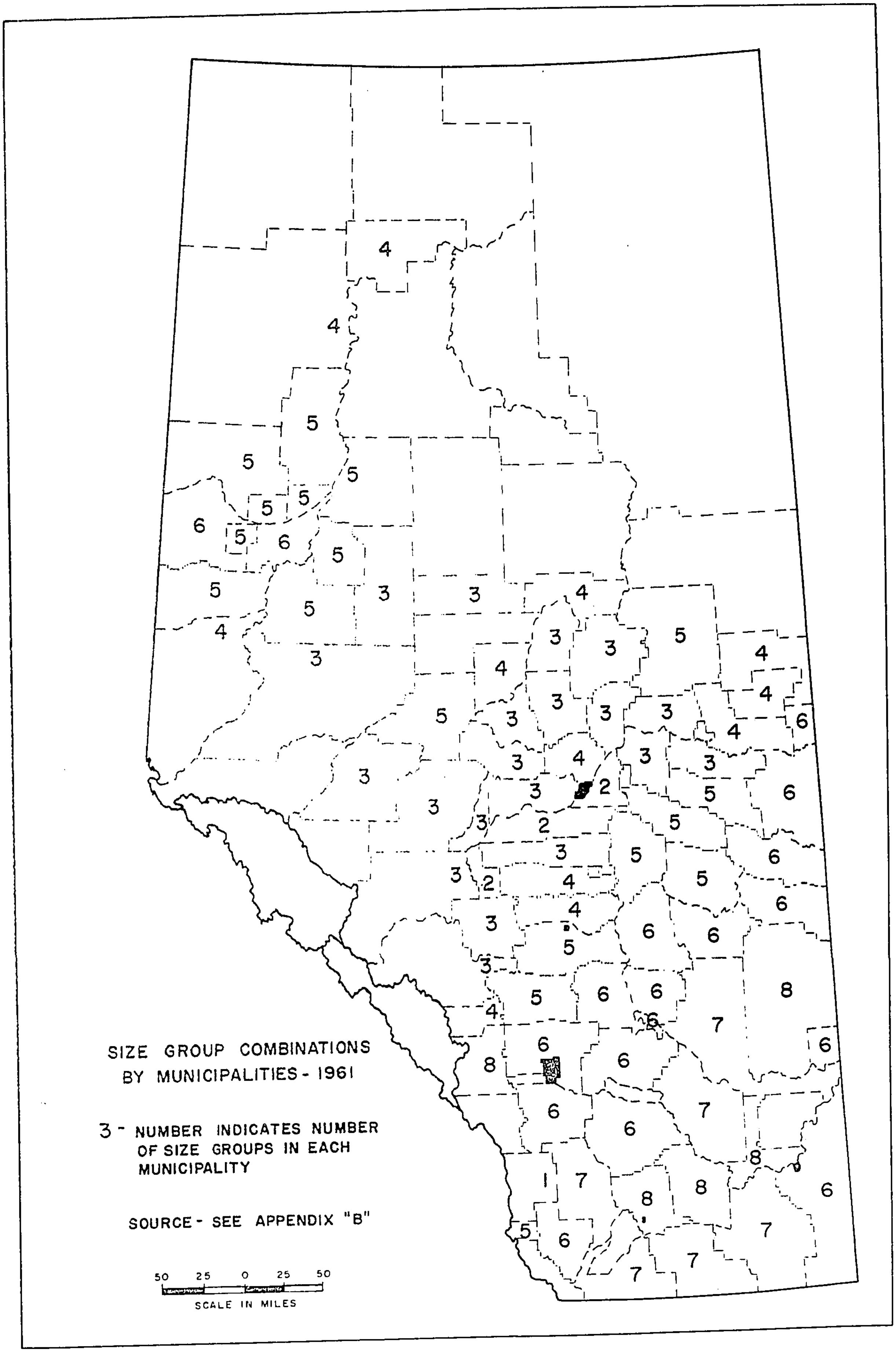
Table II. Farms by Size Groups, Midpoints of Size Groups and Average Size of Census Farms in each Size Group - Based upon 1961 Census of Agriculture, Alberta.

Size Group	Midpoint of Size Group	Average Size of Census Farms in Acres
Under 3 acres	1.5	1.6
3- 9 acres	6.0	5.2
10- 69 "	39.5	31.1
70- 239 "	154.5	158.3
240- 399 "	319.5	315.2
400- 559 "	479.5	472.9
560- 759 "	659.5	638.7
760-1,119 "	939.5	886.9
1,120-1,599 "	1,359.5	1,281.1
1,600-2,239 "	1,919.5	1,824.4
2,240-2,879 "	2,559.5	2,460.6
2,880- and over	-	7,502.4

Source: Pers. Comm. H.K. Scott, Chief, Crops Section, Dominion Bureau of Statistics, Ottawa, 1967.

converted to percentages and ranked in descending order of magnitude. Next, the data were combined into groups and compared with the theoretical curve. The combination of size groups that deviated least from the curve was then judged to be the combination of sizes that best described actual conditions in each census unit. The results of this analysis are indicated on Map 3. It is almost immediately apparent that, although, as previously established, the full range of size classes is present for almost every municipality, there is a tendency for municipalities which are characterized by small average farm size to be also characterized by the fewest classes of farm size.

Map 3


SIZE GROUP COMBINATIONS
BY MUNICIPALITIES - 1961
3 - NUMBER INDICATES NUMBER
OF SIZE GROUPS IN EACH
MUNICIPALITY
SOURCE - SEE APPENDIX "B"
50 25 0 25 50
SCALE IN MILES

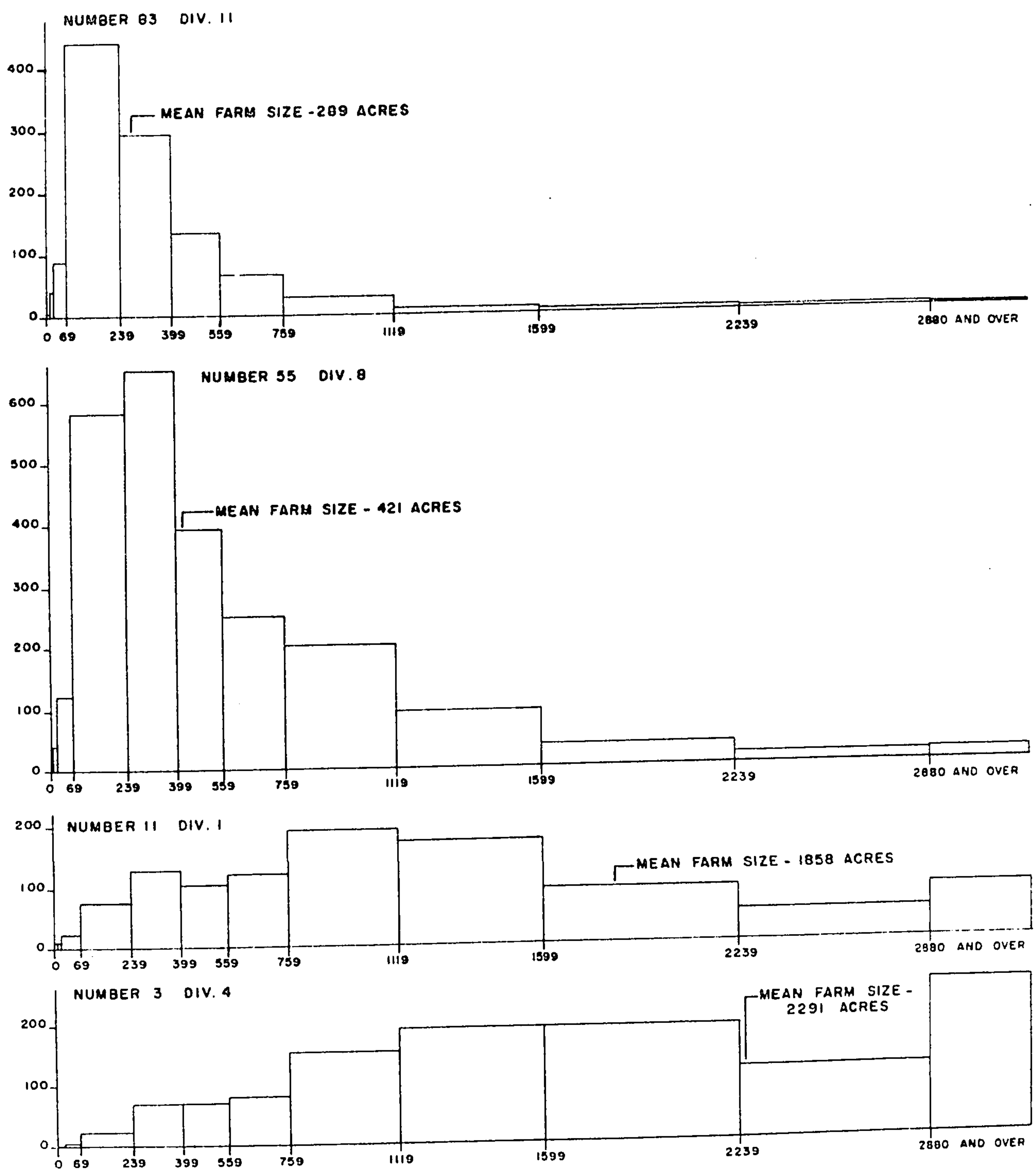
This suggests that the data are grouped more closely about the smaller mean values for farm size than about the larger. The frequency polygons in Fig. 2 offer additional evidence in support of this supposition. They are strongly peaked in Strathcona municipality (number 83, division 11), a little less so in Red Deer (number 55, division 8), and decidedly flat in municipality 11, division 1, and municipality 3, division 4, where no size group predominates. In other words it seems that the mean in areas with smaller farm size is a better representation of the majority of farm sizes as they actually exist than the mean in the south of the province where average farm size is much larger. If the frequency polygon associated with municipality 11 in census division 1 is examined again it is fairly apparent that no size group enjoys an over-riding supremacy. The central ranges tend to be larger but they by no means predominate as sharply as do the lower farm size groups in the polygons associated with municipalities farther north in Alberta.

It must be stressed that this discussion of the frequency polygons has dwelt entirely with the probability of encountering certain values of farm size in a distribution of numbers. If farm size had been discussed in terms of the frequency with which certain sizes were actually encountered while sampling in the field, then it may be assumed that large farms would appear to predominate in southern Alberta primarily because they encompass a greater area of the municipality and hence have a higher probability of being chosen. This, added to the fact that personal field experience has shown that farms of smaller size tend to occur in certain favourable locations rather than being distributed randomly throughout the southern municipalities, would seem to reinforce the above assumption.

Although Weaver's technique has provided the best measure so far of the degree of variability of the data, the actual values are still

Fig. 2

FREQUENCY POLYGONS SHOWING NUMBER OF FARMS IN EACH SIZE CATEGORY



very much in doubt. It is impossible to say with any assurance that the variability of the data around the municipal farm mean is similar for similar combinations of size groups, because, for one thing, the same size of farm size combination is not always made up of the same farm size groups. It is not even possible to determine if the coefficient of variation for municipalities with small combinations of size groups differ substantially from those which have large combinations of size groups because when the standard deviation is expressed as a percentage of the mean farm size for each municipality the size of the mean will strongly influence the result.

The two things that do appear fairly obvious from the above analysis are that the data in many cases tend to be positively skewed around the means and that they tend to be variable. Mean values for each municipality can be considered at this point to be no more than moderately good indicators of regional trends in the areal variation of farm size in Alberta. Consequently, this study will be limited to an exploration of the rudimental relationships between the dependent and independent variables with a view to ascertaining the most relevant variables. Prediction of regional patterns of farm size under similar conditions, but in different geographic areas, or the same area at different times, is therefore not anticipated because the error terms of any regression equation computed from these variable data will clearly be large. This is an important finding and worth stressing because there are large numbers of studies appearing in the professional journals of Geography and Rural Sociology which give no indication of the character of the data upon which the analysis is based. There are exceptions to this generalization, of course, a notable one being W.C. Found's[13] study of farm output in Jamaica in

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[13] W.C. Found, "A Multivariate Analysis of Farm Output in Selected Land—Reform Areas of Jamaica," Cdn. Geogr., vol. 12, no.1, spring 1968, pp. 41-52.

which a description of the sample and standard errors of estimate accompany the results of a series of multiple regression equations, but they remain exceptions.

During the course of this discussion of the distribution of average farm sizes and the characteristics and variability of the data from which the means have been derived it has perhaps been noticed that, in spite of the drawbacks of the data, the means form a pattern that is strongly similar to the pattern of natural resources available to agriculture. If physiographic, soils and climatic maps are examined for instance, there appears to be a relationship that can be established visually at this scale of analysis. In some ways however this observation appears to be contrary to the evidence provided by Map 2, which depicts the frequency of farms by size groups, because in the most difficult areas for intensive farming in southern Alberta, for instance, all size groups are well represented, even the smallest. Yet, if the scale of this study were increased it could in all likelihood be demonstrated, with the aid of land use maps and soil reports, that in most municipalities many of the smaller farms are located in areas that are better suited to more intensive agriculture because of some characteristic of the soil, such as its ability to hold large amounts of water, or perhaps because irrigation water is available. It is probable that economic and cultural factors, such as proximity to urban markets, or the desire of people employed in urban centres to live in a rural environment also play some part in the location of small farms, but it is unlikely that these influences are widespread at the moment because there are few major urban places in Southern Alberta.

Even without a change in scale the influence of irrigation is demonstrated by the frequency with which specific sizes of farms occur in municipalities 4, 14, and 25 in census division 2. A large proportion of farms fall into the 70-239 acres category giving a pattern somewhat similar to that of municipalities farther north in the more humid parts of the province in census divisions 8 and 11. Yet at the same time the influence of the subhumid conditions is also evident in the distribution of the farm sizes because the large size groups are as well represented here as in the municipalities in the subhumid areas immediately to the north and farther northeast in census divisions 5 and 7.

In spite of the doubts raised by the data of Map 2, the original statement concerning the relationship between the average size of farm and the physical resources for agriculture appears to have a fair measure of validity. Farms are large in the south where drought is a frequent hazard. They tend to diminish in size farther north where soil and moisture conditions are conducive to more intensive forms of agriculture and they increase again in the southwest, the extreme north of the main farming area in census division 12, and the Peace River district where intensive farming is somewhat impeded by rough topography, less than optimal drainage conditions and short frost free seasons.

The next section of this study will be an examination of some aspects of the physical environment and the difficulties which were encountered in utilizing, modifying and in some cases deriving objective measures for variables whose effect on farming is essentially qualitative in nature. The use of the term qualitative is deliberate because although it is the custom to refer to the incidence of temperatures below 32° Fahrenheit as an objective measure, the effects of these temperatures is qualitative because they render some agricultural areas "better" than others for specific pursuits. Again it is possible to derive indirect measures of what "better" may mean. These measures may be reduced quality of grain, for example, or reduced yields of a specific crop, or even the percentage of land occupied by a more frost tolerant crop, but in essence they remain indirect measures of the quality of the environment for agriculture.

CHAPTER II

THE STUDY VARIABLES -
THE INDEPENDENT VARIABLES

In the preceding chapter it was stated that there appears to be a spatial relationship between average farm size per municipality and the natural or physical resources available to agriculture in Alberta. Theoretically, this would appear to be a logical relationship because the physical resources set limits on the intensity with which a unit of land can be utilized under given economic and technological conditions. Other factors, such as proximity to market, also influence the intensity of land use but it will be recalled from the preceding chapter that McCarty and Lindberg felt that the importance of transportation costs to the location of specific types of agricultural production was declining relative to the characteristics of the agricultural site. It would also seem reasonable to assume that the influence of other factors, such as transportation costs, would only operate over limited distances, whereas the influence of the physical factors would be more widespread. In fact, at the very small scale at which this study has been conducted, it is likely that the influence of the physical base on the regional character of agricultural activity will be the most important explanatory variable.

The following example may serve to illustrate how the areal variation in the quality of the physical environment influences the intensity with which land is used. First, it should be pointed out that the absolute level of the intensity of land use in Alberta is determined in large part by economic factors such as, the demand for, and price of, agricultural commodities relative to the price of the inputs used by the farmer. Yet, although all farmers may be intensifying their operation, the degree to which they are economically able to intensify will be in large part related to how well their land responds to increased inputs. Fertilizer is used in every municipality in Alberta and its use is likely to increase everywhere because the increased demand for agricultural commodities warrants it. Yet, although it is used everywhere, the magnitude of its use displays a regional pattern that is consistant with the disposition of the great soil groups in Alberta.[1] Where soils have the greatest inherent fertility fertilizer has been used abundantly. Where they have lower fertility it has been used more sparingly. This may, at first, appear to be opposite to what might be expected to be the optimal use of this resource. Yet in terms of marginal analysis it makes good sense because the best soils offer a greater potential for a high rate of economic return when used intensively than many of the poorer soils in Alberta. Where rainfall is relatively high and the other climatic inputs are abundantly available then the resultant agricultural environment is able to absorb additional inputs of fertilizer and labour and to yield large economic returns. In other areas, such as on the light brown soils of southeastern Alberta, there is little value, however, in intensifying an operation by adding large amounts of fertilizer or labour to a soil which in many years lacks sufficient moisture to allow crops to utilize the inherent fertility already present. Stated another way, this example illustrates that there is no point in increasing costs unless revenue is likely to be increased by a greater amount.

It would appear then that there is ample reason to expect an association between the qualities of the physical environment and the

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[1] J.A. Toogood, Data on Fertilizer Sales in Alberta, July 1, 1963-June 30, 1964, Edmonton, 1964, 2 p., (Mimeographed).

intensity with which it is used, provided that cultural conditions, using this term in its broadest sense, exist that make its intensive use possible. The conditions seem to have been present during Alberta's early settlement for at least two reasons. First, there were large numbers of settlers coming from the United States, Eastern Canada and Europe who were aware of the technology associated with intensive farming and were fully expecting to use it in the new agricultural environment of the Canadian Prairies. Second, the Federal government was favourably disposed towards those settlers who wanted to use the land resource of Alberta intensively and it actively legislated against the ranching interests that preceded the settlers into the Canadian West. Consequently the family farm with its emphasis on intensive mixed farming was established almost everywhere in Alberta, with little concern for variations in the physical base in some cases. In fact in many areas farm size was more in keeping with the limits set by the Homestead Act than the physical resources. Where physical and economic conditions favoured the continuance of intensive mixed farming these small farms survived relatively untroubled. Elsewhere where these conditions were not as favourable the smaller homestead farms gradually became part of a much larger holding. They were still managed by one family but the land holding increased to a size more in keeping with the quality of the physical resource base. In this way farmers adjusted the size of their holding to what they thought would be an economic unit. This process is still going on today but the rate at which new land is being added to farms is still in part dependent upon the qualities of the physical environment. The resultant pattern of farm size therefore, continues to reflect in part the qualities of the physical environment.

While the physical environment influences the intensity with which land is used it also sets some limits on the optimum growth of specific types of economically valuable plants and animals. Wheat, for example, needs a longer frost free season than barley, hence there will be a tendency for barley to displace wheat in the northern parts of Alberta. Wheat also has the characteristic of producing a higher quality of grain under dry conditions than when it is grown in a more humid environment. This characteristic coupled with its deep rooting qualities makes it possible for wheat to compete favourably with other crops in the agriculturally less favourable dry parts of Alberta. Consequently, while intensifying their operation in response to the potential offered by the physical environment farmers will have a different array of plants from which to choose depending upon their location. The crops they choose will, of course, in most cases be those which yield the highest net economic return, although there will also be a strong tendency to pick others for different qualities. In some cases, for example, farmers who are just beginning to establish their major enterprise may become involved in relatively uneconomic cream production because they have unimproved land and spare labour and because they need regular income, albeit in small amounts. Others may pick crops which do not yield a direct return on the inputs of labour because they are needed in a long term rotation scheme. Choices such as these and the way in which farmers have attempted to maximize their returns from all their resources result in regional patterns of relatively homogeneous response which partially reflect the influence of the physical environment on agricultural activity. Again it will be stressed that there are other influences such as proximity to urban markets, the amount of disposable income possessed by the general buying public and so forth, but at this point it is only the influence of the physical resources which will be discussed.

Attempts have been made to measure the regional patterns of homogeneous response to the agricultural environment and to produce type of farming regions. The individual farms from which the region is constructed are normally classified by major source of agricultural income, so that terms such as cash grain farming, dairy farming, livestock farming gain an objective meaning or, in other words, the farming types are operationally defined. The results of these attempted measures have generally shown that in addition to the existing relationship between intensity of land use and the average size of farm in any particular district there is also a relationship between intensity of land use and type of farm and hence an indirect relationship between type of farm and size of farm. With regards to this relationship Symons states, " ... It is to be expected ... that a farming landscape will reflect in its farm enterprises the size of farm unit prevalent in the district."[2] Castle and Becker[3] provide additional evidence in tables in their publication which indicate that, in terms of labour and capital inputs per acre Wisconsin dairy farmers use their land resources much more intensively than wheat-fallow farmers in the American Northwest and a little more intensively than farmers producing irrigated cotton in Texas. Consequently, the average size of each of these types of farms bear a strong but not perfect relationship with the intensity with which the land resource is used. Wisconsin dairy farms were 133 acres in size, on the average, in 1958, wheat-fallow farms were 1,331 acres in extent and irrigated cotton farms in Texas were 351 acres in size for the same time period. At first glance this would seem to bear out perfectly the stated relationship between the intensity with which the land resource is

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[2] L. Symons, Agricultural Geography, Bell, London, 1967, p. 79.

[3] E.N. Castle and M.H. Becker, Farm Business Management, Macmillan, New York, 1962, pp. 20-21.

used and the average size of farm. If, however, the tables in Castle and Becker's book are examined closely the irrigated farms, although in the right rank order of size would appear to be too large in terms of the intensity with which the resources were used on them, but if long term net income per farm for 1948-1957 were also to be examined the reason would become more apparent. The Texas irrigated farms are much larger businesses than the Wisconsin dairy farms. In fact there is no type of farm business that is smaller than Wisconsin dairy farming in terms of net farm income, except cotton farming in the economically depressed Piedmont of the Southern United States. This suggests that an examination of the relationship between type of farm and size of farm must also somehow account for variations in the size of the farm business if the true relationship is to be discovered.

In summary, there appears to be good evidence for accepting the hypothesis that the distribution of average farm size in Alberta bears some relationship to the distribution of the physical resources for agriculture. It also seems reasonable in light of the findings of other researchers to expect a relationship between farm size and type of farm if a suitable method exists for defining the latter variable. It must not be forgotten however, that if a good indication of the relationship between all of these variables is to be ascertained then the size of the farm business must also be taken into account, particularly if we have any reason to believe that farm business size is not randomly distributed.

In this chapter some of the independent variables presumed to affect the areal distribution of farm size will be examined. Specifically, the variables to be examined are, measures of the suitability of the physical environment for agricultural activity, type of farm, size of the farm business and finally what is believed to be an indirect measure of the influence of proximity to city markets on the distribution of average farm size: the value of lands and buildings per acre of land in farms.

The Physical Environment for Agriculture

Many writers are in agreement that climate is an important component of the physical environment influencing the distribution of agricultural activity. Symons states,

> Climate is the principal aspect of the physical environment affecting agriculture. Every form of plant or animal life requires certain conditions from its environment for it to be able to survive, and somewhat more stringent conditions if it is to reproduce naturally.[4]

Chapman and Brown appear more emphatic in their assessment of the role of climate in agriculture. They state, "Climate dictates what crops may be grown and is mainly responsible for yearly variation in yields."[5] Climate, obviously, does not operate in a vacuum because as has been suggested previously in the introduction to this chapter the social and economic environments also play an important role in the farmer's decision-making processes, but these decisions are most successful if suitable allowance is made for climatic variables.

The two most important features of the continental position of Alberta which affect its climate are the northerly latitudinal location of the province and its position in the interior of the North American continent in the lee of the Rocky Mountains. The first factor has resulted in low annual temperatures and short frost free growing seasons which tend to become shorter in a northerly direction. The second factor has influenced the precipitation regime in Alberta

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[4] L. Symons, op. cit., p. 21.

[5] L.J. Chapman & O.M. Brown, The Climates of Canada for Agriculture, The Canada Land Inventory Report No.3, Dept. of Forestry and Rural Development, Ottawa, 1966, p. 1.

because the moisture contents of the eastward moving maritime Pacific air masses are normally reduced through orographically induced precipitation over the mountains. The operation of these two broad factors has produced a latitudinal zonation of climatic types within the province ranging from subarctic, in the Koeppen climatic notation, in the north through humid continental cool summer and mid-latitude steppe to the south.

At the provincial scale of analysis the role of the physiography of Alberta is as important to climatic variation as latitudinal position. The general landform of most of the province is a plain composed of relatively young, poorly consolidated, Cretaceous and Tertiary sedimentary rock, overlain in almost all areas by continental and in the extreme west, Alpine glacial deposits dating from Pleistocene glaciation. This plain rises gradually in altitude from east to west so that the western margin of the plain is some 2,000 to 3,000 feet higher than the plain at the Alberta-Saskatchewan border. There is also a tendency for the altitude of the plain to decrease in a northerly direction. The latitudinal advantage of Calgary over Edmonton, for example, is largely overcome by this change in elevation and it is unlikely that agriculture would be successful as far north as Fort Vermilion if elevation were not relatively low. There are a number of relief anomalies scattered over the major physiographic feature of Alberta. The Milk River ridge in southern Alberta, the Cypress Hills in the extreme southeast and a series of smaller erosional remnants and fairly extensive terminal moraine systems in central and northern Alberta all have their effect on local climatic variations and agricultural patterns. In southern Alberta, for example, the more pronounced of these features have become associated with extensive grazing systems and farther north they interrupt the pattern of cash grain production and the more intensive arable systems associated with mixed farming in central Alberta. Maps showing slope, relief, and land use patterns in an unpublished master's thesis[6] and the Atlas of Alberta[7], respectively give a visual but indirect representation of the complex relationship which exists between major variations in slope and agricultural land use.

The major effect of relief on climatic patterns, however, is most evident in the western portion of the plain. As elevations gradually increase to the west temperatures decrease. In this way precipitation is rendered more effective for plant growth because of lower moisture losses through evaporation. Conversely the same amount of precipitation would be less effective on the lower plains farther east because of the higher daily temperatures, even though both examples may occur at the same parallel of latitude. Map 4 indicates the effect of increases in latitude and altitude on the mean daily temperature. Isotherms tend to decrease in value in both a north to north-easterly direction and to the west so that there is a zonation to the north in response to latitude and to the west in response to altitude. Anomalies due largely to major changes in local topography are also fairly obvious. Average temperatures tend to decline in the extreme south and southeast parts of Alberta because of the presence of the previously mentioned major erosional remnants. The effect of the extensive moraine systems is not obvious at this scale but the fact that there is an effect will become more obvious later when the major soil groups of Alberta are examined.

The length of the frost free period is also linked to the aforementioned climatic controls of latitude and altitude. The

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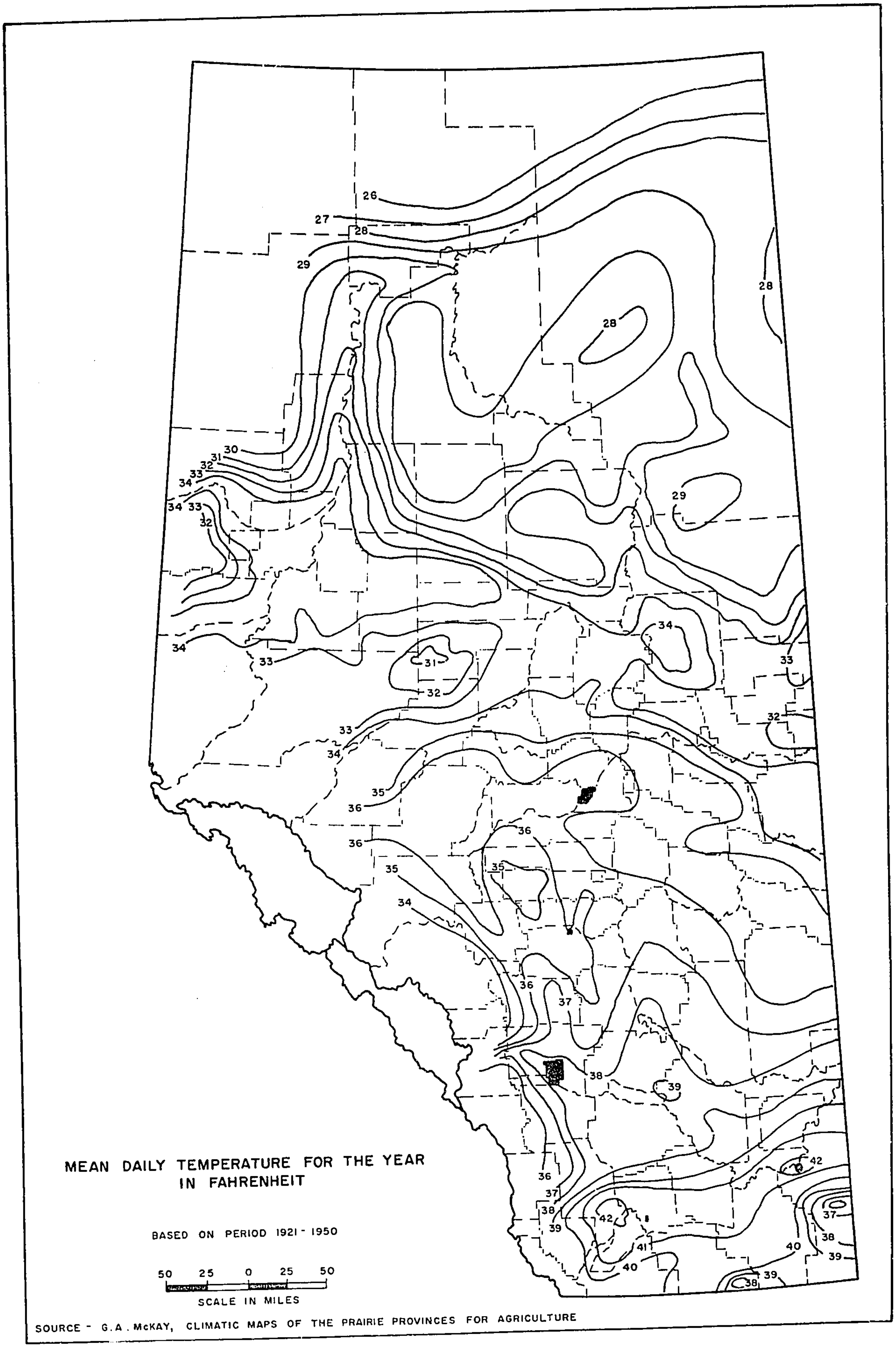
[6] M. Bullock, A Land Form Map of Southern Alberta, unpublished M. Sc. thesis, University of Alberta, Edmonton, 1966, 160 pp.

[7] Atlas of Alberta (in press)


MEAN DAILY TEMPERATURE FOR THE YEAR
IN FAHRENHEIT
BASED ON PERIOD 1921 - 1950
50 25 0 25 50
SCALE IN MILES
SOURCE - G.A. McKAY, CLIMATIC MAPS OF THE PRAIRIE PROVINCES FOR AGRICULTURE

isolines showing the length of the frost free period are shown on Map 5 and their distribution is, as may have been expected, not much different than the distribution of isotherms simply because both variables are related to the same thing: the amount of thermal energy available for plant growth. The effect of the hummocky moraine systems surrounding Red Deer and well to the south, coupled with a general westward increase in elevation, appears somewhat more pronounced in the distribution of the length of the frost free period, however than in the distribution of mean annual daily temperatures. The frost free season in this area is noticeably shorter than on the surrounding plain and in agricultural districts much farther north. Longley and Louie-Byne[8] examined early morning summer temperatures in a small district north of this area and some 30 miles farther west but their findings seem applicable to some degree because their study area possessed similar physiographic conditions to those existing in the hummocky moraine surrounding Red Deer. They discovered that there was seldom a month in which temperatures at or below 32° Fahrenheit were not experienced in the low-lying hollows and valleys of the district. This condition is associated with more than physiographic conditions, however, because temperatures were even lower in areas of muskeg but the broken relief coupled with elevations in excess of 3000 feet seem nevertheless, to be two of the most important factors affecting the length of the frost free season.

Although latitude and elevation appear to have an important effect on the thermal patterns and to some degree the distribution of moisture available to plants both directly through changes in elevation and indirectly through influences on the thermal regime, they have little

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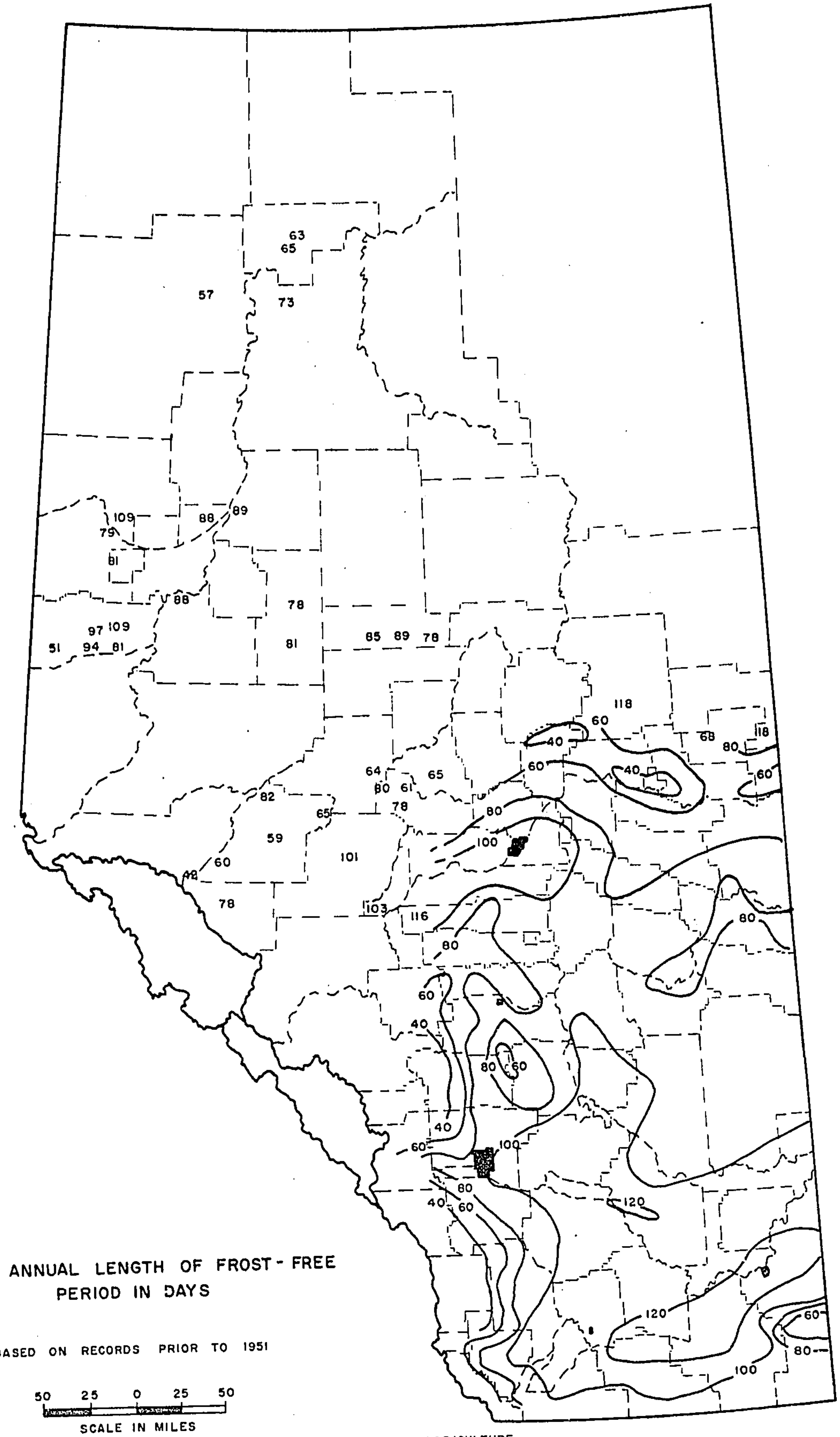
[8] R.W. Longley and M. Louis-Byne, Frost Hollows in West Central Alberta, Technical Circular of the Meteorological Branch, Canada Dept. of Transport, No. 4532, Toronto, 1967, 17 pp.

Map 5



MEAN ANNUAL LENGTH OF FROST - FREE PERIOD IN DAYS

BASED ON RECORDS PRIOR TO 1951

50 25 0 25 50
SCALE IN MILES

SOURCE - G A McKAY, CLIMATIC MAPS OF THE PRAIRIE PROVINCES FOR AGRICULTURE influence on one of the most important features of the climate for agriculture: the seasonal distribution of precipitation. As a result of increased frontal activity and thermal convection, 40 to 50 per cent of the total annual precipitation falls during the three summer months.[9] The remainder falls throughout the balance of the year leaving the spring and fall months relatively drier because of the increased availability of thermal energy. The annual and summer patterns of precipitation are shown on Maps 6 and 7. It is this regime that has made cash grain farming a relatively stable farm enterprise in much of Alberta. The relatively dry spring makes it possible to get onto the land quickly so that little of the short frost free season is lost to agriculture. Most of the precipitation falls during the period that cash grains experience their maximum need for water, then it decreases in the fall and thereby facilitates the harvesting process which must take place quickly to avoid crop damage. If the pattern is broken by unseasonable weather then the cash grain farmer experiences severe difficulty with his crop because if he is tardy in getting onto the land in the spring or his crop off in the fall the crop will likely be reduced in quality because of the effect of excessive frost and/or moisture.

It should not be assumed, however, that winter precipitation plays no role in crop production. In southern Alberta, in the Bsk climatic region, for example, there are large moisture deficits in spite of the fact that most of the annual precipitation occurs in the summer months. Under these conditions it is the wetness of the fall and the amount of winter precipitation that remains as snow in the spring that strongly influences the ultimate size of the crop. If enough snow remains to recharge the soil moisture close to capacity

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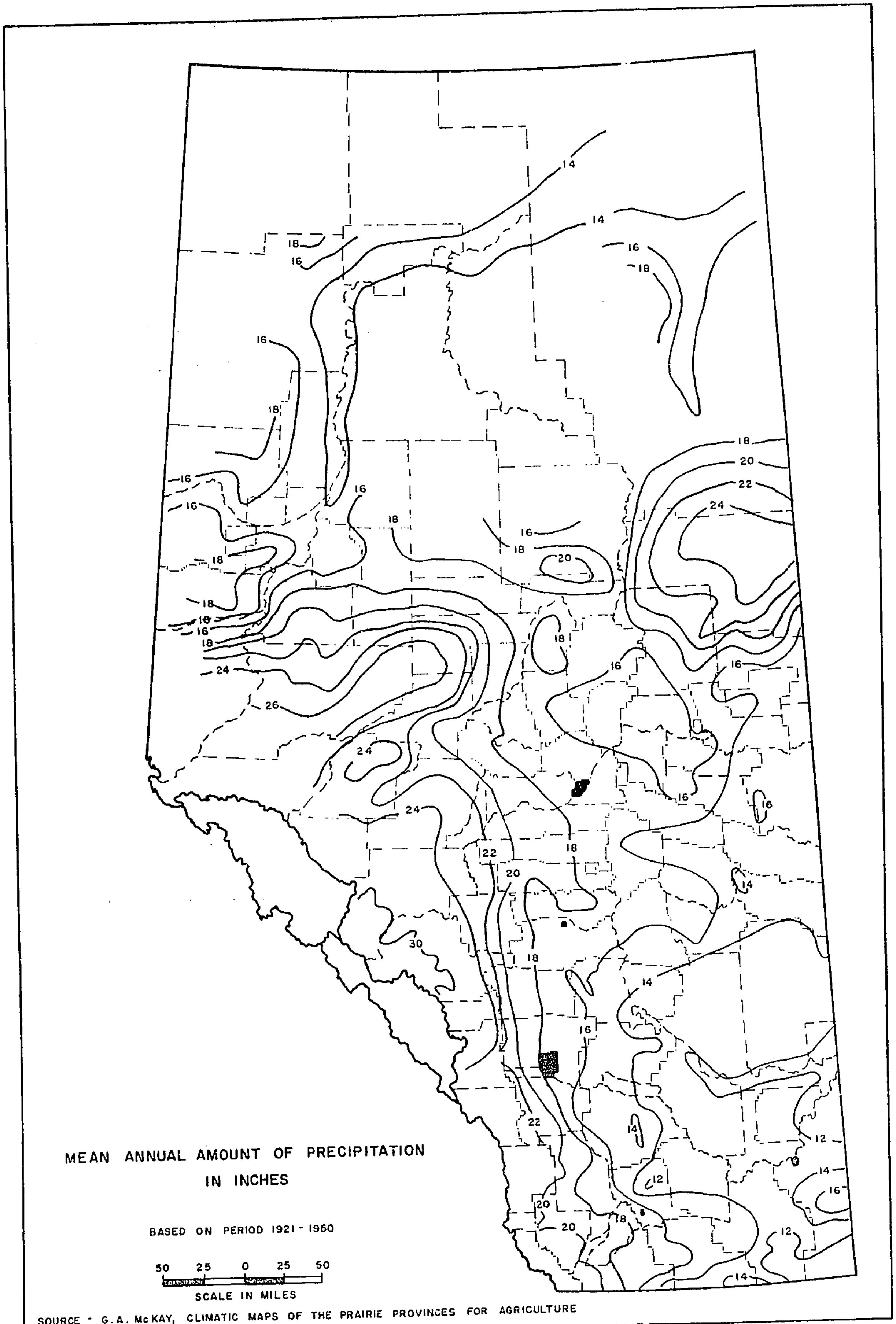
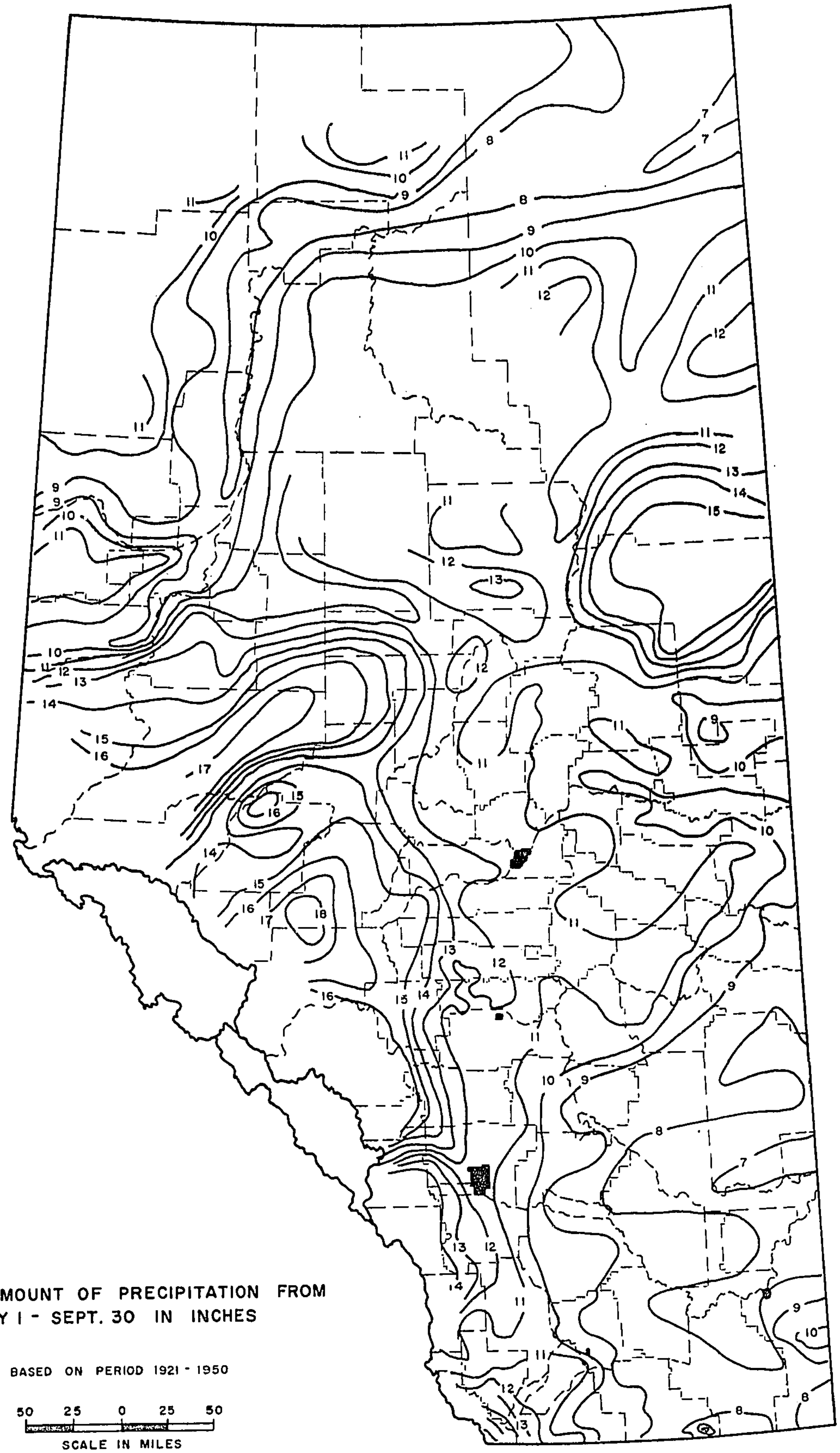
[9] L.J. Chapman and O.M. Brown, op. cit., p.3

Map 6


MEAN ANNUAL AMOUNT OF PRECIPITATION
IN INCHES
BASED ON PERIOD 1921 - 1950
50 25 0 25 50
SCALE IN MILES
SOURCE - G. A. McKAY, CLIMATIC MAPS OF THE PRAIRIE PROVINCES FOR AGRICULTURE



MEAN AMOUNT OF PRECIPITATION FROM MAY 1 - SEPT. 30 IN INCHES

BASED ON PERIOD 1921 - 1950

50 25 0 25 50

SCALE IN MILES

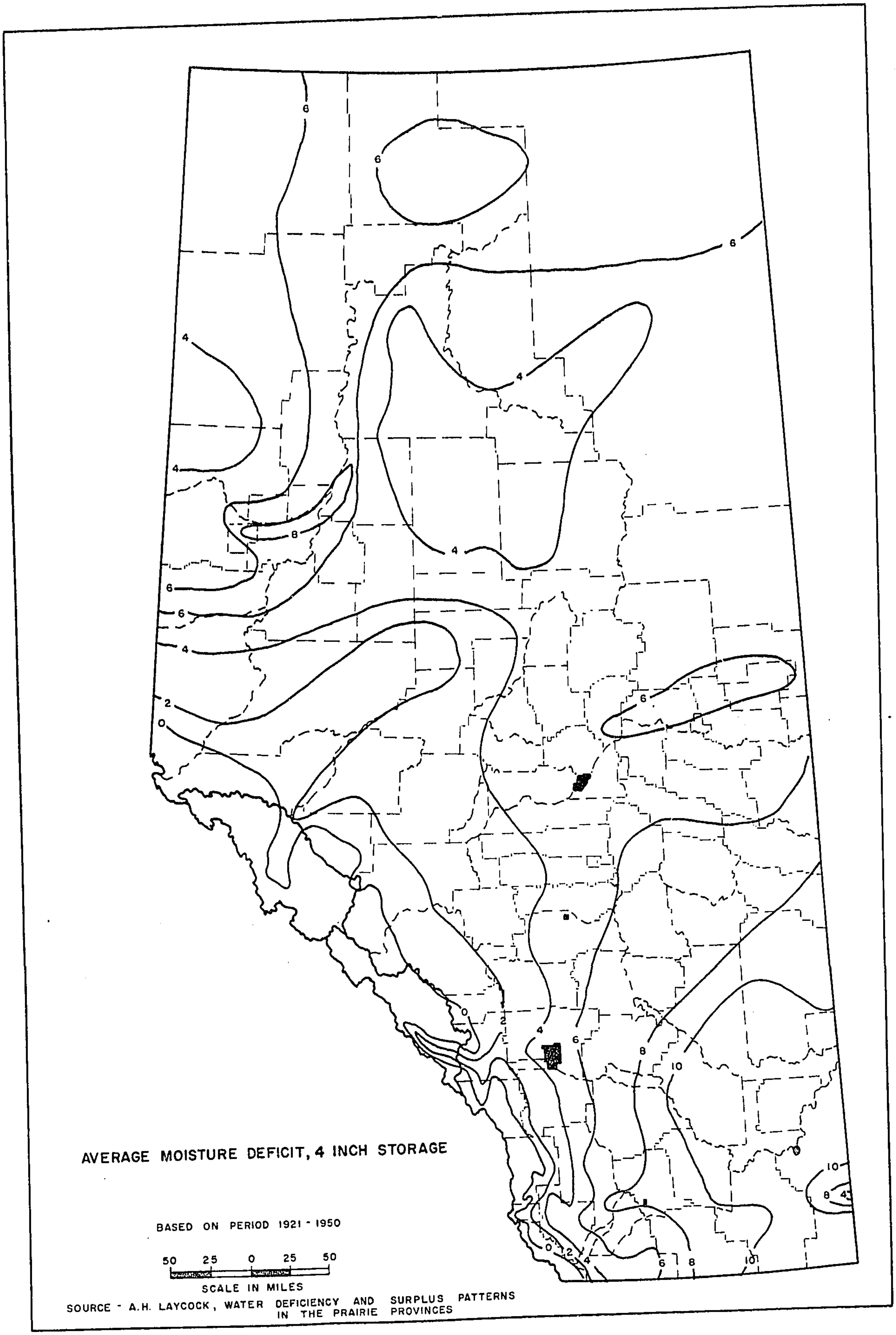
SOURCE - G. A. McKAY, CLIMATIC MAPS OF THE PRAIRIE PROVINCES FOR AGRICULTURE then the probability of obtaining a crop of average yield is high. If this initial input of water is supplemented with average or above average summer precipitation, then the probability for an above average yield is high. Although frontal activity largely determines the amount of winter precipitation, the amount that remains in the southern agricultural areas for soil moisture recharge is strongly influenced by two weather phenomena well known on the prairies: blizzards and chinook winds. If blizzards occur frequently there is a tendency for snow to be blown out of the flat prime cash grain districts into ditches, fencelines and into less useful local areas of rolling physiography. Chinook winds on the other hand remove winter snow through evaporation, particularly in southwestern Alberta in proximity to the foothills of the Rocky Mountains. This latter phenomena also has significance for other types of farming, as shall be demonstrated later.

As previously observed, even though latitudinal position and elevation do not directly control the seasonality of annual precipitation they do influence its effectiveness because these two factors affect the average temperatures in the various parts of Alberta. Consequently maps indicating the regional and seasonal patterns of precipitation do not add much to an understanding of the regional distribution of farm size if there is not also some indication of the regional effectiveness of precipitation for agriculture. In southern Alberta, for example, annual precipitation totals twelve to fourteen inches, but up to twenty-four inches could be used if it were available for plant growth because average summer temperatures are higher here than farther north. Even in central and northern Alberta where precipitation is generally more abundant there is, nonetheless, need for an additional four to five inches of summer precipitation. Within the Peace River District needs are even greater. Map 8 shows that, in spite of the northerly latitudinal position of this district, the summer thermal regime combined with low amounts of precipitation has produced moisture deficits of higher numerical value than those found farther south in the district between Red Deer and Edmonton.

Perhaps it should be stressed at this point that moisture deficit has been computed for this study using the normal four inch storage capacity. The amount of soil moisture will, of course, also vary with the texture of the soil and the type of crop grown on it. If it could be shown that large areas of an unusually heavy or light-textured soil dominates a particular part of the province then soil moisture deficit could be adjusted accordingly. The same would hold true for crop specialization. More soil moisture is available to alfalfa for example because of its deep rooting characteristics. For the purpose of the present study, however, no adjustment was made because it was felt that the variation in soil texture is so great in each municipality that it would be a meaningless gesture at this scale. No adjustment for crop specialization was made either because again it is difficult to determine at this scale where, with reference to soil texture, the specific crops in each municipality were grown. This is an interesting problem nevertheless, because it will doubtless affect the validity of conclusions derived from the following examination of the relationship between soil moisture deficit and the average size of farm.

The discussion of the characteristics of the major soil groups has been delayed to this point because the regional patterns of soil quality cannot be fully appreciated without some prior knowledge of the physiographic and climatic patterns of the province. Once these are understood, however, the underlying reasons for the location of a specific soil group becomes much more obvious because

Map 8


AVERAGE MOISTURE DEFICIT, 4 INCH STORAGE
BASED ON PERIOD 1921 - 1950
50 25 0 25 50
SCALE IN MILES
SOURCE - A.H. LAYCOCK, WATER DEFICIENCY AND SURPLUS PATTERNS IN THE PRAIRIE PROVINCES
6
6
6
4
4
4
8
6
6
4
2
0
4
6
0
2
4
6
8
10
10
8
0
2
4
6
8
10

the major soil groups are to a large degree an expression of the major climatic conditions in any area. Chapman and Brown state, "To a considerable extent soil profiles reflect the effects of climate, and soil zones serve in a general way as climatic zones."[10] Symons elaborates on this theme somewhat and says that, "The characteristics of the soil, ... are largely the product of present and past climates and the vegetation that has flourished in them ..."[11] In this statement he seems to be also suggesting that vegetation affects the qualities of the soil independently of climate. This seems reasonable in that there may be special characteristics possessed by the parent material which limit the growth of the climax vegetation normally expected under certain climatic conditions, but for the most part it would seem that the independent effects of vegetation are minimal because the vegetational complex in any region is itself an expression of the long term average climatic conditions. Symons goes on to say that, " ... the effects of relief are to no small degree expressed through [the] resulting climatic variation."[12] If his previous statements concerning the relationship between the climate and the major characteristics of the soil are acceptable then this suggests that changes in relief also produce characteristic changes in the quality of the soil. In other words even if the amount of precipitation across the southern plains of Alberta were constant, a change in the soil characteristics would nevertheless occur on the erosion remnants and in the western margin of the plain because of increases in the

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[10] L.J. Chapman and O.M. Brown, op. cit., p. 1.

[11] L. Symons, op. cit., p. 21

[12] Loc. cit.

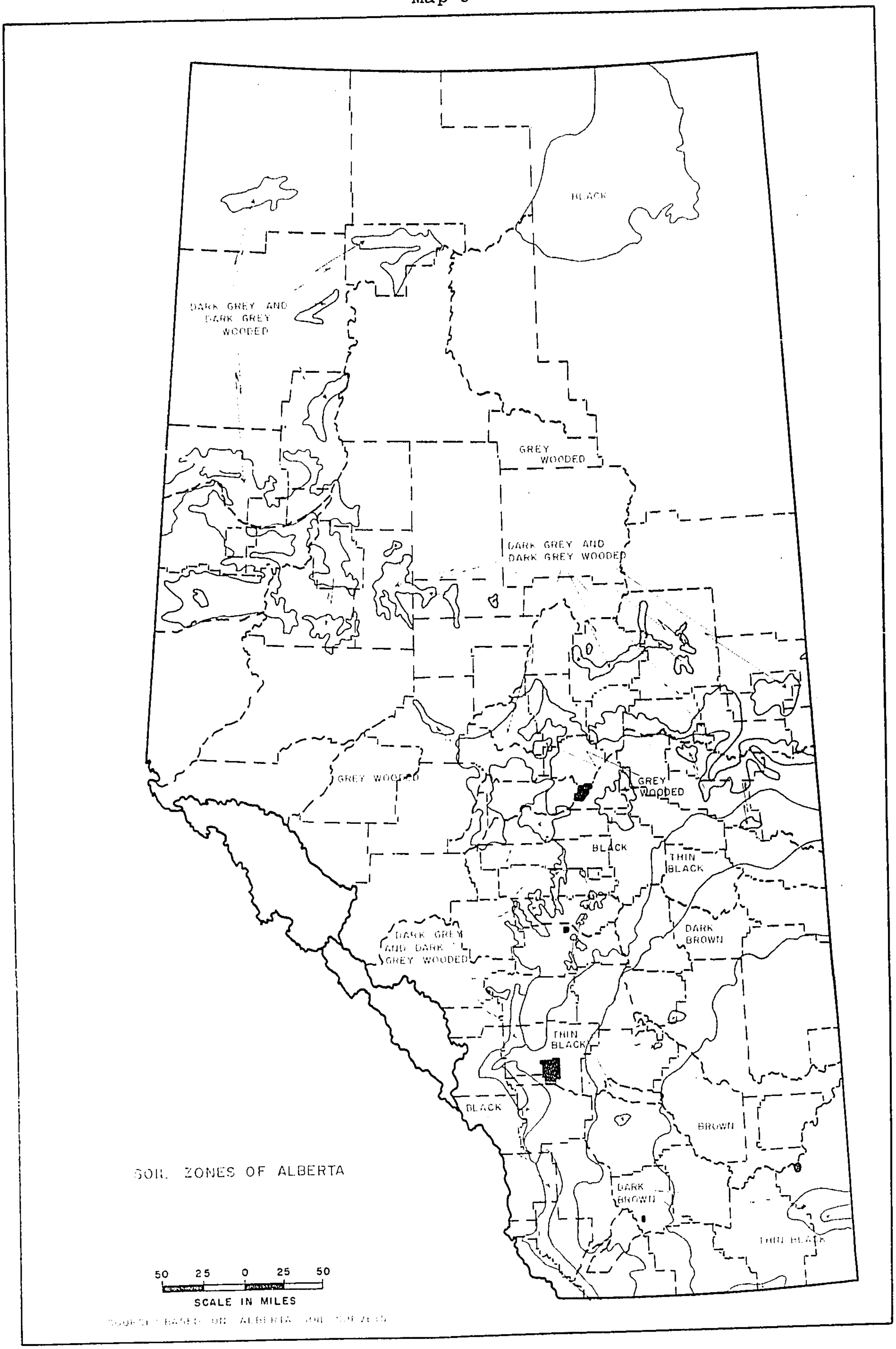
effectiveness of precipitation for plant growth due to increases in elevation, provided, of course, that plants could produce under the lower average temperatures.

The major soil groups of Alberta, shown on Map 9 are arrayed in a series of concentric arcs with the Brown Soil Zone at the core. This pattern reflects in large measure the average annual water deficit which is indirectly linked to latitude and elevation. Even the fairly minor changes in elevation associated with the erosional remnants in the south and the major moraine systems in the north are indicated on the map by corresponding changes in the characteristics of the soil. In southeastern Alberta, for example, the soils of the Cypress Hills are the more fertile Dark Brown and Thin Black, whereas the Cooking Lake moraine system to the east of Edmonton and the Buffalo Lake Moraine system between Edmonton and a point south of Red Deer are indicated by the less fertile Grey Wooded and Dark Grey and Dark Grey Wooded soils respectively.

Even though there is a reasonably close correlation between the major soil zones and the general climatic patterns it should not be inferred that the association is perfect. Chapman and Brown, for example, have mapped climatic regions for agriculture based on temperature and moisture patterns in Canada whose boundaries coincide only in a general way with those of the great soil groups in Alberta. To begin with, Chapman and Brown's regions often straddle the boundaries between two major soil zones. In other cases the southern portions of a specific soil group are shown as possessing more degree days, a longer frost free season and a larger moisture deficit than the more northerly reaches.

Variations in soil quality pose another problem in the uses of soil zones as indicators of the suitability of the physical environment for agriculture. This problem is particularly noticeable in the

Map 9


BLACK
DARK GREY AND
DARK GREY
WOODED
GREY
WOODED
DARK GREY AND
DARK GREY WOODED
GREY WOODED
GREY
WOODED
BLACK
THIN
BLACK
DARK GREY
AND DARK
GREY WOODED
DARK
BROWN
THIN
BLACK
BLACK
BROWN
SOIL ZONES OF ALBERTA
DARK
BROWN
THIN BLACK
50 25 0 25 50
SCALE IN MILES

Brown Soil Zone where high summer temperatures and low amounts of precipitation have resulted in the formation of solonetzic soils wherever the parent materials and/or bedrock are saline. Therefore, even though this soil zone is shown as a homogeneous unit, the actual conditions for plant growth vary areally in response to the physiological drought engendered by the saline soil conditions.

In spite of these drawbacks, the major soil zones of Alberta were accepted in this study as an important variable affecting the areal distribution of average farm size. It was at first assumed that the colour of the soil groups would be the best criterion by which to assess the suitability of the physical environment for intensive agriculture. This assumption arose from the observation that colour seems to be directly related to the fertility of the soil and an indirect indicator of climatic conditions for agriculture and hence of its ability to support a specific level of intensity of agriculture. It was accepted, therefore, that the soils increased in their ability to support intensive farming practices, under a given level of technology from the Brown Soil Zone through to the Black or chernozem soil group. Unfortunately no further assumptions could be made as to the rank order of the soils beyond this point. The Dark Grey, Dark Grey Wooded and Grey Wooded Soil Groups are obviously not as good for agriculture as the Black Soil Group, but it could not be determined whether they were generally better or worse than the Dark Brown and Brown Soil zones because climatic conditions for agriculture are markedly different in each zone. On the one hand crops are exposed to lower average temperatures, the hazard of frost, more humid conditions (although not always, particularly in the Peace River District) and problems with drainage in the Dark Grey and Grey Wooded areas while on the other drought is the major drawback.

Several attempts were made to resolve this problem. Soil scientists were approached and asked to rank the soils in terms of their ability to support specific levels of agricultural activity, but this proved to be a premature request because soil capability for agricultural production is just now being examined as part of the overall Canada Land Inventory conducted by the Agricultural and Rural Development Agency. Next the soil ratings presented in the Land Class Maps of the individual soil reports of Alberta were examined with a view to using the six and four miles to the inch soil rating maps as a basis for assigning an average soil rating to each municipality in the province. This was undertaken experimentally for a number of the southwestern municipalities using transparent overlays with a dot pattern spaced in such a way that each dot fell onto the centre of each quarter section shown on the underlying soil rating map. The area of each soil rating was next calculated by counting the number of dots which fell into that particular rating. Finally the total number of dots for each rating was multiplied by the area of the quarter section (160 acres) and converted to a percentage value of the total land in farms. This last value, total land in farms, was obtained from the census. The final soil rating value which potentially could range between one for the poorest soil and eight for the best was obtained by the following formula:

$$\text{Soil Rating} = \frac{\sum \text{(Percentage of Land Area in Specific Soil Rating x Soil Rating)}}{\text{Total Percentage of Land Area in All Soil Ratings in Each Municipality}}$$

Some of the actual values obtained by this procedure are as follows: municipality no. 10, division 9, soil rating 2.00, municipality no. 9, division 3 (Pincher Creek) soil rating 4.17, municipality no. 6, division 3 (Cardston), soil rating, 4.21, municipality no. 5, division 2 (Warner) soil rating 4.17, and municipality 31, division 6 (Foothills) soil rating 4.94. If these ratings are compared with the major soil groups in each municipality it will be seen that the first rating in census division 9 is represented by the Black Soil Group, the second (Pincher Creek) by Black and Thin Black, the third (Cardston) by Thin Black and Dark Brown, the fourth (Warner) by Dark Brown and Brown and the last (Foothills) by Black and Thin Black Soil Group again. If the assumptions concerning the relationship between the colour of the soil and its fertility are correct then these results would suggest that there are other factors in addition to soil fertility strongly affecting the soil ratings in these municipalities. A closer examination of the actual physical conditions for agriculture suggested that the ratings in municipalities where Black and Thin Black soils predominate, were low because of the nature of the surficial configuration of land and the high elevations. In short, although both have soils of good quality, these soils occur in the rolling terrain of the foothills of the Rocky Mountains which is not conducive to mechanized agriculture. The soil ratings for the last three municipalities, although low, are more in the order that one would expect, with Warner County (number 5, division 2) on the Brown soils ranking the lowest and Foothills County (number 31, division 6) on the Thin Black soils the highest.

This ranking procedure was pursued no farther than this initial experimental stage, however, because there were too many problems associated with it. One of the most serious drawbacks of the rating procedure for this study was that it had been developed to assess the physical environment for wheat only. This suggests that only certain aspects of the environment were considered and if these were not suitable for wheat then the area was given a low score. Yet, in reality, the area may well have had excellent possibilities for other high value crops such as rapeseed or forageseed. Another major problem associated with the use of this rating procedure is that it is not complete for the province. It had been originally hoped, by the author, that the Canada Land Inventory soil capability maps completed to date would have served to remedy the gaps in the soil rating coverage, but in actual practice it was found not possible because, in a personal interview, one of the original authors of the soil rating system suggested that for the level of accuracy demanded in an analysis of the areal variation of farm size the soil ratings could only be compared within specific soil zones, not between them.[13] It seemed wise, at this point, to abandon the idea of assigning a value to soils or arranging them in order of their fertility or value to agriculture. Instead it was decided to change the method of statistical analysis from one which demanded numerical input to one which would accept the identification of the various subclasses of the single variable. Consequently the problem now became one of determining which soil group or soil groups best described the qualities of the soil in each municipality. The results of this analysis and the association between soil zones and farm size will be described in the next chapter.

Type of Farm

The Dominion Bureau of Statistics has devised a classification of "types of farms" using the percentage of income derived from the sale of agricultural commodities as its basic criteria. They are defined in the 1961 Census of Canada by the following product types: Dairy, Cattle-Hogs-Sheep, Poultry, Wheat, Small Grains, Field Crops-Other Than Small Grains, Fruits and Vegetables, Forestry, Miscellaneous Specialty, and Mixed. The last type is subdivided further into Livestock Combination, Field Crops Combination and a residual category called Other Combinations, for farms which do not fall into any of the

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[13] Pers. Comm. W.E. Bowser, Canada Dept. of Agriculture.

above categories.[14] Farms were classified into these types if 51 per cent or more of the income was derived from the direct sale of the commodity listed in the name of the farm type. Farms could also be listed as a specific type even if the percentage of the income derived from the sale of the commodity listed in the name of the farm type was less than 51 per cent, as long as the income derived from the sale of products directly associated with the main commodity type totalled more than 51 per cent when added to the main source of agricultural income. This subsection of the rating procedure was established to handle situations like those posed by dairy farms. On many farms the sale of dairy cattle, particularly calves, is an important source of income in addition to sale of dairy products. In this type of situation it is possible for the sale of dairy products to account for less than 51 per cent of total income from agricultural sales, but if the sale of dairy cattle is considered as directly related to the production of milk then the farm could be correctly considered a dairy farm in terms of the above addition to the main definition. In some cases it was found that farms qualified for more than one type especially when the expanded definition was used. Under these conditions the Dominion Bureau of Statistics deemed it necessary to establish a priority rating. In this way when a farm qualified for two or more types it could be placed objectively into one of the established categories. The above example of dairy farms may be used once again to show how the priority system works. If the sale of cattle in the previously cited example produced 60 per cent of the total farm revenues from the sale of agricultural commodities and dairy products 40 per cent, then the farm could qualify either as a dairy

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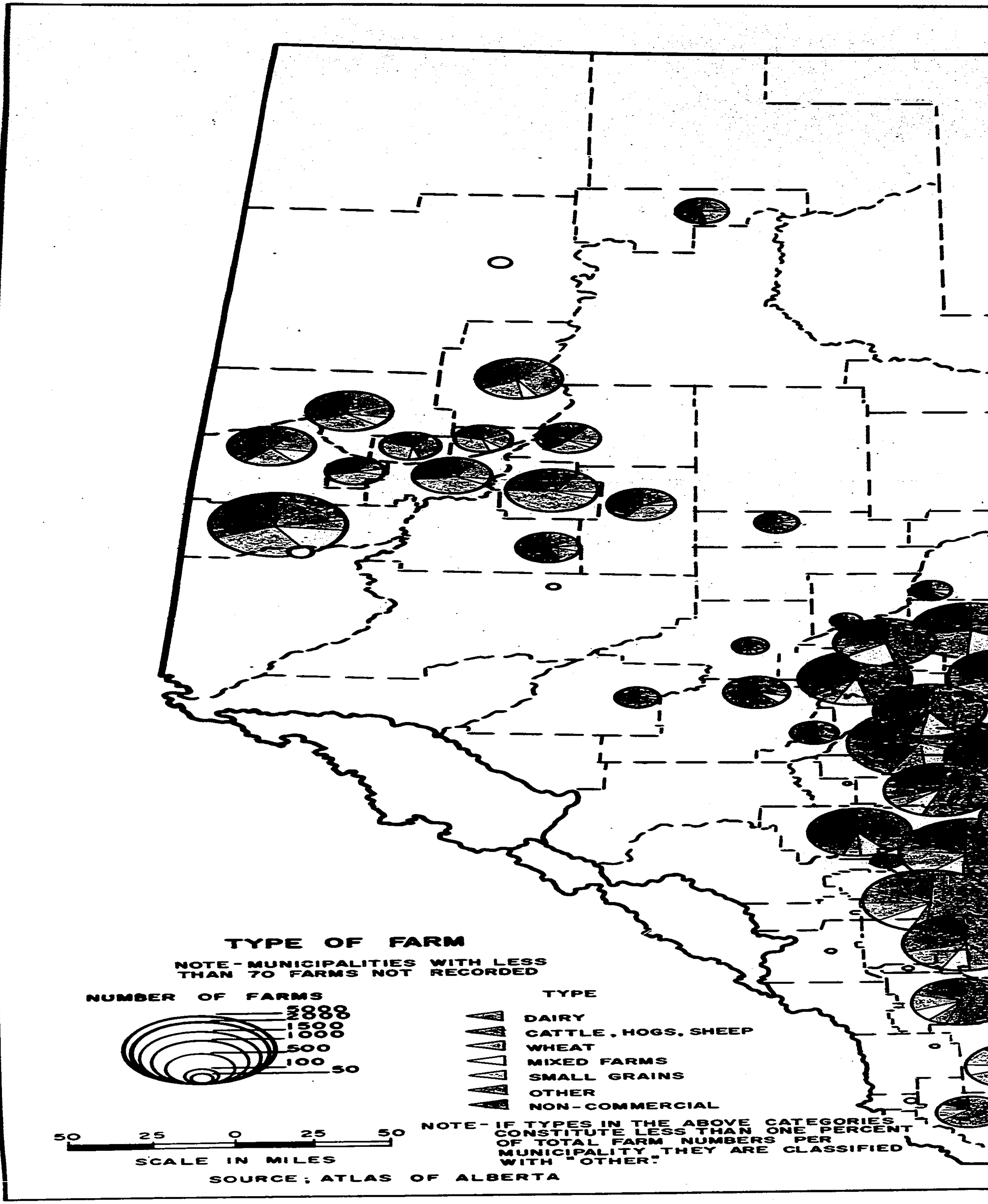
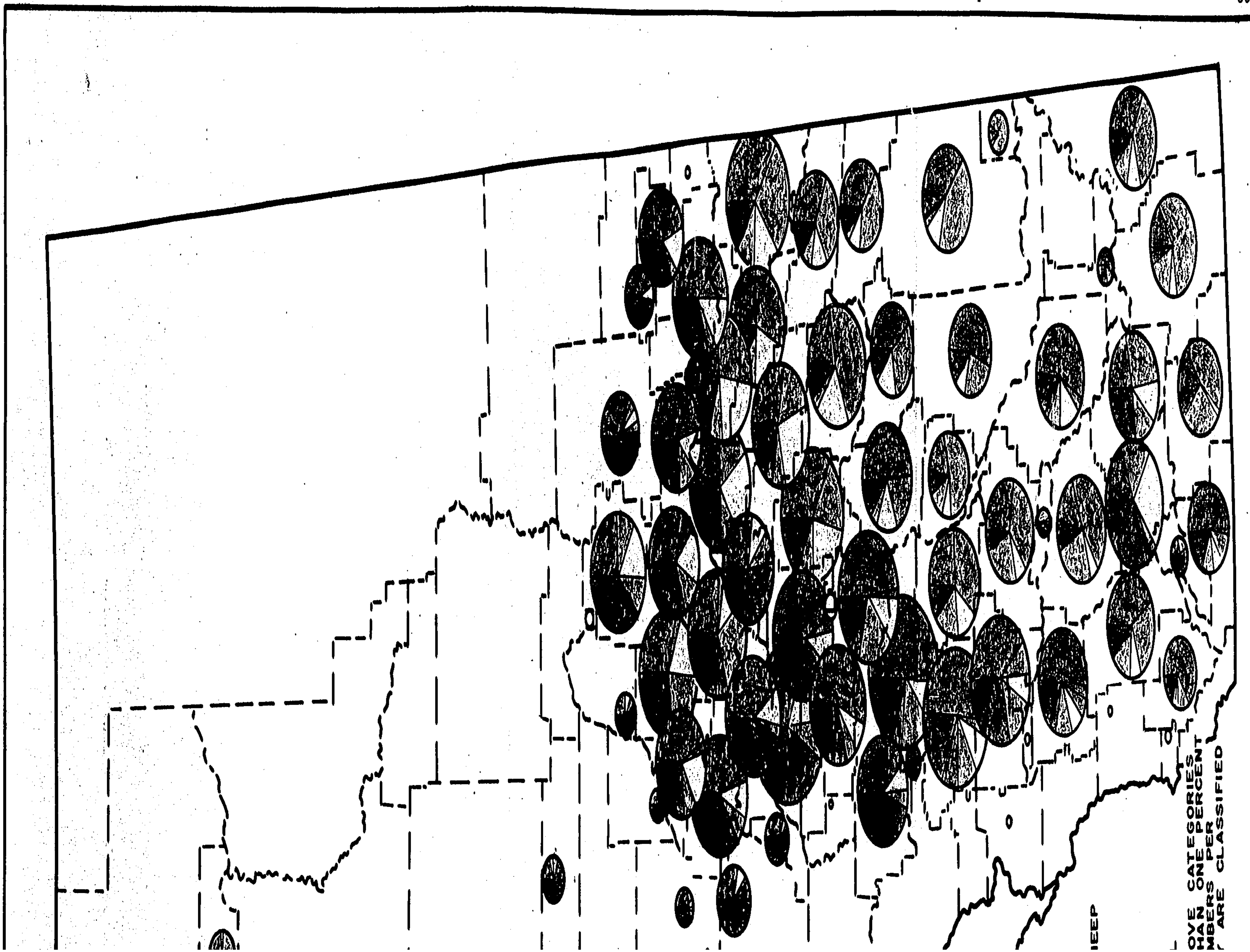
[14] Canada, Dominion Bureau of Statistics, Census of Canada, vol. 5, pt. 3, no.3, Agriculture: Alberta, Ottawa, 1961, p. xii.

farm under the expanded definition, or a Cattle-Hogs-Sheep farm, because in both cases the farm income meets the criterion of 51 per cent in one commodity. The Dominion Bureau of Statistics suggests this type of problem may be resolved by putting the farm in question into the first type of farm category in which it would fit using the rank order ranging from dairy farms to mixed farms cited in the first part of this section of Chapter Two.

Only commercial farms, that is farms on which 1200 or more dollars were received from the sale of agricultural products, were subdivided into the various categories of type of farm, but farms with less than 1200 dollars of sales could also be considered in a broad sense as another type of farm so they too were added to the above classification for the purposes of this study. The legend of Map 10 lists, therefore, seven types of farm: Dairy, Cattle-Hogs-Sheep, Wheat, Small Grains, Mixed Farms, Other, and Noncommercial. No other types were listed because they constituted less than one per cent of the farms in any municipality. Mixed farms were not subdivided for mapping purposes because so few cases existed in the mixed field crop category, but they were subdivided into the two major categories for the purposes of numerical analysis. The category of "Other" is not the residual category, "Other Combinations", which was cited above in reference to the Dominion Bureau of Statistic's list of types of farms; rather it is a category into which any type of farm was put if it formed less than one per cent of the total number of farms in each municipality. Once again, however, the actual number of a specific type of farm in each municipality was used in the numerical analysis as long as the farm type was one of the major types appearing in the legend of the map. If small grains farms constituted less than one per cent of all farms in a municipality, for example, it was not mapped but, the number of farms was, nevertheless, used in the numerical analysis.



TYPE OF FARM
NOTE - MUNICIPALITIES WITH LESS THAN 70 FARMS NOT RECORDED
NUMBER OF FARMS
5000
2000
1500
1000
500
100
50
TYPE
DAIRY
CATTLE, HOGS, SHEEP
WHEAT
MIXED FARMS
SMALL GRAINS
OTHER
NON-COMMERCIAL
NOTE - IF TYPES IN THE ABOVE CATEGORIES CONSTITUTE LESS THAN ONE PERCENT OF TOTAL FARM NUMBERS PER MUNICIPALITY THEY ARE CLASSIFIED WITH "OTHER."
50
25
0
25
50
SCALE IN MILES
SOURCE: ATLAS OF ALBERTA


IEEP
OVE CATEGORIES
HAN ONE PERCENT
MBERS PER
ARE CLASSIFIED

If, on the other hand, Forestry farms or Poultry farms constituted less than 1 per cent of the number of farms in a municipality they were neither mapped nor recorded for numerical analysis because their total numbers are so small that their possible effect on the distribution of farm size was considered to be insignificant. The last category, Non-Commercial farms, is made up of those farms for which less than 1200 dollars of agricultural sales was reported during the 1961 census year and it has been subdivided no further with regards to product specialty because these data are not available.

The pattern displayed by the spatial arrangement of the various types of farms seems to lend some credence to the original assumption that there is a degree of relationship between the concentration of at least some types of farm and the characteristics of the physical environment and, more important to this study, a relationship between some types of farm and average size of farm per municipality. Wheat farms, for example, occur in their greatest relative numbers in the drier southeastern and east central parts of Alberta with a secondary concentration in the Peace River District where it will be recalled the values for moisture deficiency, while not as great as those in the extreme southeast of the province in census divisions one and four, are in the same order as those recorded for the municipalities situated on the outer fringes of the southeast zone. The average size of farm in each of these areas is well above that found elsewhere in the province which suggests that farmers have been forced to enlarge the areal size of their holdings in response to the quality of environment to maintain an economically viable unit and that under present economic and technological conditions and because of the drought resistant qualities of wheat this product grown under extensive conditions, has been the crop emphasized.

The relationship between the other types of farming and the physical environment and the average size of farm is not as clear cut. Small-Grains farming, for example, appears to be associated for the most part with the more humid conditions but this type of operation reaches its highest concentration in terms of the percentage of the farms falling into this category in the Peace River District where the short frost free season seems to hinder the economic production of wheat. One of the difficulties in establishing the assumed relationships for this type of farming is that the Small-Grains heading covers so many different grains with markedly differing economic values per unit of production. It has been shown in the Atlas of Alberta that there are marked regional concentrations in the production of the various types of small grains. Consequently, it is entirely possible that Small-Grains farms may vary substantially in size from place to place, not only in response to differing environmental conditions, but, because the crop emphases are different.

Mixed farms pose a similar problem in that all that is known about this type is that 51 per cent or more of the income derived from the sale of agricultural products is either derived from the sale of livestock and livestock products or, field crops. Which specific product or array of products is sold is not specified and hence the intensity with which farming is pursued and concomitantly the areal size of the farm is difficult to ascertain. Their distribution, however, seems once again coincident with the better conditions for agriculture found in the areas of darker soils. The density of mixed farms tends to decline away from this core area so that they form a lower percentage of the total number of farms in municipalities in either the Brown soils or the Dark Grey and Grey Wooded soils. One of the more obvious deviations from this generalization occurs in the irrigated areas of the Brown and Dark Brown soils. Here one encounters a larger percentage of mixed farms than may have been expected under the natural physical conditions, assuming that mixed farming is more intensive than extensive types of farming such as wheat.

Dairy farming is more narrowly defined and this fact seems to be reflected in its distribution. There are two characteristic locations: in the Black Soil Zone, and near major cities. It is difficult to determine which is the major factor affecting its location at this scale. Research done for an unpublished master's thesis suggests, however, that the physical environment plays an important role in the location of this agricultural pursuit.[15] The basis for this statement is that dairy farmers produce a surplus of dairy products in the Black Soil Zone which are sold in extraterritorial urban markets particularly in British Columbia, while dairy farmers in southern Alberta are unable to meet even the needs of most of the local urban markets. As a result, most of the southern urban markets are net importers of milk from the Black Soil Zone. Again there is one major exception to this generalization because the irrigated areas of southern Alberta produce large volumes of milk and milk products. The most noticeable example of irrigated milk production, as shown on Map 10, occurs in an area tributary to Lethbridge in municipality 25, census division 2. It is possible, of course, to argue that the original generalization which links surplus milk production to the conditions existing in the physical environment for intensive farming has not been violated by this example. It can be shown that with the application of irrigation water this area, which would otherwise be unable to support as intensive a form of agriculture, has gained characteristics which are similar to those existing in the Black Soil

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[15] A.A. Lupton, Some Geographical Aspects of Dairying in Alberta, unpublished M.A. thesis, University of Alberta, Edmonton, 1965, 149 pp.

Zone. Therefore in any attempt to link type of farm and the overall physical environment, or the great soil groups, consideration must be given to whether or not irrigation was practiced.

Dairy farming is also an important adjunct to the other agricultural pursuits practiced in those municipalities characterized by large percentages of non-commercial farms and located on the northern and western fringes of both the main agricultural zone of Alberta and in the Peace River District. Its presence is not obvious, however, first, because the noncommercial farms are not further subdivided into production types and second, because it is likely that no type of agricultural production, including dairy farming, predominates on the non-commercial farms, in these areas in any case. It is important to remember, however, that these districts are characterized by the production of such agricultural products as cream, which is, in most cases, an uneconomic agricultural pursuit. This will help to explain why some of the expected relationships between the average size of farm and the physical resources available to agriculture are poorly defined in those areas in which large proportions of the farms are non-commercial.

The last type of farm, Cattle-Hogs-Sheep, has been reserved until the end of this discussion because of the difficulties that it presents in an analysis of, first the relationship between type of farm and the characteristics of the physical environment and second the relationship between type of farm and the average size of farm per municipality.

To begin with the only thing that farms have in common in this category is that 51 per cent or more of the income earned on them was derived from the sale of one of the three kinds of livestock mentioned in its name. Yet anyone familiar with this type of agricultural production will immediately realize that hog production in Alberta is at the intensive end of an intensive-extensive continuum whereas the

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To begin with the only thing that farms have in common in this category is that 51 per cent or more of the income earned on them was derived from the sale of one of the three kinds of livestock mentioned in its name. Yet anyone familiar with this type of agricultural production will immediately realize that hog production in Alberta is at the intensive end of an intensive-extensive continuum whereas the production of cattle and sheep can be carried out at numerous levels of intensity, depending upon the farmer's goals and on the quality of the physical resources. Cattle production, for example, can be separated into at least three distinct types which occupy reasonably well-defined geographical locations: the extensive type located particularly in southern Alberta, the more intensive cow, calf, and steer fattening operation found in the same parts of Alberta as the other types of more intensive farming, such as dairying and mixed farming, and the very intensive type which usually takes place in a feed lot located near major urban markets.

The first type, which is often referred to as ranching, has had a long history in the Foothills and plains of southern Alberta. It originally occupied most of southern Alberta, but through time, it has been forced into those agricultural areas in which it can successfully compete with the more intensive forms of agricultural production for the land resource. Therefore, this type of enterprise may occur in almost any municipality today depending upon the quality of the physical resources. In reality, however, it occurs in its greatest concentration in southern and western Alberta. Municipalities 11 and 22 in census division 1, municipality 4 in census division 2, all of census divisions 3 and 4, excepting municipality 34 in census division 4, and those parts of census division 9 which are used for agriculture are particularly noted for the extensive production of livestock. The transition between extensive and the more intensive production associated with the more fertile areas of Alberta occurs in census divisions 6 and 7. The western parts of census division 6, for example are traditionally accepted as ranching areas whereas, the more easterly sections are utilized for more intensive agricultural pursuits. In census division 7, farming appears to become more intensive in a northerly direction. Interviews with District Agriculturists suggest, however, that there is a tendency for extensive livestock production to continue in a northeasterly direction into census division 10.

The more intensive types of cattle production are found in geographical proximity to the other types of livestock production which occur in the remaining areas of the province so that in these areas the term Cattle-Hogs-Sheep farming becomes more meaningful. This does not mean that cattle, hogs and sheep are produced on the same holding in these areas. They may be but, in that case the farm would fall into the mixed farm category.

Clearly then, this type of farm does not indicate one homogeneous class of agricultural production because there are three kinds of livestock produced and one of these, cattle, can be separated into at least three distinct sub-types which appear to be concentrated in certain parts of the province. Therefore, the use of this type of farming category poses major difficulties to an analysis of the distribution of average farm size simply because it fails to distinguish between the various kinds and subcategories of livestock production. As suggested earlier, this category of farm type is not the only one which fails to distinguish between the various levels of intensity with which the product it categorizes could be produced. The problem is inherent in some of the other categories too, but it is so obvious for the Cattle-Hogs-Sheep type of farm that to be of much use in establishing the effect of type of farm on the areal variation of farm size the category ultimately must be modified in some way so that clear and objective distinctions can be made between the various levels of intensity with which livestock can be raised.

A closer examination of type of farm has suggested that, although type of farm may indicate the relative intensity with which the agricultural resources are used to produce a certain type of agricultural commodity, there are variations in intensity within any specific type of farm category which are partially dependent upon its location with respect to the physical environment. It was expected initially that the various types of agricultural production are regionalized in such a way that variations in the intensity of agricultural production could be isolated completely by the type of farm variable. In other words, those farm types which are normally considered to be intensive, such as dairy farms, hog producers, mixed farms, etc. would be generally located in those districts which were best suited to it in terms of the physical resources available, whereas the more extensive types of farm such as wheat producers, ranching, etc. would be forced onto the remaining agricultural areas. This regional pattern may exist but if it does it cannot be adequately demonstrated by the use of the type of farm variable in its present form. This does not mean that it cannot be demonstrated at all because a rudimentary regional pattern of farm types is discernible on Map 10. Unfortunately the pattern is not as clearly defined for the purposes of justifying the previously stated hypothetical relationships as one might wish.

For the purposes of the following numerical analysis it was, nevertheless, assumed that farm type indirectly indicated farm size. Therefore one need only know the predominant farm type in any municipality to gain some indication of the average size of farm in that municipality. This is based on the assumption that farm types truly do indicate intensity of production which in turn rests on the assumption that their regional pattern of distribution is linked to the quality of the physical environment. If, however, a certain type of farm occurred outside of its major area of concentration, if such area exists, it was still assumed that it provided an indirect measure of the intensity with which the land resource was being used. If, for example small-grains farms were found mixed in with the other types of farms in the Black Soil Zone it was assumed that they would be among the largest farms on the average, in that zone. Conversely, if dairy farms occurred in the Brown Soil Zone it was expected that they would be the smallest type of farm in that area, because dairying is normally accepted as being an intensive form of agricultural specialization in terms of inputs per acre.

It would have been better if only one factor had been examined at a time so that the effect of type of farm on the average size of farm could have been separated from the effect of the physical environment on farm size. In this way it would be possible to hold soil type constant so that the systematic changes in farm size in response to changes in the type of farm could have been observed. Unfortunately, this was not feasible because it was virtually impossible for technical and economic reasons to draw a stratified random sample for each soil zone in the province in which all types of farms would be represented in some ratio of their total numbers. The only type of data available at this scale of study is that collected for the 1961 agricultural census and reported for each municipality in Alberta. Consequently, to have controlled for soil type would have meant that the sample size would have been limited to the very few municipal means available in each soil zone. If this type of data were used, then not only would the sample be too small to be of much use statistically, it would have been composed of data that were so variable, as shown in Chapter One, that the variability of the data around the municipal mean would have obscured the possible variation of farm size in each soil zone which was attributable to variations in type of enterprise.

Table III, Part A, illustrates the problem of attempting to study the effect of type of farm on the average size of farm with no statistical controls for regional variation of the physical resources. It should be stressed that these data represent an extremely generalized view of the actual conditions in each soil zone because they are

Table III Average Size of Farm in Acres and Their Rank Order for Six Types of Farm in Fifteen Census Divisions - Based on 1961 Census of Agriculture - Alberta.

Average Size of Type of Farm - Part A

Census Division	Dairy	Cattle-Hogs-Sheep	Wheat	Mixed Livestock	Mixed Field Grains	Small Grains
1	1040	3864	1080	1248	1040	1120
2	307	1094	947	651	438	954
3	474	1310	763	786	721	863
4	1220	3390	1475	1378	1790	1958
5	574	1150	867	750	958	896
6	488	810	630	560	645	624
7	608	1120	715	673	796	788
8	384	474	420	416	470	430
9	263	1920	-	293	-	800
10	392	604	474	444	502	507
11	342	362	327	338	376	383
12	433	505	425	461	458	468
13	361	438	406	398	439	446
14	391	456	464	690	588	619
15	566	600	525	510	605	578

Rank Order of Size of Type of Farm - Part B

Census Division	Dairy	Cattle-Hogs-Sheep	Wheat	Mixed Livestock	Mixed Field Grains	Small Grains
1	5.5	1	4	2	5.5	3
2	6	1	3	4	5	2
3	6	1	4	3	5	2
4	6	1	4	5	3	2
5	6	1	4	5	2	3
6	6	1	3	5	2	4
7	6	1	4	5	2	3
8	6	1	4	5	2	3
9 *	4	1	-	3	-	2
10	6	1	4	5	3	2
11	4	3	6	5	2	1
12	5	1	6	3	4	2
13	6	3	4	5	2	1
14	6	5	4	1	3	2
15	4	2	5	6	1	3

* Census Division 9 cannot truly be ranked because there are only four types of farms.

Source: Pers. Comm. R. Ellis, Assistant Director (Agriculture) Census Division, Dominion Bureau of Statistics.

available only for the fifteen census divisions. They do, however, illustrate the broad regional effect of the physical environment while at the same time they provide a means for checking the earlier assumption that wherever a specific type of farm is found the relative intensity with which the physical resources are utilized will be indicated.

Perhaps the most noticeable thing about the data in Part A of Table III is the wide variation in average farm sizes in the various census divisions. This was not unexpected, of course, because it has been established in Chapter One that there is a marked regional pattern of farm size in Alberta which corresponds to the soil zones that these census divisions are intended to represent but, this table particularly emphasizes the extent to which the variation in farm size is carried through to all types of farming. Dairy farms, for instance, are not small, intensively worked operations wherever they occur in Alberta even though they do rank as the smallest type of farm in twelve of the fifteen census divisions, and hence in a majority of the soil zones. They vary in size from a mean of 1220 acres in census division 4 to a mean of 263 acres in census division 9. This pattern immediately suggests further, that it is not the physical conditions alone that may influence farm size within a single type of farm category because, as has been shown previously, physical conditions for dairy production are not much better in census division 9 than they are in division 4. It would appear then that there is a difference in the size of the dairy farm business in each division. Correspondence with R. Ellis has substantiated this. He reported that total gross income from the sale of all agricultural products on dairy farms in 1960 in census division 4 was 6,220 dollars whereas total gross income in division 9 was only 3,595 dollars.[16] The corresponding provincial mean was 7,913 dollars.

The relative reliability of each type of farm as an indirect indicator of farm size in each municipality is also revealed in Part B of Table III. Cattle-Hogs-Sheep farms are ranked the largest type of farm in eleven of the fifteen census divisions and dairy farms the smallest in twelve of the fifteen census divisions. The other types are not nearly as clearly defined. Mixed livestock farms appear to be the next largest, after dairy farms, in nine of the fifteen divisions, followed by wheat farms in nine of the census divisions, but it is difficult to distinguish any characteristic ranking for the Mixed Field Grains and Small Grains farms. Both were ranked fifth largest in nine census divisions with the ranks in the remaining census divisions for these two farm types, ranging from second to sixth. Interesting anomalies in the rank order of the various types of farm are also evident in Table III. Some of these, like the rank order of wheat farms in census divisions 11 and 12, are difficult to explain because wheat farming is normally considered a fairly extensive operation; certainly more extensive than dairy farming. What this reversal in rank order may indicate for census division 11 at least is the trend towards urban inhabitants engaging in farming on weekends. It would be natural to expect this type of land owner to choose one of the most extensive types of farming no matter what areal size of holding he possessed. Others, like the rank order of Cattle-Hogs-Sheep farms, lend credence to previous statements made concerning the changes in the method and intensity of livestock production in the more westerly and northerly parts of the province. In the south this type of farm generally ranks

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[16] Pers. comm. R.Ellis, Assistant Director (Agriculture) Census Division, Dominion Bureau of Statistics, 1967.

first in size, but in the northern census divisions with the exception of census division 12 the ranks are lower.

In this short discussion of type of farm a number of problems have become obvious. The first pertains to the concept of type of farm itself. It has been generally assumed in the geographic literature regarding the distribution of agricultural activity that intensity of production can be assessed by determining the major type of crop or animal speciality in a specific area. This assumption is based on studies which have determined the amount of labour expended in the production of one acre of a specific crop or one animal of a specific type.[17] Unfortunately, this amount of labour or, stated another way, the productive man work units can be spread over different amounts of land for livestock. It would also appear that in any rating system of labour needed for a particular crop the location must be held constant because changes in location result in differences in the labour requirements per unit area, for a particular crop.[18] Yet in spite of this it is generally assumed that type of farm indirectly indicates intensity of land use because it is based on yet another assumption. This assumption has to do with the optimum location for a particular type of agricultural production. It is generally assumed that a crop will occupy a fairly precisely defined geographic area and consequently the labour requirements for that particular crop will be relatively homogeneous. Even if these assumptions are true a very sophisticated definition of type of farm would be required to detect the subtle shift

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[17] Standards for man work days per acre by geographical location are shown in the Kansas Farm Management Association Accounts Book, Rev. ed., Manhattan, Kansas, 1965, 1 v. (unpaged)

[18] See for example the Appendix in Canada, Dept. of Agriculture, Types of Farming in Canada, Ottawa, 1939, pp. 41-43.

in crop or livestock emphasis from place to place. It has already been shown that the foregoing classification of type of farm is lacking in this respect. Therefore, its value will be somewhat limited simply because the crop classifications used for the various types of farm include crops which can be grown in different parts of Alberta and hence will require different amounts of labour per unit area.

The second problem concerns the assumption of a regional pattern of agricultural specialization which has developed in response to optimal growth conditions. It might be argued that if the physical environment influences the distribution of type of farm, why use type of farm as an independent measure of the intensity with which land is used. It has been used in this study because in actual practice it has been found that there are other regional factors which affect the location of a specific type of farm and that many different types of crops with different labour and capital requirements can be grown under a given set of physical conditions. Therefore, although type of farm may reflect the broad regional patterns of conditions for agriculture, it should also reflect the decisions that farmers in any area have made concerning the intensity of their operations. In this way more information is gained about the average size of farm than perhaps could have been gained using information about the physical environment alone. Table III illustrates this point. For the same type of farm, average size varies from one part of the province to another largely in response to the physical conditions available for agriculture. An examination of Part B of Table III however suggests that when the physical conditions for agriculture are held constant (for the purposes of this discussion it will be assumed that these conditions are constant for a given census division, particularly a southern one) type of farm does appear to have some association with average size of farm because dairy farms most often rank the smallest and Cattle-Hogs-Sheep the largest.

Finally, if type of farm is presumed to indicate the relative intensity of farming then it may be asked why a more direct measure of intensity was not used. This problem will be resolved here in two ways. First, the author had a genuine interest in the relationship of the type of farm classification presented earlier and the average size of farm, and second, data for all capital inputs and particularly labour inputs are not available for more than relatively few sample farms in Alberta.

Before going on with the next independent variable, the average size of farm business per municipality, it should be noted that type of farm was determined from only one year's sales of agricultural products. It may be argued that this period is not long enough because fluctuations in crop yields in response to annual variations in climatic conditions may well produce abnormal patterns of type of farm in any one year. In spite of this apparent danger, however, these census data have been accepted for the purposes of this study as a valid representation of actual conditions in Alberta, because 1960, the year for which income data was collected for the 1961 census, is not considered an "abnormal year"[19] and because any abnormalities would be difficult to establish at this scale in any year because it is extremely unlikely that a secondary type of activity exists of sufficient importance to establish a new type of farm pattern in the event that the first should fail.

<u>Average Size of Farm Business</u>

Even though the distribution of various types of farms may be

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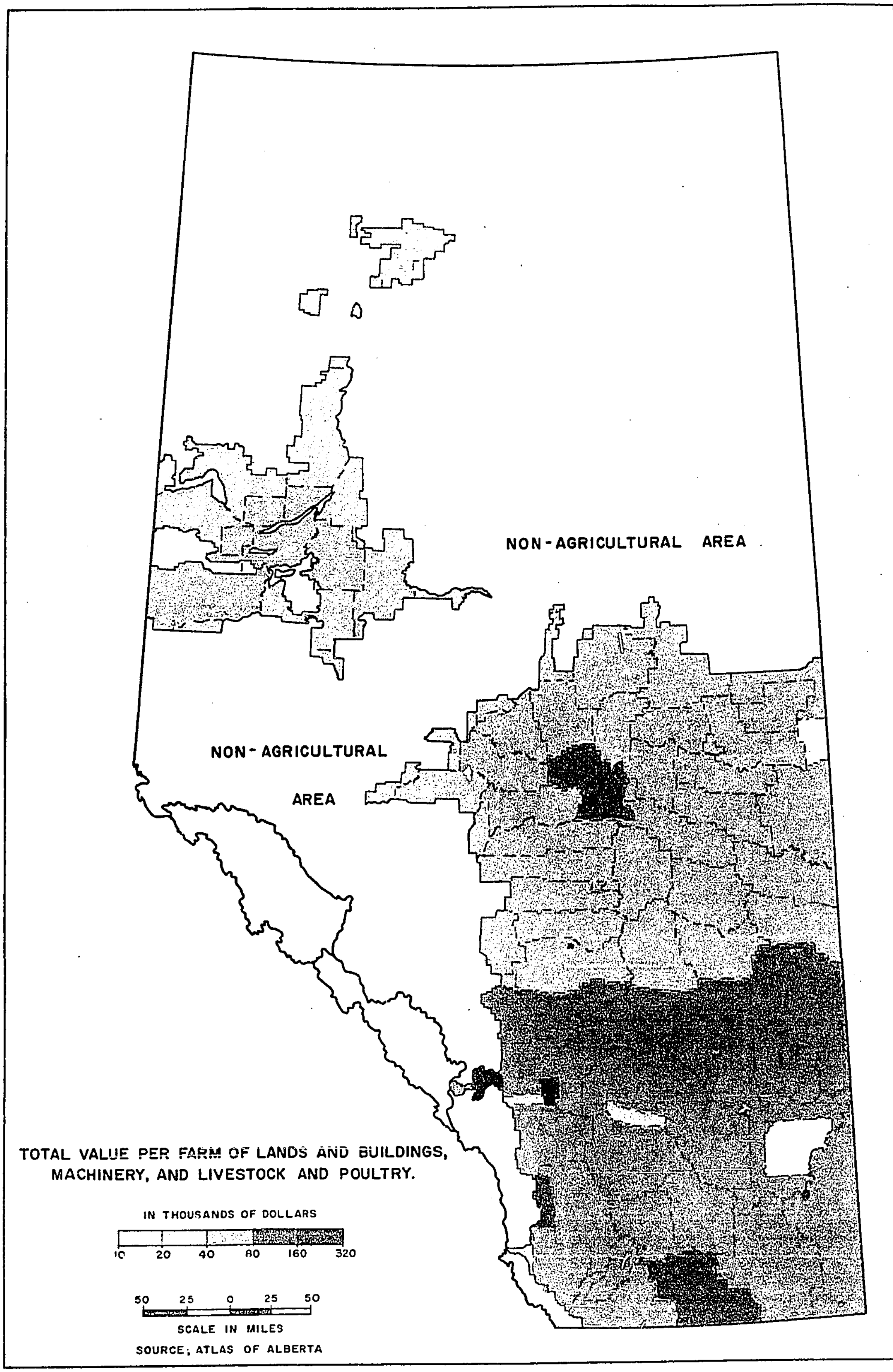
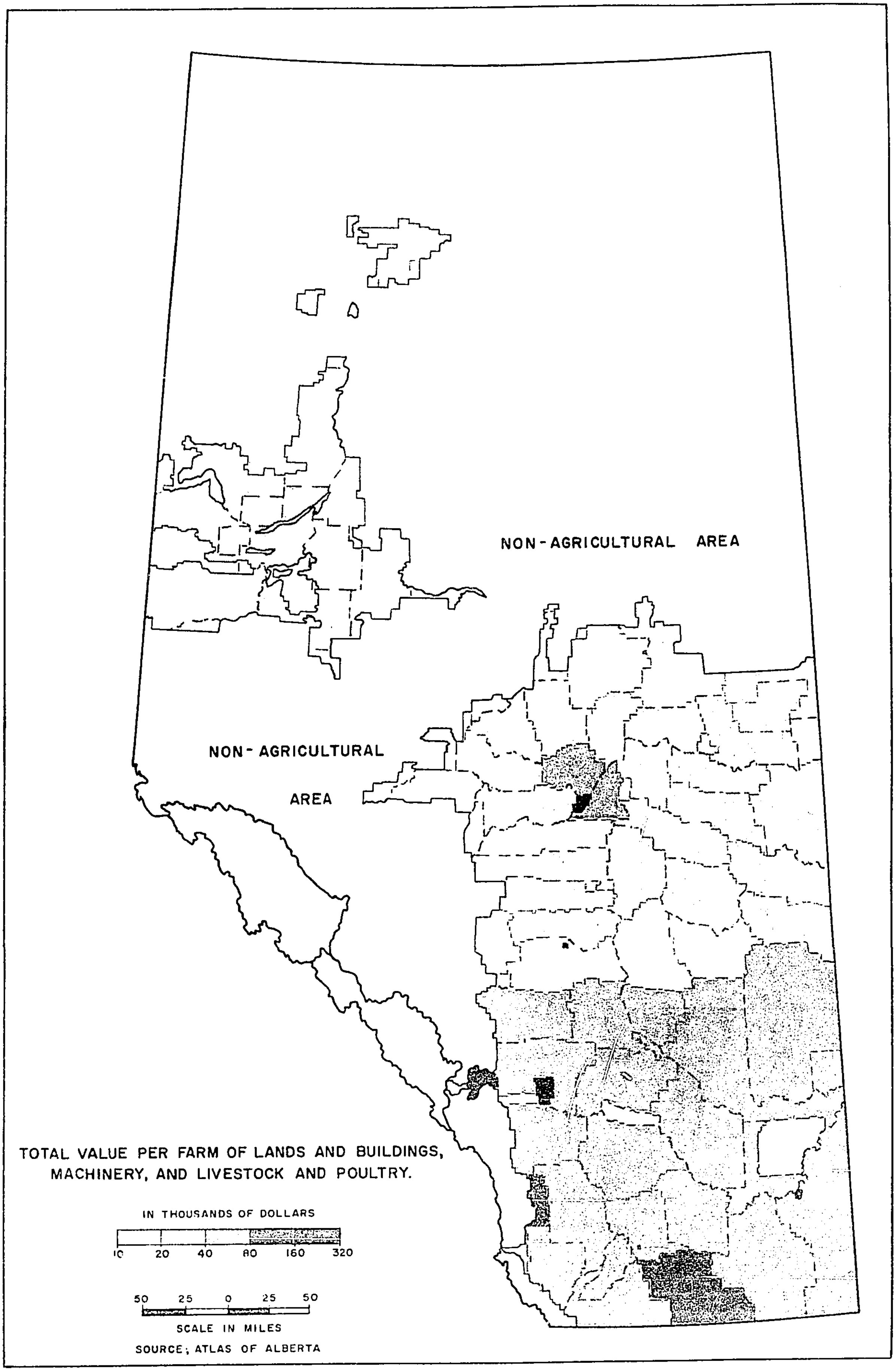
[19] Pers. Comm. R.E. English, Statistician, Farm Economics Branch, Alberta Dept. of Agriculture. Mr. English was commissioned to produce a report concerning agricultural conditions in 1960. He concluded that 1960 was an "average year" for the agricultural sector.

known, the variation in the size of the farm business within any specific type may act in such a way as to modify the influence of type of farm on size. In other words, if it can be shown that there are regional variations in the size of the business then it cannot be expected that the relationship between size and type of farm will be readily understood even in areas with similar physical conditions.

There are several measures of farm business size, such as, the total annual gross sales of agricultural products, and the total capital under the control of the operator. Which of these two measures of farm business size is used is immaterial because each has its strengths and weaknesses but, the way in which each was used in this study has been determined by how readily available each was in the 1961 Census of Canada and in special tabulations obtained from the Dominion Bureau of Statistics.

The best overall measure of business size which can be obtained from the 1961 Census, is the total capital under the control of the operator. It is comprised of the total value of land, buildings, machinery, livestock and poultry for each municipality divided by the total number of farms in each municipality. The values obtained by this method are shown on Map 11. The pattern assumed by these values suggests that farms are larger in the southern part of Alberta in business size as well as areal extent. The southern municipalities with the largest capital value are those which occur in the extreme west and are dominated by livestock farms. From the information provided in the foregoing section on the physical environment for agriculture and to anyone familiar with agricultural distributions in Alberta, it will be recognized that this area is a fairly old and well established ranching district in the foothills of the Rocky Mountains. There are other distinct regional variations in the south and indeed within the widely distributed 40 thousand to 80 thousand dollar capital


NON-AGRICULTURAL AREA
NON-AGRICULTURAL
AREA
TOTAL VALUE PER FARM OF LANDS AND BUILDINGS, MACHINERY, AND LIVESTOCK AND POULTRY.
IN THOUSANDS OF DOLLARS
10 20 40 80 160 320
50 25 0 25 50
SCALE IN MILES
SOURCE; ATLAS OF ALBERTA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SCALE IN MILES
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value category itself. Warner County (municipality 5) for example, which is dominated by grains and extensive livestock production, falls into the 80 to 160 thousand dollar category. It may be of interest to note that part of this county is dominated by the same type of surficial configuration as that previously mentioned for the municipalities in the extreme west and it is on this steeply rising southern part of Warner County, the Milk River Ridge, that the extensive livestock production takes place.

The other municipalities in the 40 to 80 thousand dollar category in which the largest farm businesses occur are arranged in a crude arc beginning in municipality 11 and continuing through municipalities 22, 8, 14, 2, 16 and 44. Grain production is very important in most of these municipalities although 2, 22 and 44 are dominated by the production of livestock. This observation has been made to allay possible suspicions that farm capital is not an accurate measure of farm business size. These doubts may have arisen with the realization that livestock values were included in the assessment of farm value whereas crop values were not. This may have suggested that farmers who engage in livestock production would appear to have a larger business size than those emphasizing cash grains but, the fact that the municipalities in which cash grains are the most commonly occuring type of activity also are those in which the largest business size in the 40 to 80 thousand dollar category occur tends to dispel these doubts. One of the reasons why inclusion of the value of the southern livestock farmer's crop does not unduly inflate his business size is that most livestock producers in this area are producing extensively and hence have a relatively low value for machinery inputs whereas, although grain producers do not report the value of their grain crop, they have much higher machinery input values. These relative values will be discussed in more detail later.

The smallest farm businesses in the 40 to 80 thousand dollar category in southern Alberta are located in census division 4 where average farm size is among the largest in Alberta. From the previous discussion on soils it is obvious that this is one of the poorest areas in southern Alberta for agriculture. Therefore farmers must have large land holdings if they wish to maintain a standard of living comparable with the provincial average. The fact that the business size is the smallest in the 40 to 80 thousand dollar category suggests that farmers have not yet adjusted the areal size to a large enough extent to make their levels of income comparable with the rest of the farmers in southern Alberta. Farmers have adjusted to the poorer soil conditions by emphasizing extensive livestock in both the Special Areas (municipalities 2 and 3) and extensive wheat production in the more favourable areas, particularly the clay soils of municipality 34.

The only other area with farms in the 40 to 80 thousand dollar capital value category is located immediately adjacent to Edmonton. A closer examination of the individual values within the broader capital value category suggests that a larger proportion of the farm business size is made up of the value of lands and buildings in the two municipalities adjacent to Edmonton in this farm business size category than is the case for other municipalities in the area. In fact, the percentage of the total capital figure contributed by lands and buildings is similar to that found in the southern municipalities where land is the most important input for the extensive livestock industry. This immediately suggests at least two reasons. The land value may be inflated above its worth to agriculture because of urban demand for land for expansion, country estates, hobby farms, and the like, or it may be a reflection of the intensity with which land is used close to a major urban centre. If the latter reason is the correct one, the other inputs ought also to be high. While the per cent value of machinery inputs is low in these two municipalities the absolute value per farm is higher than in any of the surrounding municipalities. It seems reasonable to assume therefore, that land is likely used more intensively immediately adjacent to Edmonton but, at the same time it would be extremely unwise to assume that the urban market for farms is not an equally if not more important factor affecting land values. The results of field work in the Edmonton area suggest that a growing proportion of the farms in the two municipalities in question is owned by people who reside and work in Edmonton. This may be one of the reasons for the extremely large percentage increase between 1961 and 1966 in the number of farms ranging in size from 3 to 69 acres in Alberta. Farms under 3 acres increased by 35.7 per cent, farms between 3 and 9 acres increased 16.0 per cent and farms between 10 and 69 acres increased 26.7 per cent. Comparable figures for Canada, as a whole are, an increase of 1.6 per cent and decreases of 4.9 and 11.2 per cent respectively.[20]

Except for the anomaly near Edmonton farm business size declines in a northerly and to some extent a westerly direction outside of the southern district previously discussed. Perhaps one of the most striking features of this decline is the fact that farm business value declines more rapidly in the northeast of the main agricultural area where average farm size is bigger than in the more westerly parts where average farm size falls into the smallest size category. Again, in view of the previous discussion on the physical resources of this district, it would appear that while farmers in this northeastern area are increasing the areal size of their farms in an attempt to make

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[20] M. Wilman, "Changes in Farm Size and Numbers in Canada to 1966", Canadian Farm Economics, Vol. 2, No. 4, Oct. 1967, p. 23

them into economic units they have not yet succeeded to the same degree as those farmers located farther west. The situation appears even worse in the extreme northern and western fringe of census divisions 13 and 14, where physical conditions for agriculture are not much different, yet average farm size is even smaller. It is in these areas, particularly census divisions 12 and 14, that special studies of agricultural conditions are being conducted under the auspices of the Agricultural and Rural Development Agency.

The Peace River District is interesting in that the pattern of farm business size shows the same tendency towards high values at the core of the district and low values around the fringe as that in the northern part of the main farming area of Alberta. This suggests that there are similar processes impeding the development of large businesses at the margins of continuous agricultural settlement in this district and farther south in the main agricultural area of Alberta. Whether these processes are a blend of homestead laws, ethnic origin, physical conditions or even length of time the area has been settled is not important here but it is important to note that in the areas of poorest agricultural potential the average farm business size falls into the smallest category. This will be an important observation later on when the relationship between non-commercial farms and areal extent of farm is investigated.

It is by now fairly apparent that there is a distinct regional pattern to the distribution of average farm business size. Therefore, it would seem advisable to recognize this fact in any final analysis of the regional variation in farm size. Before going on with such an analysis, however, it may be of interest to note that type of farm is not likely the significant underlying cause for such a regional pattern. That is to say, it is not because of the fact that farms are wheat farms or extensive livestock farms that they are of large economic size, because farm business size is larger in general in the south than in the north no matter what the type. This is stressed at this point again to suggest that farm capital value is a reasonably accurate measure of farm business size that is not unduly influenced by concentrations of farms of a specific type.

The value of gross sales of agricultural products in 1960 is the measure used to show that almost all types are larger in the south than in the north. There was no choice in the selection of this measure because it was the only one available from the Dominion Bureau of Statistics that showed farm business size by type of farm for political divisions in Alberta. Unfortunately it is only available for fifteen census divisions, not the smaller municipal districts. These values are shown in Table IV and it may be seen that there is a general tendency for all farm types to be larger in those municipalities which are characterized by large business size than those which are not. There are exceptions, of course, census division 9 being one of the more notable ones. Although the farms in this division fall into the largest farm business size, the average size of the ten dairy farms are the smallest for the entire province. The small grains and mixed livestock farms are also much smaller than expected but, these farm types form an insignificant proportion of the total numbers of farms in this predominantly ranching district; therefore their anomalous condition does not seriously detract from the original statement which suggests that the municipal average value for size of farm business represents fairly well the size of the farm business for all farm types in that municipality.

Average Value of Lands and Buildings Per Acre

This last variable was chosen in an attempt to study the influence of urban centres on the distribution of farm size. It has been

Table IV Average Size of Farm Business in Dollars for Six Types of Farms in Fifteen Census Divisions Using Gross Sales of Agricultural Products in 1960 as a Measure. Based on 1961 Census of Agriculture, Alberta.

	Type of Farm					
Division	Dairy	Cattle Hogs Sheep	Wheat	Small Grains	Mixed Livestock	Mixed Field Grains
1	68,800	90,500	56,700	63,400	52,800	51,000
2	67,100	69,000	75,040	77,800	71,500	55,400
3	44,500	83,000	55,000	71,500	60,000	54,300
4	21,800	55,500	39,200	45,800	37,000	35,200
5	59,500	75,600	56,000	69,700	59,300	61,400
6	61,700	61,500	55,000	60,000	58,400	63,500
7	33,700	46.300	33,800	37,000	33,900	34,800
8	35,800	39,300	29,500	37,000	34,200	37,200
9	19,000	72,500	-	38,700	20,100	-
10	32,900	36,900	27,500	32,800	30,200	30,500
11	48,800	36,600	35,800	44,000	34,900	37,600
12	23,200	24,000	19,300	25,000	23,000	20,800
13	24,300	28,000	22,600	29,900	26,800	27,000
14	25,800	22,900	15,800	25,700	30,400	29,200
15	32,700	27,000	23,600	27,500	25,400	29,700

Source: Pers. comm. R. Ellis, Assistant Director (Agriculture) Census Division, Dominion Bureau of Statistics. Note that these data do not include off-farm income.

established elsewhere[21] that a relationship does exist between the size of urban centres, the value of lands and buildings per acre and the average size of farms in those areas directly linked to a specific urban place. From previous discussions, it has been suggested that the physical resources set some limits on the intensity of agricultural production. If this assumption is correct then, the quality of the physical resources also influences the monetary value of farms in any particular area. Consequently, the value of lands and buildings per unit area may be considered a function of proximity to urban places, the population size of these centres and the inherent potential of the physical resources. It would be extremely interesting to assess the relative influence of each variable on the ultimate land value, particularly when the highest concentration of urban centres and major traffic arteries also occur in those parts of Alberta which are normally considered among the best for agriculture. If such a study were to be carried out it might suggest that the concentration of urban places was itself an indirect function of the quality of the physical resources available to agriculture.

Before a study of the influence of proximity to urban places on the distribution of farm size could be undertaken, however, it would be necessary to measure the extent to which every farm district was influenced by the urban place nearest to it. In practical terms this means that it would be necessary to work at a much larger scale and to employ sampling techniques because the area of a city's influence is not necessarily coterminous with the boundaries of the municipalities surrounding it. This approach was not judged feasible in light of the

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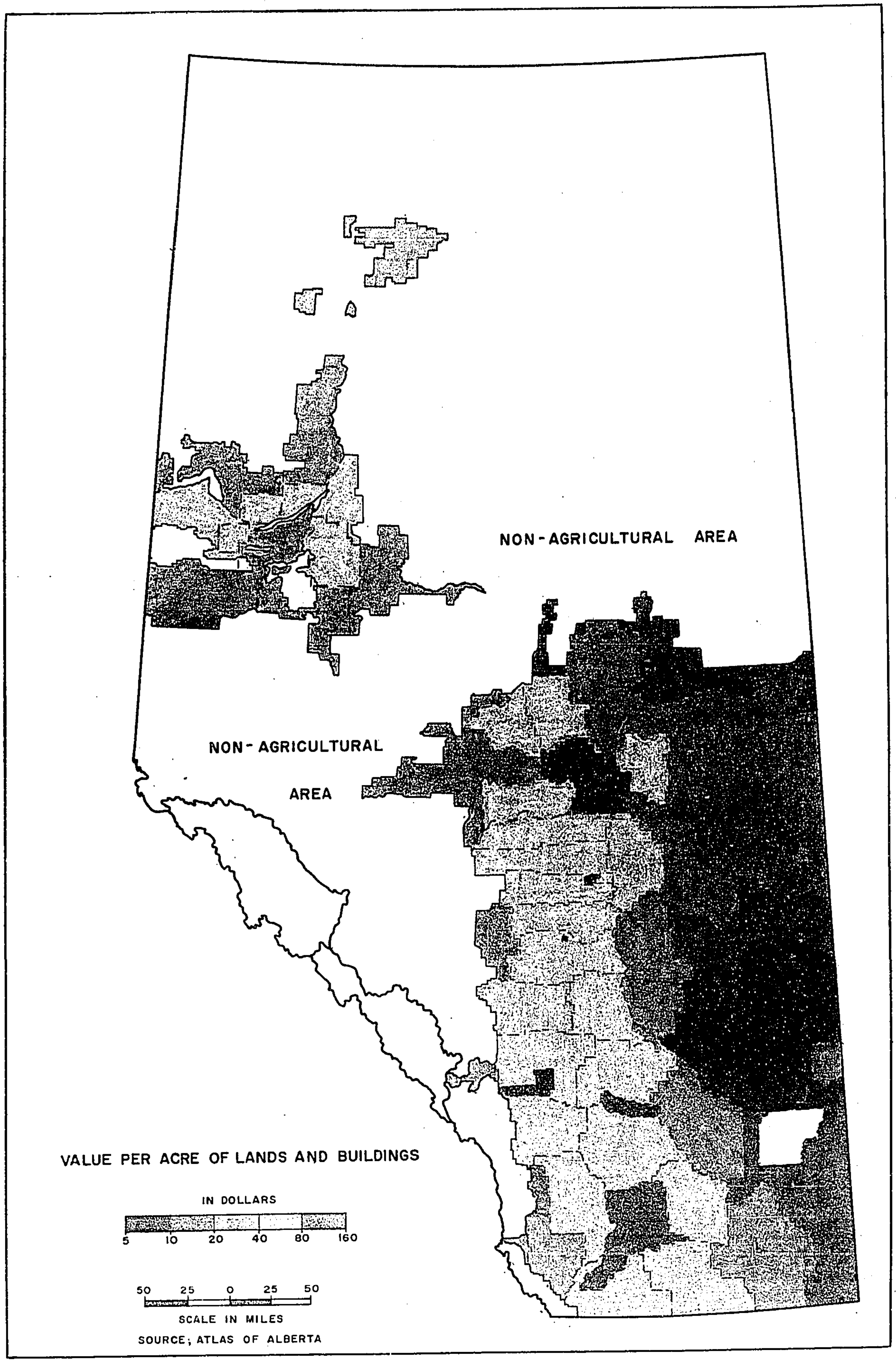
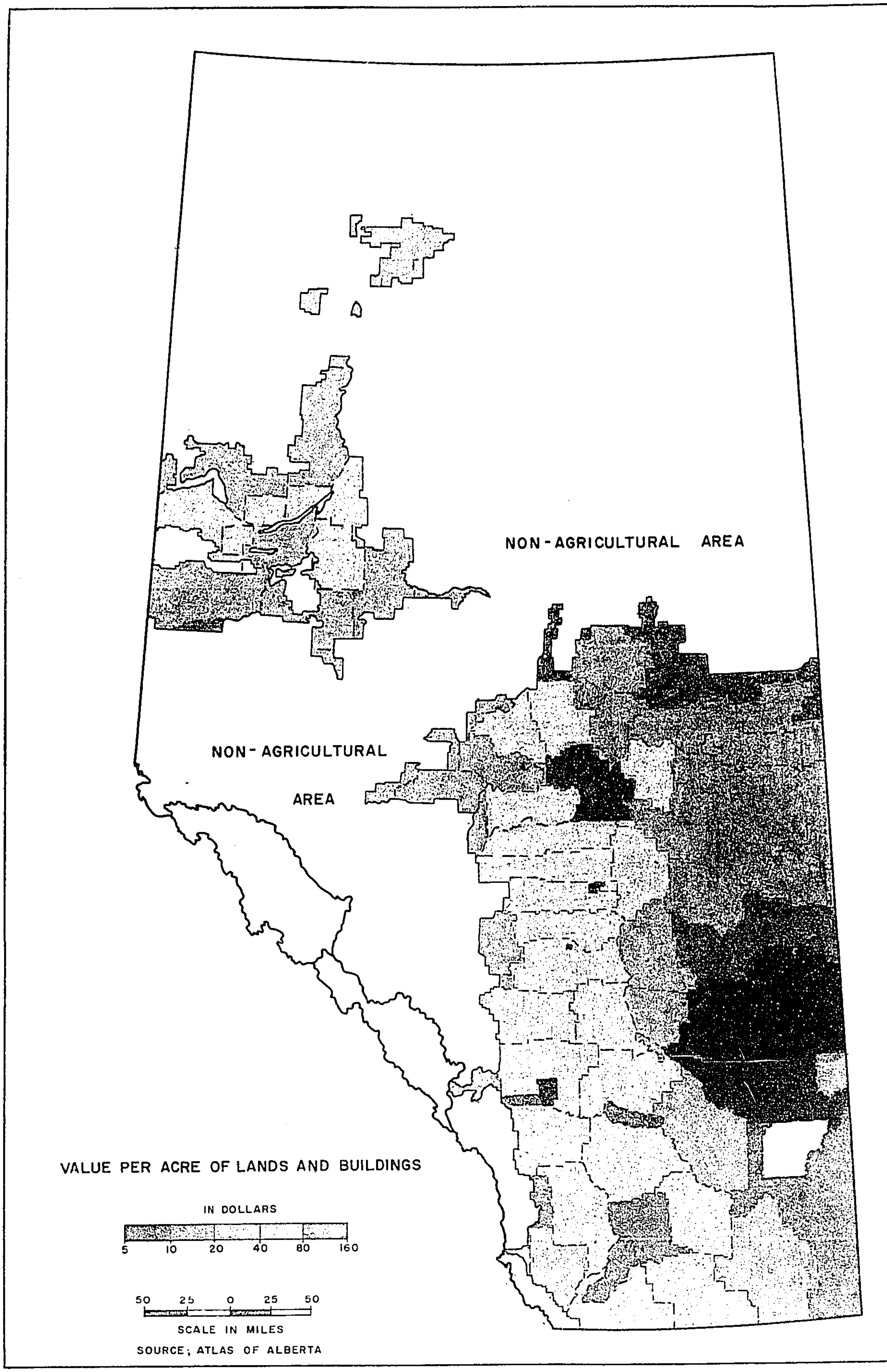
[21] See for example: J.D. Tarver, "Locational Aspects of Population Densities, Farm Sizes, and Farm Land Values", Rural Sociology, Vol. 31, No. 1, March 1966, p. 40-52.

resources available for this study so it was deemed necessary to take a more indirect course of action. It was assumed that if rural land values reflect more than just the quality of the physical resources for agriculture then this variable should also account for more of the variablility of the distribution of farm size than would measures of the quality of the physical resources alone. In this way differences in results of the analysis between measures of the physical environment and the distribution of average size of farm on the one hand and the value of lands and buildings per acre and the distribution of average size of farm on the other could be assumed to reflect, at least in part, the influences of urban concentrations.

The value of land and buildings per acre of land in farms used in this analysis have been grouped into the six categories shown on Map 12. It can be immediately seen that the pattern of values does indeed correspond somewhat with the physical resources available to agriculture as outlined in the earlier part of this chapter. It is by no means a perfect correlation but the tendency for the highest land and building values to occur on the more fertile soils is evident. If the actual values had been subdivided into smaller categories the tendency for the highest land and building values per acre to occur on the most fertile soils in Alberta, the black soils, would be even more evident. The influence of the major cities on land values is not as clearly evident on this map as the influence of the physical resources seems to be. Only Edmonton and Lethbridge appear to have a strong enough impact on land values to cause a disruption in the broad pattern of land and building values per acre shown on the map but, in all fairness it should also be noted that this may well be a function of the nature of the size categories. If the actual values for each municipality are examined then there appears to be a tendency for those municipalities in which a fairly large urban centre occurs to have


NON-AGRICULTURAL AREA
NON-AGRICULTURAL AREA
VALUE PER ACRE OF LANDS AND BUILDINGS
IN DOLLARS
5 10 20 40 80 160
50 25 0 25 50
SCALE IN MILES
SOURCE; ATLAS OF ALBERTA


NON-AGRICULTURAL AREA
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AREA
VALUE PER ACRE OF LANDS AND BUILDINGS
IN DOLLARS
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50 25 0 25 50
SCALE IN MILES
SOURCE; ATLAS OF ALBERTA

higher average rural land values than those which occur in the same general area but possess no urban places within their boundaries. Another reason for the exceptionally high land values in the municipalities immediately associated with Edmonton and Lethbridge may be that in terms of surficial configuration, soil quality, climatic conditions, and the availability of irrigation water these municipalities are among the most favoured for agriculture in Alberta. This observation has been made at this point in order to stress, once again, the difficulty of separating the influence of urban places on land values from the influence of variation in the quality of physical resources on land values, particularly when working at this small a scale.

Summary and Conclusions

This chapter has dealt with a description of the broad physical and economic variables that are assumed to influence the distribution of farm size. Some of the difficulties in choosing the most significant variables to explain the influence of the physical environment on the distribution of farm size and in determining objective measures of these variables also have been illustrated. It has been demonstrated, for example, that there are a number of elements in the physical environment which influence agricultural activity, such as temperature, precipitation, duration of the frost free season and soil quality but the choice of the best variable or combination of variables presents significant problems because if variables are chosen that are themselves highly related, their individual effect on the areal variation of farm size cannot be determined by the regression model chosen for this study. The problem of measurement is also significant because the influence of some variables cannot be measured in the usual way with the use of interval scales. Soil quality, for example, is one of the elements for which classes must be established because no objective measure of its natural qualities and hence its value to agriculture has been established. Before these classes, or nominal scales, which are really just groupings of phenomena that cannot be ranked with respect to the degree to which they possess a certain characteristic, can be of any use however, modifications must be made to the original regression model.

CHAPTER III

DATA PREPARATION AND ANALYSIS OF THE RELATIONSHIP BETWEEN THE DEPENDENT AND THE INDEPENDENT VARIABLES

In this chapter the relationships between each of the discussed variables and the dependent variable will be examined with a view to determining how well each measures what it was expected to measure and to what extent it accounts for or, "explains" the variation in the dependent variable, average farm size. Maps of the residuals from a regression analysis will also be presented so that the areal variation in the degree of correlation between specific independent variables and the dependent variable can be observed. By examining the maps of residuals, other variables, which may operate at either a local or provincial level, may become apparent to the observer. In this way the pattern of residuals from regression may suggest modifications of previous hypotheses concerning the existence of an areal association between the dependent variable and one or more of the independent variables.

Before the analysis could be carried out, however, it was necessary to establish values for the variables in question for each municipality. For some variables, such as average size of farm business and average value per acre of lands and buildings, measures for each municipality were readily available from the 1961 Agricultural Census and, indeed, have already been presented on maps in the previous chapter. For others, however, particularly those whose municipal means are derived from so-called point data, such as measures of frost free seasons and soil deficit, measurement posed a more difficult problem. In cases such as these it was necessary to generalize the conditions encountered at the collecting point to the broader surrounding area using an objective technique that could be duplicated by others.

Preparation of Data For Analysis

As stated above, mean values for lands and buildings and size of the farm business were established for each municipality by simply dividing the total value of each variable reported for each municipality in the 1961 Agricultural Census by the total number of farms in the appropriate municipality. No distinction was made between non-commercial and commercial farms because census data are not classified by economic type of farm for municipalities.

Values for type of farm were derived differently. Each type of farm was expressed as a percentage of the total number of farms reported in the 1961 Agricultural Census for each municipality. In this way seven different types of farms were recorded for almost every municipality excepting those in which a specific type of farm did not occur. It will be recalled from the previous discussion of the variable that, although mixed farms were not separated into the two subcategories of livestock emphasis or crop emphasis for mapping purposes, they were for the statistical analysis. The total number of types of farm remains at seven, however, because the category of Other shown on Map 9 was not employed in this analysis as it contains a mixture of farming types.

The remaining variables, measures of the physical environment, were treated differently. Mean values could not be as readily derived as they were for the other variables because it could not be assumed that the mean values derived from one or two reporting stations accurately portrayed climatic conditions for the whole of the municipality. In those cases where climatic stations were scattered over a wide area it was sometimes necessary to accept the results of one station as the best measure of climatic conditions for one or more municipalities. Even under these circumstances, however, the location of the station with reference to surficial configuration and exposure was taken into account and if the values reported at a particular station appeared anomalous with reference to those reported at stations in the surrounding areas then the values recorded at that station were modified with the help of subject specialists when they were generalized to include the whole of the municipality. Duration of the frost free season in the Peace River District, as shown on Map 5, for example, was treated in this fashion.

In spite of the difficulties experienced in some areas with the point data, the general procedure employed to derive area measures for the variables associated with the physical environment was as follows. Isopleths, which were derived from long term point data and which are shown in McKay's atlas of Climatic Maps of the Prairie Provinces for Agriculture[1], were superimposed on a base map of Alberta showing the outlines of all municipalities. Next, the midpoint between every set of isopleths was determined and an additional line was drawn through these midpoints so that in effect the number of isopleths was doubled. These new isopleths were not given their own numerical value however, but rather were assumed to mark the outer limit of the influence of the original isopleth that they bracketed. This is obviously not true because values vary gradually between any two isopleths but this technique made measurement of the areal extent of the climatic factor much easier than it otherwise would have been. If, for example, the way in which the values actually vary between any two isopleths had been considered then it would have been necessary to make innumerable measurements and calculations between every set of isopleths. The area in each municipality which was enclosed by each set of isopleths

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[1] G.A. McKay, Climatic Maps of the Prairie Provinces For Agriculture, Toronto, 1963, 18 pp.

was then measured and expressed as a percentage of the total area of land in farms per municipality. Finally, these percentages were multiplied by the value of the original isopleth. For example, if 20 per cent of the area of a municipality was located between an isopleth measuring 110 frost free days and the outer limit of the influence of this 110 day frost free period as determined by a line drawn through the midpoints between the isopleths measuring 110 and 120 frost free days then the 20 per cent was multiplied by 110. All such values for any municipality were then summed and divided by 100 to give an average value for the frost free season, or whatever variable was being measured, for the entire municipality.

All characteristics of the physical environment which were considered in this study were handled in this way with the single exception of soils. It will be recalled from the previous discussion of this variable that no measures beyond the nominal ones, which merely classified soils by colour and the characteristics of the natural vegetation that they supported were available for this study. Therefore, it was necessary to group the soil categories in such a way that each municipality could be described as belonging to a certain category. To achieve this end, the soil groups were superimposed on a base map showing the outlines of the municipalities. It was found that if the soils were grouped into the following six categories, Brown, Dark Brown—Thin Black, Black-Dark Grey Wooded—Grey Wooded, Dark Grey Wooded—Grey Wooded, Dark Grey Wooded—Grey Wooded-Peace River District and a final category called Foothills, that the municipalities would fit roughly into the modified soil pattern. This was quite satisfactory for most municipalities but in those cases where the fit was not as good the municipality was placed into its proper soil group by determining which of the above six groups occupied 50 per cent or more of the municipality in question, beginning with the Brown Soil Zone and working through the six categories in sequence. Therefore even though the odd municipality may have been composed of up to three soil groups, the soil group which occupied more than half of the municipality was the one used to identify the municipality.

For most municipalities this procedure worked well because well over 50 per cent of the area of most municipalities fell within a single soil group. It was only at the fringe of the settled areas of central and northwestern Alberta and the northern parts of the province that more than two soils covered equal areas of any single municipality. This necessitated the formulation of a category with three soil types in it, the Black-Dark Grey Wooded—Grey Wooded category. It had been originally hoped that the Black Soil Zone could have been isolated from the others because this zone is rated as the most fertile in the province. Consequently it would have been of interest to examine the distribution of average farm size in municipalities characterized by this soil type alone because there is a tendency for the smallest average farm size to occur in those municipalities occupied to a large degree by this soil group alone.[2]

Soil scientists[3] advised the formulation of the larger Black-Dark Grey Wooded—Grey Wooded category and the separation of this category from the Dark Grey Wooded—Grey Wooded category however because they noted that the Dark Grey Wooded Soil Zone is in reality a transitional soil from Black to Grey Wooded. Therefore wherever Black and Dark Grey Wooded combined covered 50 per cent or more of the municipality it was placed into the Black-Dark Grey Wooded—Grey Wooded soil zone.

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[2] Compare for example, the average size of farm by municipality and the soil zones as shown on Maps 1 and 9.

[3] Pers. Comm., A. Goettel, Head, Soils Branch, Plant Industry Division, Alberta Dept. of Agriculture.

Moreover in some ways this procedure helped to isolate the association of the Black Soil Group and average farm size because as previously indicated many of the municipalities characterized by the three soil type categorization are located at the margins of continuous agricultural settlement. The settlement pattern however is not continuous to the edges of these municipalities but rather forms a discontinuous fringe pattern particularly in the Grey Wooded Soil Zone. In some cases in fact agricultural settlement has not progressed to the western or northern boundaries of the municipalities in question. This tendency has been illustrated by the boundary of settlement line superimposed on most maps in the agricultural section of the Atlas of Alberta. This suggests then that the physical conditions for agriculture in these municipalities will in all likelihood be most strongly influenced by the Black Soil Group and the transitional Dark Grey Wooded soil groups in the tripartite Black-Dark Grey Wooded-Grey Wooded soil classification.

Although the actual data developed by these procedures will be discussed later during the analysis of the relationship between soil zones and average size of farm per municipality, it may be of interest to examine how the various cutoff criteria were used to establish the margins of the Black-Dark Grey Wooded-Grey Wooded category. In municipality 44, census division 6, for example, there are roughly 216 sections of Black soil (approximately 10 per cent of the total agricultural area) but this municipality was not included in the above category because more than 50 per cent of the municipal area was taken up in a category of higher sequential priority in the six soil category sequence. Because the soil categories were ennumerated from south to north if there was any doubt as to the grouping of a particular municipality it was placed into the first category in the aforementioned list for which it was eligible. Even if this municipality had been eligible for inclusion in the Black-Dark Grey Wooded-Grey Wooded category it still would not have actually been included because only 25 per cent of occupied area was composed of the tripartite soil grouping. Consequently this municipality was grouped with the others in the Dark Brown-Thin Black soil category. Municipality 7 in census division 13, on the other hand, was placed in the Black-Dark Grey Wooded-Grey Wooded category because first, it could not be placed in a higher sequential priority category and second, more than 50 per cent of its total area was composed of the Black-Dark Grey Wooded-Grey Wooded category. In fact over 25 per cent of its agriculturally occupied area is composed of Black soils alone. It may seem, after an examination of the Soils Map (Map 9), that the Black soils do not truly occupy 25 per cent or more of the agricultural area of this municipality but in reality they do because only 74 per cent of the total area of the municipality is occupied by land in farms. This is an important observation because it illustrates the nature of the settlement pattern with reference to particular soil groups on the northern margins of the comprehensively settled agricultural areas to the south. The last municipality, number 11, census division 13, to be examined here posed a major problem because even though the three requisite soil types were present, the Black soil group comprises a very minor part of the total occupied area (less than 8 per cent). However even though the Dark Grey soil occupies the requisite 50 per cent of the total surface area it was nevertheless decided that the area occupied by Black soil was virtually nonexistent and therefore the municipality was placed into the only category open to it in the

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[4] This figure has been derived from a comparison of the area value for land in farms reported in the 1961 Census of Canada with the total area of the municipality which was taken from the 1964 Annual Report of the Alberta Dept. of Municipal Affairs, Edmonton.

sequential list of soil zones, the Dark Grey Wooded-Grey Wooded soil zone.

Irrigated soils and the location of the major soil groups with respect to slope also posed problems for the classification procedure. In the case of irrigated soils, for example, the problem was how to take into account the improved conditions for agriculture in those municipalities where irrigation is practiced on a fairly wide scale. The problem of slope is similar, only in the case of this variable the difficulty was how to modify the classification procedure so that the adverse effect that slope has on cultivation might also be taken into consideration. It is important to be cognizant of this latter feature because the reason for regionalizing the province is to develop areas in which it is expected that the physical conditions for agriculture are relatively homogeneous.

Although supplemental irrigation is widespread in Alberta, it is only in three municipalities in the southern part of the province that it was considered important enough by the author to warrant some modification to the soil classification procedure. Farmers in these municipalities, 4, 14 and 25 in census division 2 have traditionally used their land resource more intensively than have farmers in other municipalities where irrigable land, irrigation water, and irrigation facilities are available. This intensity of use is reflected in two important indices which have been developed from 1961 census data: the percentage of the area of the municipality which was irrigated in 1961 and the percentage of the total number of farms in each municipality reporting irrigation for the same year. The values for the first index for municipalities 4, 14 and 25 respectively are approximately 15, 14 and 20 per cent and the values for the second one 89, 73 and 70 per cent. The municipalities with the next highest values, after these three, are 6 in census division 3 and 16 in census division 5, but in spite of the fact that these two municipalities rank fourth and fifth, their values for the two indices are only 3 and 1 per cent for the portion of the agricultural area that was irrigated and 38 and 24 per cent for the percentage of the farms reporting irrigation. Municipality 16 in census division 5 is a particularly interesting example of how the availability of irrigable land, irrigation water, irrigation facilities, and proximity to an urban market for irrigated crops, Calgary, do not necessarily lead to irrigated farming. The Western Irrigation District is located primarily in this municipality and although it extends over half of the agricultural area of the municipality only approximately 3 per cent of its area, as was shown above, was actually irrigated in 1961.

Although these indices provide clues as to the importance of irrigation in the southern part of Alberta the problem of how to change the rating of the soil in some meaningful way remains. It was decided finally to account for the importance of irrigation in the three main irrigated municipalities by assuming that their soils were improved for agriculture by the application of irrigation water to the extent that they might be considered as falling into the next higher soil category. In this way municipalities 4 and 14, which are located in the Brown Soil Zone, were moved to the Dark Brown-Thin Black Zone and municipality 25 was moved from the Dark Brown-Thin Black zone to the Black-Dark Grey Wooded-Grey Wooded category. Although this adjustment was made, it was not assumed that the irrigated soils of any particular soil zone were identical with the non-irrigated soils of the next higher category. It is entirely possible, in fact, that, with the application of irrigation water these soils are able to support higher intensities of land use than is found elsewhere because, for one thing, the climatic conditions for agriculture, in terms of the amount of heat available for plant growth in the irrigated areas are better here than almost anywhere else in the province. It was assumed, however, that the combination of irrigated and non-irrigated soils would produce intensities of land use, when averaged together, that would be comparable with the average intensity in the next soil category.

Although larger scale relationships have been established elsewhere between land use and slope[5], it was presumed that, because the major land form in Alberta is a plain, local variations in slope would be averaged out at this small scale of investigation. This statement is not meant to convey the impression that some municipalities are not more favoured for agriculture than others in terms of their surficial configuration. What is meant, rather, is that it is not likely that any major soil group in Alberta has a significantly higher percentage of its area in steeper slope than any of the others. There is, however, one obvious but minor exception along the southwestern border of the province. In this district, which is comprised of municipalities 10, 27, 946, 50 and 58 in census division 9, more than half of the area of agricultural land is in slopes well in excess of the 11° value suggested, by Macgregor, as the limit for land that is to be ploughed and cut annually in Britain.[6] Although no comparative studies have been conducted in Western Canada, visual comparison between a generalized land use map compiled by A.H. Laycock and a slope map presented in an unpublished master's thesis suggests that the limit is valid under the climatic conditions experienced in this part

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[5] See for example, D.R. Macgregor, "Some Observations on the Geographical Significance of Slopes, Geography, Vol. 42, pt. 3, July 1957, pp. 167-173, and J.J. Hidore, "The Relationship Between Cash-Grain Farming and Landforms", Econ. Geogr., Vol. 39, No. 1, Jan. 1963, pp. 84-89.

[6] L. Symons, Agricultural Geography, Bell, London, 1967, p. 54.

of Alberta.[7]

The major soil type, as shown on Map 9, for the five municipalities in question, is either Black or one of the Grey or Dark Grey Wooded groups. Yet, even though this district is shown to possess homogeneous zonal soils, it is difficult, particularly after some insight into the slope conditions has been gained, to accept these groups as being comparable with the other Black and Grey Wooded soil groups located elsewhere in Alberta. The difficulty is based on the fact that, even in the relatively flat areas of the province, variations in slope produce variations in the degree to which the general soil category accurately portrays general conditions within any one soil group. In areas where slope conditions are mapped as being well over 11° the problem is obviously much worse. Consequently, the exclusion of the soils in these five municipalities from the other major soil groups appears reasonably well justified.

The Grey Wooded-Dark Grey Wooded Soil Group was also subdivided on a similar basis. This produced two distinct zones of Grey Wooded soils: the agricultural fringe at the northern and northwestern limits of continuous agricultural settlement, and the Peace River District. The need for this type of separation became apparent during the course of field examinations in this part of the province. It was noted for example, that drainage conditions and settlement patterns were somewhat different in the Peace River District when compared with the remaining areas of Grey Wooded soils. In the Peace River District agricultural settlement appears confined more to the better drained Dark Grey Wooded soils than is the case farther south. There is, in addition, the distinct possibility that some of the soils in the Peace River District may be of a higher quality than has been shown on the map of the soil zones of Alberta. Soils on the lacustrine plain just outside of Grande Prairie and along the broad

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[7] These maps are presented in the Atlas of Alberta (in press) and in a thesis by M. Bullock, A Land Form Map of Southern Alberta, unpublished M.Sc. thesis, University of Alberta, Edmonton, 1966, 160 pp.

lacustrine plain across which the Peace River now flows, for example, are shown in the same category as the Dark Grey Wooded soils farther south. Yet their general characteristics for agriculture make them much more valuable for agriculture than the generalized soil zones map would suggest.

Summary

It is by now obvious that it is difficult to achieve measures for each variable that are suitable for further analysis. It is necessary in a few cases to generalize the data in some way and in other cases to modify generalized categories that have been established previously in the literature. Soil quality is a particularly difficult variable for which to establish reasonably objective classes. The major problem, of course, is that soil quality itself is a highly complex variable that, as was stated earlier, reflects the influence of many other factors.

In spite of these difficulties, however, the nature of the relationships between these variables, as here described and the average size of farm per municipality will be examined in the next section.

The Analysis of the Areal Relationship Between the Dependent and Independent Variables

The major statistical test employed for this stage of the analysis was a regression and product moment correlation model. In those instances where this model was inappropriate, because of the nature of the data, or, because an additional check on the original results derived from the regression and correlation tests was desired, other statistical tests were employed.

Although both regression and correlation tests were executed, the results of the latter were considered more important to this study because of its exploratory nature. Blalock gives some indication of the importance of correlation, particularly when the stated goals are exploratory, in his statement that,

> When interest is focused primarily on the exploratory task of finding out which variables are related to a given variable we are likely to be mainly interested in measures of the degree or strength of relationship such as correlation coefficients.[8]

If suitable data had been available then this study could have proceeded to the next stage whereby prediction, within certain limits, could have been made with the use of regression analysis of the value of one variable from the knowledge of the value of another. The variable nature of the data in part precluded this but a regression analysis was carried out, nevertheless, so that with the aid of the residuals from regression some idea could be gained of the areal variation in the strength of the relationship, as stated by the correlation coefficients.[9] It is unfortunate that fuller use could not have been made of the regression analysis but,

> When we note that most correlations in the social sciences are considerably less than 0.7 [the point at which regression may be of use for predictive statements] we realize that prediction becomes out of the question.[10]

Therefore, as is the case in most problems in social science, attention in this study is focused more on locating the important variables and in this task correlation analysis is more useful than regression analysis. Before correlation analysis could be used, however, some

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[8] H.M. Blalock, Social Statistics, McGraw-Hill, New York, 1960, p. 273.

[9] For a fuller discussion of the use of residuals from regression see E.N. Thomas, Maps of Residuals from Regression: Their Characteristics and Uses in Geographic Research, Publication of the Dept. of Geography, State University of Iowa, No. 2, Iowa City, 1960, 60 pp.

[10] H.M. Blalock, op. cit., p. 299.

adjustment to the basic formula seemed to be necessary to take into account the geographer's areal point of view. As stated by Hagood and Price, "correlation analysis has been designed for studying relationships between characteristics as distributed among units of equal importance."[11] Yet, it is fairly obvious that the units from which the mean values for farm size and size of farm business, etc. were drawn are not equal. A.H. Robinson also was fully cognizant of this problem of variation in the size of the areal units from which social scientists often draw their data and noted that,

> ... when the areal units to which the values relate are not the same size, as is unfortunately usually the case, significant discrepancies in size should be taken into account; otherwise the results of computations may be meaningless.[12]

To solve his particular problem he suggested adding weights to the regression equation which are proportional to the area of the municipality so that the formula then became

$$r = \frac{\Sigma W \; \Sigma WXY \; - \; \Sigma WX \; \Sigma WY}{\sqrt{\Sigma W \; \Sigma WX^2 - (\Sigma WX)^2} \; \sqrt{\Sigma W \; \Sigma WY^2 - (\Sigma WY)^2}}$$

where W was the areal size of the unit from which a specific mean was drawn and X and Y were the individual mean values to be correlated. Robinson was particularly interested in developing this system of weighting because he wished to make inter-regional comparisons among phenomena that came from districts that had been subdivided into different numbers of areal units. In other words, with this technique he was able to obtain accurate measures of correlation even when the various regions of the study area had been divided into states in some sections and counties or townships in others. Robinson's assumptions

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[11] M.J. Hagood, and D.O. Price, Statistics for Sociologists, Holt, New York, 1952, pp. 354-356.

[12] A.H. Robinson, "The Necessity of Weighting Values in Correlation Analysis of Areal Data", Annals, Association of American Geographers, Vol. 46, No. 2, June 1956, pp. 233-236.

have been substantiated in part in an article by E.N. Thomas and D.L. Anderson, but these authors noted that the method cannot be used for comparisons of the degree of correlation for the same two variables outside of the original region unless certain assumptions about the data are satisfied.[13]

The subject of this study, as was stated earlier, is not an inter- or even an intra- regional comparison of the various indices of correlation, but rather, it is an attempt to identify those variables which are most closely associated with the areal variation in farm size. The criticism of Thomas and Anderson against the broader application of Robinson's solution is, therefore, not applicable here. Furthermore, because no change was made during the course of the study in the size of the subdivisions into which the study area was divided, area weights were not necessary either, but the original problem of inequality of size of the units from which the mean values for this study have been derived still remained, if suitable weights were not used.

The weights finally chosen were the numbers of farms located in each municipality from which the means were drawn. There are two reasons for choosing this particular form of weighting. The first is related to the size of the municipal unit.

It was observed, for example, that the smallest municipalities in Alberta, in terms of both numbers of farms and occupied area were also the municipalities which possessed means that deviated most from the average conditions encountered in the surrounding areas. Average farm sizes in municipalities 22, census division 1, 27 and 946, census

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[13] E.N. Thomas and D.L. Anderson, "Additional Comments on Weighting Values in Correlation Analysis of Areal Data", Annals, Association of American Geographers, Vol. 55, No. 3, Sept. 1965, pp. 492-504.

division 9, and 85, census division 12, are a good illustration, as are the distribution of the types of farms in the same municipalities plus those in the northern-most fringe of the main southern agricultural district. Once this observation had been made, the question arose as to why each of these municipalities should be allowed to influence the analysis to the same degree as one in which the mean value represented average conditions for far greater numbers of farm units. This technique of weighting appeared to offer a solution, although admittedly not a complete one. It was noted for example that those larger municipalities which were occupied by larger than average farms and hence fewer numbers of farms were given less weight than municipalities of similar areal size occupied by smaller farms. In other words the use of this weighting procedure likely resulted in discrimination against areas with large farms.

The second reason had to do with the nature of the independent variables. Smillie suggests that "If the regression problem is that of determining the regression of some concomitant variable on a number of treatment means, then the weights may be taken as proportional to the sample sizes with a constant of proportionality of unity".[14] Although it may be easier to accept some of the independent variables in this study as being more closely akin to treatments (for example, changes in soil quality or even changes in the nature of the farm enterprise) than others, all are like treatments in that it is conceivable that they might be manipulated in some way to produce a corresponding change in the dependent variable.

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[14] K.W. Smillie, An Introduction to Regression and Correlation, Ryerson Press, Toronto, 1966, p. 151

Analysis of Moisture Deficit, Frost Free Season and Soil Zones

Each of the measures of the various characteristics of the physical environment, cited in Chapter Two, could have been correlated with average farm size, but it was decided that although all are meaningful indices of general climatic conditions in Alberta, some have more relevance to agriculture than others. Knowledge of variables which limit growth, such as moisture deficit and frost free season, would seem to be of greater value to a farmer than the average annual temperatures or possibly even the amount of precipitation normally available between May and September. In a statistical sense these two variables are also influenced by the other climatic variables in that, average temperatures are related to the length of the frost free season in Alberta and May to September precipitation is linked to soil moisture deficit. This statement is not meant to convey that these are the only factors affecting the values for frost free season or soil moisture deficit, but it would be difficult, on the other hand, not to acknowledge that these variables are related and that, in fact, soil moisture deficit and frost free season are variables that summarize the limiting climatic conditions for agriculture.

Soil quality is of a similar nature because again the general characteristics of any particular soil group are influenced directly and indirectly by the climate through soil leaching and the type of vegetation growing on it. Admittedly, this is a broad generalization because there are many other variables which affect the quality of soil, such as parent material, slope, intensity and duration of rainfall, etc., but, in light of the scale at which this study was undertaken and for the sake of discussion, this assumption was made. The validity of this position will be tested by assessing the degree to which it aids our understanding of the areal variation in average farm size.

All of the relationships were presumed to be linear within the limits of the data. Scatter diagrams did not suggest otherwise, but it should be noted that once the weighted regression model was employed the scatter diagram became difficult to interpret because, although the means derived from the unequal units were displayed in their unweighted form, their effect on the regression and correlation coefficients was in some proportion of their associated weights.

Moisture deficit was the first variable to be examined. Its relationship with the average size of farm was assumed to be a direct one because moisture deficit is related to the intensity with which farming may be carried out under present economic and technological conditions. Consequently it was expected that increases in the values of soil moisture deficit would be associated with increases in farm size. The values for soil moisture deficit, which were derived by the method outlined earlier, are shown on Map 13 and the residuals from the regression analysis of farm size and soil moisture deficit are indicated on the next map (Map 14). The results of the correlation and regression analysis indicated that the correlation coefficient had the correct sign in keeping with the hypothesized relationship between farm size and soil moisture deficit and its value was 0.66.

The next problem requiring consideration was how to assess the statistical significance of this value. In normal circumstances, if a random sample is drawn from a larger population there is the possibility that the results obtained from a correlation analysis could arise through chance factors alone. In this case they would not represent the true relationship between the two study variables in the larger population. Some sociologists, however, seem to have accepted mean values drawn from all municipalities in any particular state as being identical to the population values and hence representative of the true state of affairs in the larger population.[15] In such cases

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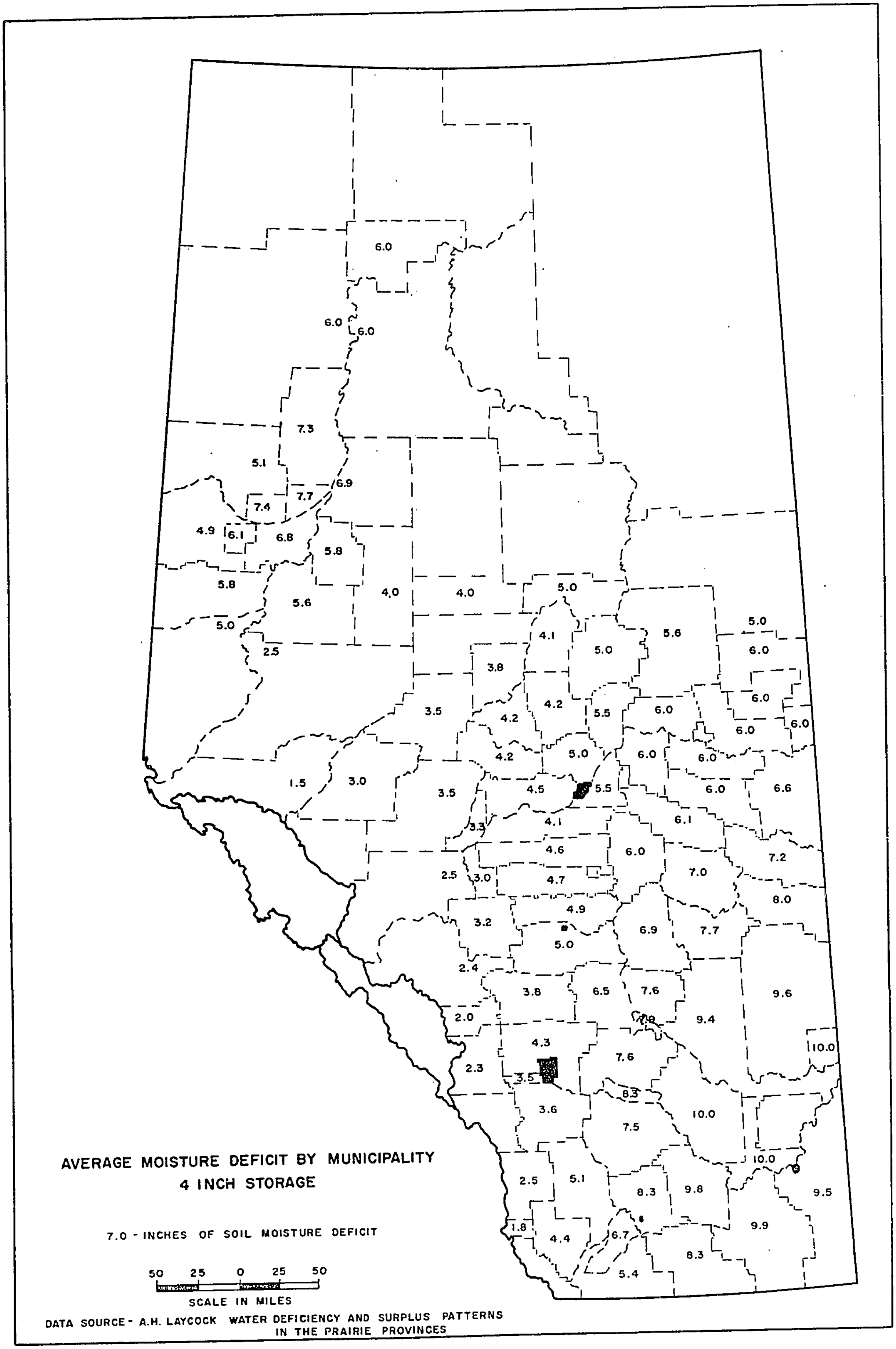
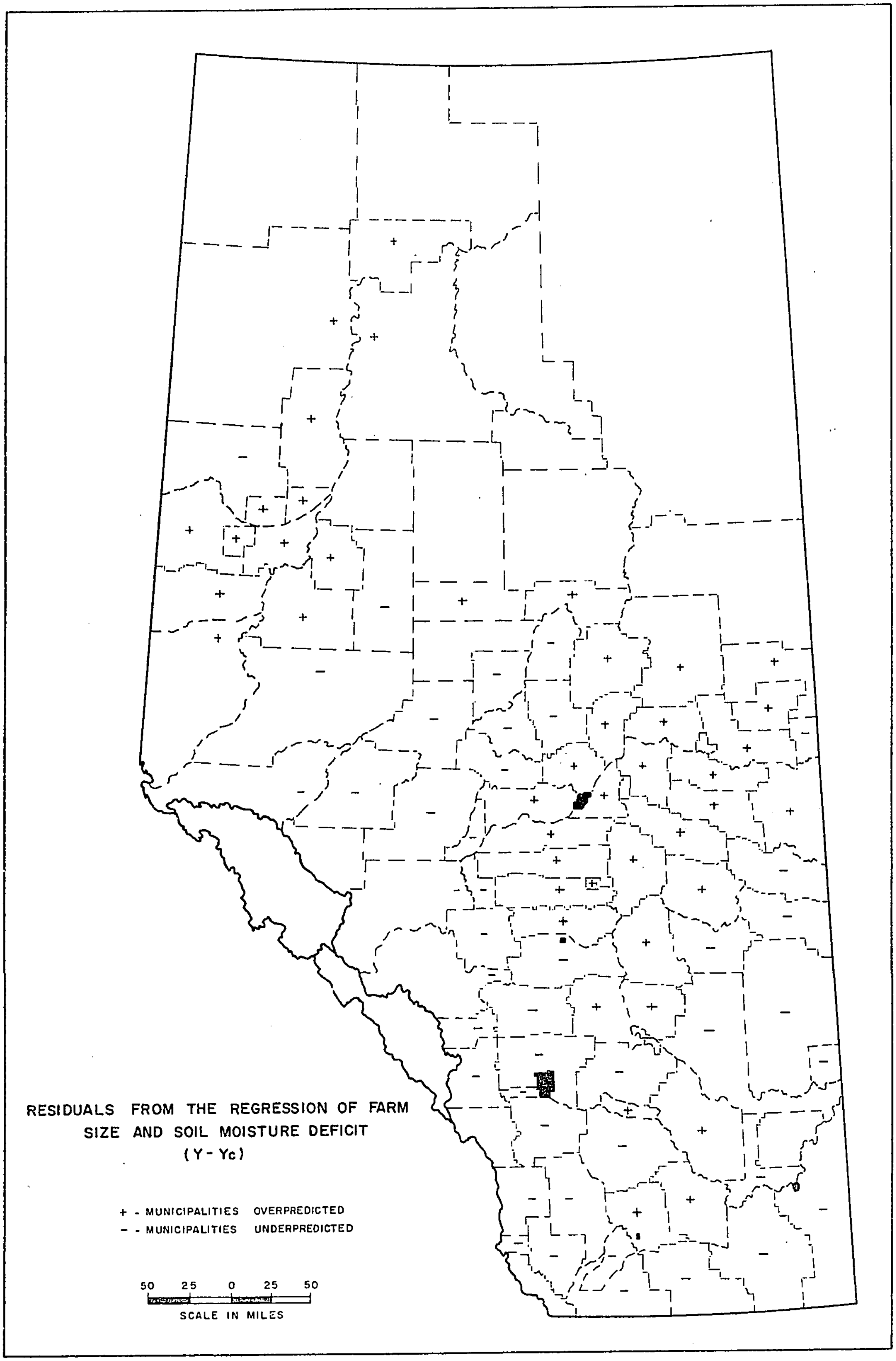
[15] See for example, M.J. Hagood and D.O. Price, <u>op. cit</u>.


AVERAGE MOISTURE DEFICIT BY MUNICIPALITY
4 INCH STORAGE
7.0 - INCHES OF SOIL MOISTURE DEFICIT
50 25 0 25 50
SCALE IN MILES
DATA SOURCE - A.H. LAYCOCK WATER DEFICIENCY AND SURPLUS PATTERNS IN THE PRAIRIE PROVINCES

Map 14


RESIDUALS FROM THE REGRESSION OF FARM SIZE AND SOIL MOISTURE DEFICIT
(Y - Yc)
+ - MUNICIPALITIES OVERPREDICTED
– - MUNICIPALITIES UNDERPREDICTED
50 25 0 25 50
SCALE IN MILES

the correlation results are accepted as being statistically significant no matter how small their value. The only test of significance then becomes the more subjective one of whether the stated relationship is large enough to be concerned about. Other analysts, in both Geography and Rural Sociology, have accepted data, which, in essence, represent the entire population, as being a sample from a larger population or universe of events that did happen and might have happened if everything else had remained the same but the random shocks.[16] J.D. Tarver, in his study of the relationships of population densities, farm sizes and farm land values, examined all counties in eastern United States, located 352 with characteristics which met certain stated criteria and then assumed that these counties were in reality a sample which had been, "randomly drawn from a larger conceptual population of counties having the specified characteristics."[17] There appears, then, to be differences of opinion as to what constitutes a sample and, in fact, E.N. Thomas and D.L. Anderson note that even the differentiation of the terms "population" and "universe" are not equally acceptable to all statisticians.[18] For the stated purposes of this

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[16] E.N. Thomas and D.L. Anderson, op.cit., p. 497. The authors suggest that the justification for this construct which they have used as a rationale for studying the entire population with inferential statistical techniques lies in a statement made by R.A. Fisher to the effect that: "Any body of numerical observations, or qualitative data thrown into numerical form as frequencies, may be interpreted as a random sample of some hypothetical population of possible values." R.A. Fisher, "Theory of Statistical Estimation", Proceedings, Cambridge Philosophical Society, Vol. 22, Pt. 5, 1925, p. 701.

[17] J.D. Tarver, "Locational Aspects of Population Densities, Farm Sizes and Farm Land Values", Rural Sociology, Vol. 31, No. 1, March 1966, pp. 41 and 45.

[18] See for example, footnote 9 in E.N. Thomas and D.L. Anderson, op.cit., p. 496.

study however, the data were accepted as being a random sample and hence eligible for the appropriate tests of significance.

Both the correlation and the beta coefficients were tested for significance even though it would appear from the discussion outlined in Blalock's text that a test of the beta coefficient would have sufficed in the case of a simple regression and correlation analysis. The reason for this is that the significance test assumes the null hypothesis that beta is equal to zero. If such actually proves to be the case then it cannot be assumed that there is a linear relationship in the population and hence no matter what the computed value of r may be it cannot be accepted as significantly different than zero except in the remote eventthat the relationship between the study variables is curvilinear.[19]

Both of the coefficients were significantly different at the 5 per cent level of confidence. It would appear, therefore, that the original assumption of a relationship between moisture deficiency and average size of farm per municipality was justified.

The residuals from regression were plotted on Map 14 on the basis of their sign rather than their value because of the variability of the data. If too close attention had been given to the actual values then there would be the real danger of attributing significance to patterns that may well have been the result of chance. A comparison of the maps showing average farm size, soil moisture deficit and the residuals from regression led to a number of interesting observations.

First it was noted that average size of farm was underpredicted, on the basis of soil moisture conditions, in most of the southern half of Alberta. Some of the reasons for this pattern may be related both

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[19] H.M. Blalock, op. cit., p. 302.

to variations in soil texture and quality, and the size of the farm business. It was noted, for example, that the largest anomalies occurred in municipalities 22, census division 1, and 27, census division 9. The first municipality is located in an area in which the soils are of extremely poor quality for arable farming and the second is located in the steeply sloping Foothills area of western Alberta. Therefore farm size in some parts of southern Alberta may well have been larger than expected in terms of the soil moisture deficit because of modifications made by the farmer in response to other physical conditions, over and above moisture conditions. However, part of the pattern of underprediction may also be attributed to the regional variation in farm business size, because, as was shown earlier, the total value per farm of lands and buildings, machinery, and livestock and poultry was highest in southern Alberta. Therefore, even though there has been a regional adjustment in farm size in response to moisture conditions for agriculture, farms in the south have also been adjusted in such a way as to have produced a larger average farm business size than is found elsewhere in Alberta. The reasons underlying this regional pattern are not immediately obvious, but it may be that the larger farm business size found in southern Alberta represents an indirect response to the physical conditions for agriculture because where the values for soil moisture deficit are highest seasonal rainfall is least predictable. This suggests that farm business size must be large in any one year to compensate for the higher than average incidence of crop failure. Time may also be an important factor underlying the regional variation in farm business size particularly in southwestern Alberta because this was one of the first parts of the province to have been used on a broad scale for commercial agriculture. There is some evidence which suggests that the original ranching concerns established in this area may well have formed the base of a viable farm economy that was able to develop the surpluses needed for a long term policy of farm expansion.[20]

These are only two of the variables that may have influenced the different regional rates of farm expansion in southern Alberta. Undoubtedly there were others. Government policy towards the depopulation of census division 4 during the late twenties and thirties, for example, may also have been among the most important for at least some parts of the southern half of the Province.

One of the most noticeable reversals in the trend to underprediction of farm size in southern Alberta on the basis of soil moisture deficit occurred in municipalities 4, 14 and 25, census division 2. Average farm size was smaller here than was expected because no allowance was made for the fact that irrigation water is used in large quantities in these municipalities to supplement atmospheric moisture. It is interesting to note, particularly in light of the previous discussion concerning how the great soil groups were modified in those municipalities in which irrigation was considered relatively important, that overprediction was not a problem in any other municipality in which irrigation structures occurred.

Bearing in mind the previous statements concerning the reliability of individual residuals from regression, the actual values for census divisions 7, 8 and the southern half of 11 were close enough to zero to have suggested that average farm size per municipality was very near to being what was expected in terms of soil moisture deficit. Elsewhere in northeastern Alberta and the Peace River District farms were overpredicted whereas in the Grey Wooded Soil areas in the northwestern part of Alberta, farms were underpredicted.

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[20] A.A. Lupton, "Cattle Ranching in Alberta, 1874-1910: Its Evolution and Migration", The Albertan Geographer, No. 3, 1967, pp. 48-58.

The reasons for these anomalies are not as readily apparent as were those for the southern part of the province, but it would appear that farming operations have not been adjusted for soil moisture deficit to the same degree as they were farther south. In census division 12, for example, soil moisture deficit is as pronounced as on the much better soils in census division 10, yet average farm size is in the same general size category. It may be argued that farmers in this area traditionally use other resources more intensively than farmers in the census divisions farther south, but there is little direct evidence to support this supposition and a better explanation would seem to be that the farms are too small to produce an income from the sale of agricultural products similar to that produced farther south. The prevalence of non-commercial farms in this area and the low average values of farm capital accruing to each operator would seem to be evidence for this viewpoint. Similar arguments may be used for the Peace River District, but conditions for agriculture and the response to these conditions are not identical with those found in northeastern Alberta. One difference, for instance, is the greater emphasis on small grains and wheat farming. Nevertheless, in terms of soil moisture deficit farms are smaller on the average in the Peace River District than in other parts of Alberta with similar moisture conditions. In the core area of the Peace River District, in municipalities 132, 135, and 136, for example, soil moisture deficit is as severe as that experienced in some parts of the Dark Brown Soil Zone, yet average farm size is much smaller. In economic terms the adjustment of farm size in response to drought appears to have been much better than that encountered in northeastern Alberta because the total value of farm capital accruing to the Peace River farm operator is similar in value to that of central Alberta. Outside of the core area conditions are similar to those in northeastern Alberta.

Although farm size was underpredicted in northwestern Alberta, the existing farm size is still well below the average in economic terms. Roughly 50 per cent of the farms were classified as non-commercial in the 1961 census and their average worth in terms of the value of capital inputs was lower than the provincial average. The reason for the underprediction is simply that soil moisture deficit is extremely low here, therefore in terms of the original hypothesized relationship the smallest farms should also have occurred here. The fact that they did not, only emphasizes the agricultural problems of this area which are associated with poor soil quality, climate and possibly distance to the major urban markets.

The last area chosen for discussion in this section of the study is the group of three municipalities surrounding Edmonton: 15, 83 and 84. Here farm size was again overpredicted in terms of soil moisture deficit. It may be recalled from the previous discussion that the values for average farm size are among the smallest in these three municipalities while at the same time, the average value of the farm business is among the highest for the entire province. This suggests that, even though average farm size is smaller than would have been expected, knowing the moisture conditions of the area, other factors, such as proximity to a rapidly growing urban centre, compensate for this limitation on agricultural activity. How this particular factor affects farm size is not clear because as suggested earlier in Chapter Two, urban demand for rural land may have inflated its value, which in turn would tend to keep farms small in size, while at the same time urban market demands may have encouraged a more intensive use of the land. Both of these trends are evident in an analysis of the total value of capital inputs per acre. Although the value of lands and buildings are the highest in the province, the value of machinery inputs per acre are also in the highest provincial category. It cannot be forgotten, however, that the physical conditions for agriculture around Edmonton, in terms of moisture, frost free season and soil quality, are perhaps the best, outside of the southern irrigation areas, in the province. Therefore the relationship between a farmer's attitude towards the physical resource base and proximity to a major urban place remains in doubt.

The linear relationship of the second variable, frost free season, and the average size of farm was also significant at the 5 per cent level of confidence, but although the correlation coefficient (+ 0.45) was statistically significant it did not verify the original hypothesized relationship because its sign indicated that the actual direction of the relationship was opposite to that predicted. It had been originally assumed that if frost were a problem a farmer in Alberta would generally adapt to it by using his land more extensively thereby necessitating a larger size of farm if his returns were to approximate the provincial mean. This assumption was based on the length of the longer growing season usually required for crops normally associated with more intensive farming. The basis for this assumption can be best explained with the aid of the previous map of the residuals from the regression of soil moisture deficit and mean size of farm.

If soil moisture patterns had been the only information possessed by an observer then it would have been expected that farm size would continue to decrease in a westerly and northerly direction away from the driest part of Alberta in the southeast. This did occur in the Black Soil Zone but not at the rate expected on the basis of soil moisture information because the positive residuals indicated that farm size should have been smaller than was actually the case. It would appear then, that other variables were retarding the decline of farm size. One of these variables could well have been frost because even though moisture is generally more plentiful in these regions the farmer cannot take full advantage of it because the frost free season is progressively shorter to the west and north. If market conditions are favourable then the farmer can adapt his operation somewhat to these physical conditions by emphasizing the production of dairy products which depend in large measure on short season fodder crops. As was noted earlier, on the Type of Farm Map (Map 10) this is one of the adaptations that farmers in census divisions 8 and 11 have made. It was also noted that in these areas the residuals were almost zero in value. This suggests that on the basis of soil moisture alone the farms were the expected size and that farmers did not need to respond to frost by increasing the size of their land holding because they could intensify their operation by emphasizing dairy farming.

Outside of the Black soil area farms were larger than expected in the west and smaller than expected to the north on the basis of soil moisture alone. If the above assumptions were valid then the farms in the west were underpredicted because farmers in this area have modified the areal size of their farms partly in response to the greater incidence of frost (although the surficial configuration of the land surface is likely of equal if not greater significance). Since they did not have the same option open to them as was available to farmers in divisions 8 and 11 they appear, from the evidence presented in the Type of Farm Map (Map 10) to have established a livestock oriented economy. The evidence that it is likely far more extensive than the small average size of farm would seem to indicate, may be found in the low value of capital inputs per farm and the high percentage of non-commercial farms. Consequently, although farm size appears to have been modified to some degree in response to the frost hazard and the other variables indicated earlier, it does not appear to have been modified sufficiently. Farther north, particularly in the northeast, farm size in many municipalities is smaller than expected already on the basis of soil moisture deficit. When the additional frost problem is considered then the average farm size seems ill-suited to the physical resources available, particularly in light of land use practices in much of the area.[21]

Although the above observations seem to provide some evidence to support the original hypothesis of an inverse relationship between average farm size and the length of the frost free season, the actual results did not support it. This does not mean that the hypothesis was incorrect. It merely suggests that it was not substantiated with the data or the form of the data used to indicate the length of the frost free season. If other kinds of measures could have been used, such as the probability of frost or the effect of frost on the grades and prices of grain in each area, then it is likely that the sign of the correlation could have been reversed.

An attempt, using dummy variables instead of actual indirect measures of frost, was made to achieve this end, but again the results were inconclusive. They are reported here only to indicate the nature of possible solutions to the problem of frost and to provide a fuller illustration of the areal distribution of this phenomenon.

The frost free data were broken into three classes on the following basis. It was accepted that areas with 100 frost free days or more were ideal for wheat production, whereas areas with less than 75 days were marginal for most of the major cereals grown in Alberta. The resultant three zones are illustrated by Map 15. In light of the previous discussion of the conditions for agriculture near Edmonton it should be noted that the three municipalities surrounding the city fall into the same category as those in the southeast of the province. Next,

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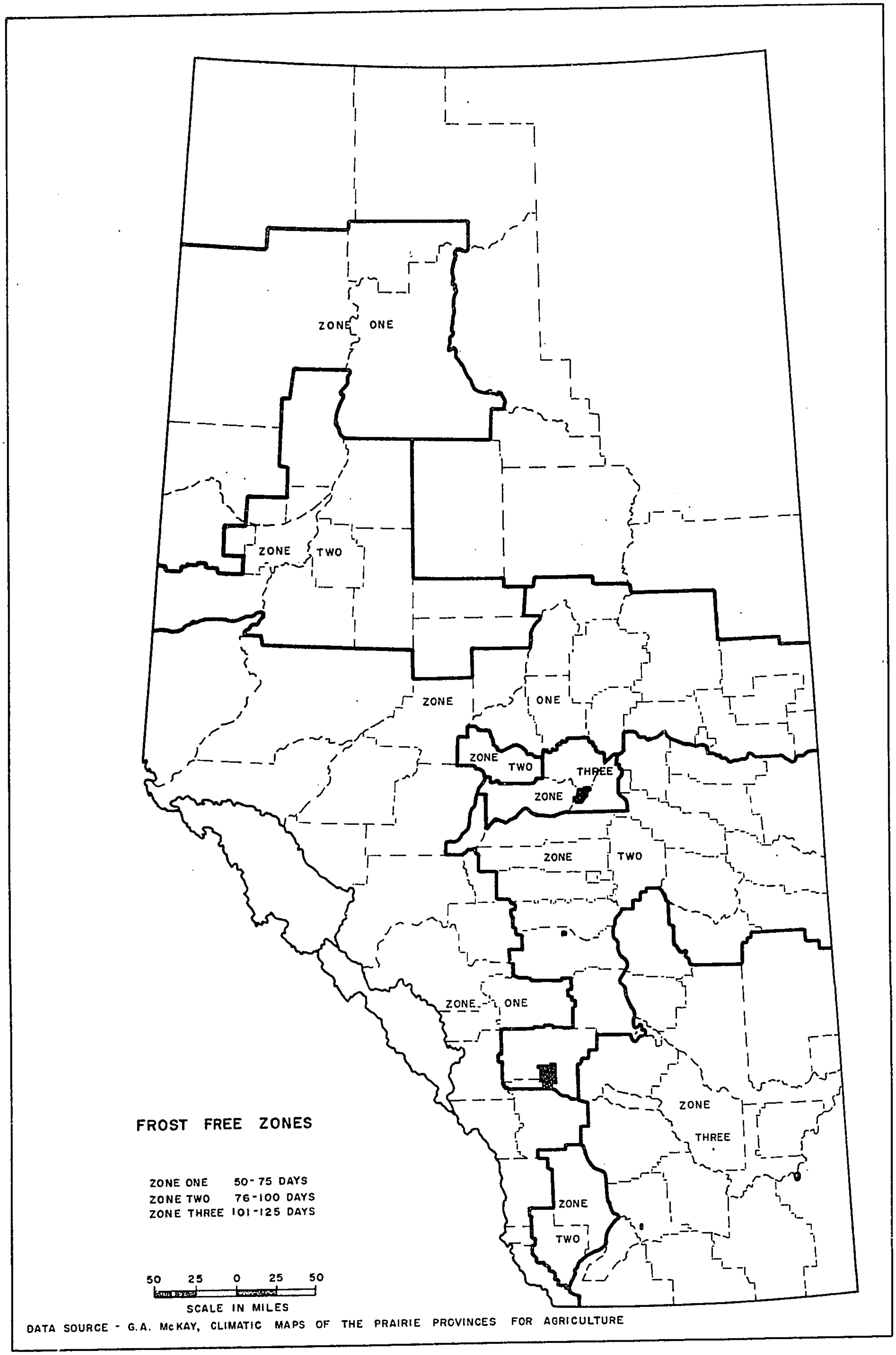
[21] See for example a generalized land use map by A.H. Laycock, Atlas of Alberta (in press)

Map 15


ZONE ONE
ZONE TWO
ZONE ONE
ZONE TWO
THREE
ZONE
ZONE TWO
ZONE ONE
ZONE THREE
ZONE TWO
FROST FREE ZONES
ZONE ONE 50-75 DAYS
ZONE TWO 76-100 DAYS
ZONE THREE 101-125 DAYS
50 25 0 25 50
SCALE IN MILES
DATA SOURCE - G.A. McKAY, CLIMATIC MAPS OF THE PRAIRIE PROVINCES FOR AGRICULTURE

the municipalities in each of the three zones were scored as if they were affected by a new frost variable so that the regression and correlation relationship was restated in terms of three functions instead of one. Previously it had been hypothesized that average farm size (y) was a linear function of the length of the frost free season (x). Now the equation was changed to state, average farm size is a function of frost in zone one (x_1), frost in zone two (x_2) and frost in zone three (x_3). The frost variables associated with each municipality were then scored yes or no, indicated by a one or a zero in response to the question of whether or not they were assumed to influence farm size in the municipality in question. Any municipality in zone three, for example, was scored zero for variable x_1, zero for variable x_2 and one for variable x_3. Finally, these dummy variables were added to soil moisture deficit, a continuous variable, to study their effect on the total correlation. The step-wise multiple regression programme available in the Department of Computing Science at the University of Alberta was modified[22] to accept the numerical weights and employed to give the following results. By itself, moisture deficit accounted for roughly 44 per cent of the variability of farm size (correlation coefficient + 0.66, T value 8.15, F ratio 66.44 with 1 and 83 degrees of freedom - all significant at the 5 per cent level). With the addition of the dummy variables there was virtually no change in the variability of farm size explained so that, although all indices remained significant at the 5 per cent level of probability, the variance remained roughly the same (48.54). Again this does not mean that frost has no influence on farmers' decisions and hence indirectly on farm size. It may simply mean that the data

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[22] This modification was done by Mr. D. Barry, graduate student in the Dept. of Computing Science, University of Alberta.

were not broken into the correct number of size categories, or that many farmers in the more northerly sections of the province switched their crop emphasis to the more valuable forageseed and rapeseed, or that some modification to the frost free data should have been carried out to take into account the increasing length of day to the north. All of these and more are possibilities, but the question was pursued no farther and instead the relationship between soils and average size of farm was examined. It was expected that this would prove to be a more suitable approach to the influence of soil moisture deficit and the incidence of frost because the soil zones are, in reality, broad summary variables which include these two effects on crop patterns and farming activity within them.

All of the municipalities were examined, using the dummy variables technique discussed previously, and then placed into one of the major soil groups established earlier. The results are shown on Map 16. These municipalities were again scored with a one or a zero to indicate whether or not the average farm size was associated with a specific soil group. The dummy variables were then analysed with the step-wise multiple correlation and regression programme and the association between soil type and average farm size per municipality examined. The results of the regression-correlation programme were significant which indicates that soils and farm size are related at this scale of investigation. The last two steps of the programme, however, have been summarized in table form and included in the text because they provide clues about the character of major soil groups as they were established for this study.

The results show generally that over 80 per cent of the variability of farm size can be accounted for by the soil groups alone. As each soil type was added to the regression it did not have the same effect, however. This was to be expected, of course, because it is the nature

Map 16

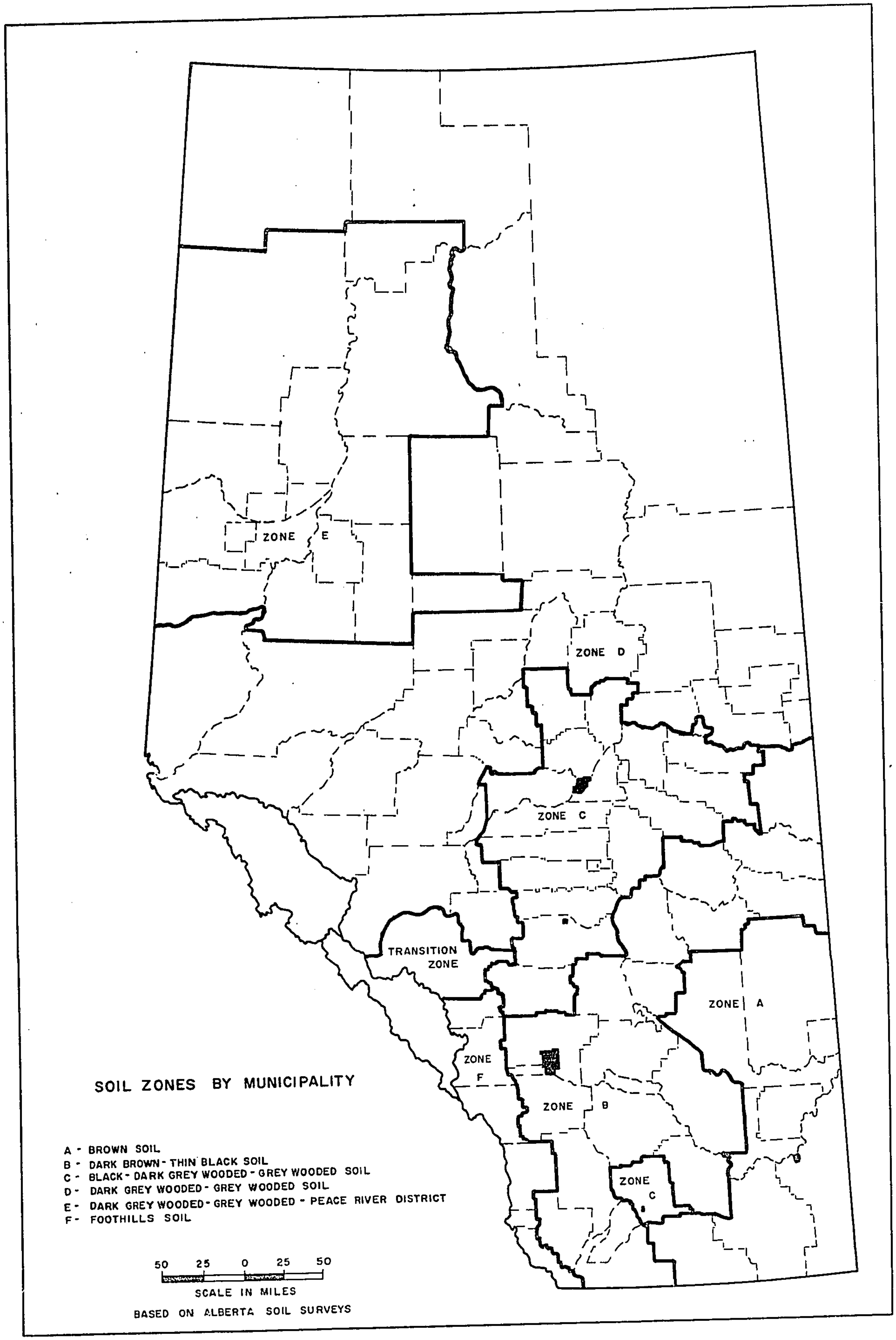
ZONE E
ZONE D
ZONE C
TRANSITION ZONE
ZONE A
ZONE F
ZONE B
ZONE C
SOIL ZONES BY MUNICIPALITY
A - BROWN SOIL
B - DARK BROWN - THIN BLACK SOIL
C - BLACK - DARK GREY WOODED - GREY WOODED SOIL
D - DARK GREY WOODED - GREY WOODED SOIL
E - DARK GREY WOODED - GREY WOODED - PEACE RIVER DISTRICT
F - FOOTHILLS SOIL
50 25 0 25 50
SCALE IN MILES
BASED ON ALBERTA SOIL SURVEYS

Table V

Multiple Regression and Correlation Coefficients - Step 4

Relationship of Farm Size to Soil	b Coefficient	Standard Error	T-Value	Variance (Per Cent)
A	1507	104	14.48	63.3
B	377	76	4.96	18.6
C	-112	72	-1.57	0.2
D	-106	84	-1.27	0.3

Multiple Correlation Coefficient	F Ratio
.90*	94.45*

Multiple Regression and Correlation Coefficients - Step 5

Relationship of Farm Size to Soil	b Coefficient	Standard Error	T-Value	Variance (Per Cent)
A	-479	718	-0.67	63.3
B	-1609	714	-2.25*	18.6
C	-2100	714	-2.94*	0.2
D	-2093	715	-2.93*	0.3
E	-2001	716	-2.79*	1.5

Multiple Correlation Coefficient	F Ratio
.91*	84.10*

*Significant at the 5 per cent level of confidence - A.L. Edwards, Statistical Methods for the Behavioral Sciences, New York, 1954, pp. 501, 502, 504-507.

of the dummy variables in this situation that they reveal the influence of the other variables indirectly. For example, once it had been established that certain municipalities were not in the first soil zone in the regression correlation equation, Light Brown (A), then the possibility that the average farm size of these municipalities was large was reduced. When it was established that they were not in the second soil zone either, Light Brown-Thin Black (B), then the possibility that the average farm size in these municipalities was large became even less likely. In other words, it appears that farm size is so closely related to the first two soil zones, plus all the others lumped into one major group, that additional subdivision of the soil zones appears unnecessary. This statement is based on a number of observations which can be examined further with an analysis of the mean values for farm size derived from the municipal means in each soil group as shown on Maps 1 and 16 and as recorded in Table VI.

The use of dummy variables is based on the assumption that the last category will not be used because its influence on the dependent variable will be revealed indirectly by the other variables in the regression equation. Furthermore the successful use of multiple regression itself depends upon the use of independent variables that are truly independent of one another in the sense that they are not indirect measures of the same influence upon the dependent variable. In keeping with the first assumption associated with dummy variables the last soil zone, Foothills, was not used. In spite of this it would appear that the second assumption associated with multiple regression was violated because of the dramatic reversal (shown in Step 5 of Table V) in the values for the b coefficients, standard errors and T values while the coefficient of determination (summation of the variances) remained high and valid. This condition is known as multicolinearity and arises when the individual independent variables are not truly clear cut and independent of one another. It will be noted that this condition became evident when the values for the soil zone classified as Dark Grey Wooded-Grey Wooded-Peace River District were added to the step-wise multiple regression. It would appear then, if all of the above observations and assumptions are correct, that the inclusion of this soil zone triggered a reaction which suggests that the soil zones cannot be considered as having an independent effect on the dependent variable in spite of the characteristics of each soil zone which were enumerated earlier in this chapter.

In an effort to determine if specific sizes of farms really were associated with certain types of soil, an examination of the mean farm size in each soil zone, as previously defined, was undertaken next using the Student t test to determine which of the mean farm sizes for each soil group were significantly different.[22] On the basis of this analysis the following table was constructed in which every possible combination of means was examined.

Table VI Student t Values for Differences Between All Pairs of Unweighted Means of Average Size of Farms for Six Soil Zones

Soil Groups	Average Farm Size in Acres	B	C	D	E	F
A	2130	4.80*	6.66*	6.57*	6.25*	.08
B	910		11.38*	12.05*	9.62*	1.66
C	390			.48	2.61*	2.01
D	380				3.29*	2.02
E	460					1.97
F	3390					

* Indicates a significant difference at the 5 per cent level of confidence on a one tailed test. A.L. Edwards, Statistical Methods for the Behavioral Sciences, New York, 1954, p. 501.

It may be seen from the table that average farm size was significantly different in the Brown Soil Zone (A) and the Dark Brown-Thin Black Soil Zone (B) from the unweighted mean farm size in every other soil zone except that designated Foothills (F). Farm Size on the

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[22] The t test is discussed fully in A.L. Edwards, Statistical Methods for the Behavioral Sciences, Rinehart, New York, 1954, pp. 246-277.

Black-Dark Grey Wooded-Grey Wooded soil zone (C) was significantly different from the unweighted average farm size in all except the Dark Grey Wooded-Grey Wooded (D) and Foothills (F) soil zones. Lastly, farm size in the Dark Grey Wooded-Grey Wooded-Peace River soil zone (E) was significantly different from the unweighted average farm size in every other group except that designated Foothills. In essence, what the t test revealed about the independent soil variables was, firstly, that the Black-Dark Grey Wooded-Grey Wooded (C), and the Dark Grey Wooded - Grey Wooded (D) soil zones do not seem to have an independent effect in the regression on farm size because the farm sizes for each zone were not significantly different, and secondly, that in spite of the large average size of farm in the Foothills Zone (F), the data are so variable within this category very little can be said about the significance of this soil zone.

There are a number of possibilities as to why there was no significant difference in farm size between the Black-Dark Grey Wooded-Grey Wooded and the Dark Grey Wooded-Grey Wooded soil zones but the two most important ones are likely that the association between average farm size and the fertile Black soils could not be isolated because the municipalities in which they are found overlap the Grey Wooded soils and that farmers in the Dark Grey Wooded-Grey Wooded Soil Zone (D) have not increased the size of their holdings in keeping with the nature of their physical resources and provincial trends in farm consolidation. No matter what the underlying reasons may be, however the finding of major importance in this analysis is that the soil categories are not completely independent of one another. In fact, from the appearance of the values of mean farm size per soil zone it would appear that in terms of the farmer's response to the physical qualities of the environment as shown by farm size alone the three soil zones in the Black and Grey Wooded area of the province may be considered subcategories of one major soil zone for the purposes of statistical analysis.

This observation is interesting in itself because the question immediately arises as to why there should be virtually no difference in average farm size for these two soil groups. It may be, as suggested above, that the major reason for the lack of significant differences in farm sizes in the two soil types, which offer decidedly different opportunities for agricultural development in terms of their qualities may simply be a problem of classification. It is equally likely however that there are other significant causes, such as differences in the length of time that each soil has been settled, concentration of ethnic minorities on the fringes of continuous agricultural settlement, particularly in census division 12, the settlement of the poorer Grey Wooded soils under a homestead policy which allowed unsuccessful farmers from other districts and/or inexperienced young men to settle there, and so on.

In any case this analysis of the mean farm size has provided additional clues as to why the step-wise multiple regression failed at step 5. The fact that it did fail does not appear particularly serious however, because the first two major soil zones had "explained" most of the variability of farm size and the addition of the remaining soil variables added very little more to an understanding of the areal association between farm size and soil zone. They did however, indirectly emphasize the existing regional disparity in economic development between that part of the province in which the Black soils predominate and the remaining areas which are characterized by Grey Wooded soils. In the Dark Grey Wooded-Grey Wooded soil zones (D and E), for example, average farm size was smaller in one zone and only 70 acres larger in another than farm size in the Black-Dark Grey Wooded-Grey Wooded soil zone (C) where economic and physical factors have produced conditions which foster a more intensive form of agriculture.

Analysis of Average Size of Farm Business

The value of the correlation coefficient between average farm size and economic size of farm was +0.56. Both the correlation and beta coefficients were significant, which indicates that the assumption of a direct linear relationship between these two variables within the limits of the range of the data was acceptable. These results also substantiated the original hypothesis that average farm size in Alberta has a regional pattern that reflects the size of the farm business as well as the physical resources available for agriculture. In other words, the size of the farm is larger in the southern half of Alberta, both because the average farmer has extended the areal size of his farm in response to physical conditions and because he has increased the areal dimensions of his farm at a faster rate than elsewhere in the province to produce a larger size of farm business.

Analysis of Average Value of Lands and Buildings Per Acre

As was stated previously, the influence of urban place upon the distribution of farm size is difficult to isolate from the influence of the physical resources at this scale of analysis. If all factors, other than distance to the urban place which provides the marketing function for a surrounding region, could have been held constant then it is reasonable to assume, in terms of existing theory, that farm size would have been correlated with the distance to the centre of the dominant city. This exploratory study was not conducted at the requisite scale for reasons stated previously and hence other indirect measures of the influence of the city had to be employed. The measure chosen was the value of lands and buildings per acre of land in farms because it was theorized that this value was influenced by both physical produced conditions which foster a more intensive form of agriculture.

Analysis of Average Size of Farm Business

The value of the correlation coefficient between average farm size and economic size of farm was +0.56. Both the correlation and beta coefficients were significant, which indicates that the assumption of a direct linear relationship between these two variables within the limits of the range of the data was acceptable. These results also substantiated the original hypothesis that average farm size in Alberta has a regional pattern that reflects the size of the farm business as well as the physical resources available for agriculture. In other words, the size of the farm is larger in the southern half of Alberta, both because the average farmer has extended the areal size of his farm in response to physical conditions and because he has increased the areal dimensions of his farm at a faster rate than elsewhere in the province to produce a larger size of farm business.

Analysis of Average Value of Lands and Buildings Per Acre

As was stated previously, the influence of urban place upon the distribution of farm size is difficult to isolate from the influence of the physical resources at this scale of analysis. If all factors, other than distance to the urban place which provides the marketing function for a surrounding region, could have been held constant then it is reasonable to assume, in terms of existing theory, that farm size would have been correlated with the distance to the centre of the dominant city. This exploratory study was not conducted at the requisite scale for reasons stated previously and hence other indirect measures of the influence of the city had to be employed. The measure chosen was the value of lands and buildings per acre of land in farms because it was theorized that this value was influenced by both physical and economic factors and hence should account for more of the variability of farm size than the physical factors alone. This assumption does not appear to have been substantiated with the techniques and data used in this study, however, because although the correlation coefficient is significant at the 5 per cent level of confidence the regression coefficient is not. Therefore, even though the sign of the correlation coefficient (-0.35) is in keeping with the hypothesized inverse relationship between the value of lands and buildings per acre and mean farm size, it cannot really be assumed that the linear relationship is significantly different than zero. This does not mean that another non-linear form of relationship exists but if it does it was not immediately apparent from the data.

This lack of strong linear association between land and building values and average farm size was unexpected because it indirectly indicates a correspondingly weak relationship between land and building values and the soil zones. This statement is difficult to verify, however, because an examination of the Soils and Value per Acre of Lands and Buildings Maps (Maps 9 and 12), revealed that the highest values per acre for lands and buildings occur in the same areas as the best soils for intensive agriculture and the lowest in the poorest soil areas. Yet although this is generally true, the degree of correspondence is not precise. In the southeast of the province, for example, conditions are not as favourable for intensive agriculture as those in the Black Soil Zone farther north, but the value of lands and buildings remains in the same category. This may be related to the fact that farm business size is larger and that consequently it has produced a larger discretionary income which has been expended in part on the improvement of farm buildings. Similarly in the northeast of Alberta, there is a transition from Black soils in census division 10 to Grey Wooded soils in census division 12 which is not reflected in the areal pattern of the Value per Acre of Lands and Buildings (Map 12). This may be a function of the size of the categories used on the map, of course, but the actual census values also appear to substantiate the above observations. Another attempt was made to examine the relationship between the value of land and buildings and average farm size by visually comparing the patterns of land and building values (Map 12) with the map of average farm size (Map 1) and then comparing average farm sizes again with the soil zones (Map 9) as established originally. Admittedly this is not a technique that can be expected to produce precise results, but the pattern of farm size does appear to conform more with the soil zones than does the areal distribution of the value of land and buildings.

In summary, it was theorized that the value of lands and buildings would be more closely associated with the areal variation in farm size than would soil zones because this study variable was expected to account for the influences of both economic factors and the physical environment on the intensity of farming. If this had proved to be true then there would have been some justification for assuming that a major part of the increased association was due to urban influences, such as proximity to a marketing centre and proximity to increased flows of traffic. Although, in reality, this relationship may exist as a complex non-linear function or may become evident at another scale of analysis there is no evidence for it. All the evidence presented so far, in fact, seems to indicate that, although there is a degree of correspondence between the value of lands and buildings and farm size, and between the value of lands and buildings and soil zones, it is not a strong one.

Analysis of Type of Farm

The analysis of the relationship between type of farm and average size of farm has been delayed until this point because, as will be demonstrated as this section develops, there are serious problems associated with the Census Type of Farm concept in terms of the way in which it was employed for this kind of analysis. The partial solution to these difficulties will provide the subject matter of the next chapter.

The degree of association between type of farm, as defined in the 1961 Census, and average size of farm is summarized in Table VII.

Table VII Relationship of Type and Size of Farm

Type of Farm	Simple Regression and Correlation Coefficients		
	r Coefficient	T	Variance (Per Cent)
Dairy	-.35*	1.56	12.2
Cattle, Hogs Sheep	+.11	.43	1.2
Wheat	+.57*	3.35*	32.7
Small Grains	-.10	-0.41	1.0
Mixed-Livestock	-.42*	2.04*	17.6
Mixed Field Crops	+.10	0.42	1.0
Noncommercial	-.45*	-.2.24*	20.3

*Indicates a significant difference at the 5 per cent level of confidence. A.L. Edwards, op. cit., pp. 501-502.

Only in one case is the degree of association between type of farm and average farm size more than +0.5. All other coefficients are less than this value and three of them are not significantly greater than zero. This number increases to four if, as was the case for this study, a linear association is assumed to exist between the study variables. (Where linear associations are assumed, the T values must also be significantly different from zero. From the preceeding table it may be seen that only three of the values have this characteristic).

Part of the reason for this pattern of association between type of farm and size of farm seems to lie in the definition of type of farm itself because in some cases many types of crops and combinations of crops and livestock are grouped under the same heading even though they are comprised of different commodities which may be raised under widely differing physical conditions. Small Grains, Mixed Farm—Livestock Emphasis and Mixed Farm—Field Crop Emphasis are cases in point. Another reason appears to be that some crops or livestock products can be raised under varying levels of intensity, yet they too are grouped under a single heading when major source of farm income is the only criterion used to establish type of farm. It would seem fairly apparent from this kind of evidence that some attempt to include the relative intensity with which the various agricultural activities are conducted is justified, in spite of the difficulties mentioned earlier in obtaining data.

The association between the incidence of wheat farms and average size of farm is likely relatively high because specialized wheat production occurs in a location which is not conducive to many other types of agricultural production and may therefore be one of the most homogeneous categories in the Census Type of Farm classification. The association between wheat farms and the percentage of the arable land per farm in wheat, and soil moisture deficit is +0.73 and +0.77 respectively, for example. Yet, when the residuals from the regression of the percentage of wheat farms on the average size of farm were plotted and examined, it became obvious that some adjustment should have been made for the areal variation in yields or possibly farm business size because farms in the south of the province particularly in the southeast, were bigger than expected, i.e., underpredicted, and those farther north, particularly in census division 10 and the southern part of 12 where wheat farms are relatively important, were smaller, or overpredicted. What this adjustment should have been is not immediately obvious because if the simple regression model were extended to include other characteristics of the physical environment then the danger of multicolinearity would be clearly very high because, as has already been demonstrated, there is a high degree of association between the incidence of wheat farms and soil moisture deficit.

In reality then, one of the major problems with the type of farm variable appears to be that it does not adequately reflect intensity of production. In other words the original assumption, upon which this analysis was based, that the various types of farms were associated with the physical resources available to farmers in Alberta was placed in doubt by the results of the regression and correlation analysis.

As a further check on the validity of this original assumption, an additional analysis was undertaken. It was intended that this analysis would indirectly test the use of percentage measures in the above regression analysis. More particularly however, it was expected that the additional analysis would provide an indirect assessment of the validity of the results of the correlation and regression analysis between average farm size per municipality and the major soil zones conducted earlier in the study. To this end it was assumed that, if average farm size was highly correlated with the soil zones and if farm type was poorly correlated with average farm size, then farm type and soil zones should be weakly related.

The additional test consisted of a Chi square analysis of the relationship between soil zones and all types of farm. The null hypothesis was framed to state that there is no relationship between type of farm and soil zones in Alberta. A summary of the results of this analysis is shown in Table VIII.

Table VIII Chi Square Analysis of Type of Farm and Soil Zones

$\Sigma \frac{(\text{Observed Frequencies})^2}{\text{Expected Frequencies}}$	Number of Frequencies	Degrees of Freedom	Chi Square
85,936	68,899	35	17,037*

*Indicates a significant difference at the 5 per cent level of confidence, A.L. Edwards, op.cit., p. 500.

On the basis of this analysis the null hypothesis was rejected at the 5 per cent level of confidence although it could also have been rejected at the .01 per cent level of confidence. This means that we can assume that there is a relationship between the physical resources and farm type as was originally assumed. The results of this test if taken alone do not appear to substantiate any of the previously tested assumptions regarding the relationship between type of farm and size of farm. Nor does it seem to contradict the original premise upon which these expected relationships were based. There is one important aspect of the Chi Square test however, which should be noted before discarding or doubting the previous statements made concerning the originally stated relationships between farm type and average size of farm, or even the previously tested association between farm size and soil zones. The aspect or characteristic in question is if large numbers are used in the analysis the probability of achieving a significant result is increased.[23] This means that although the assumed relationship between type of farm and soil zones is statistically

[23] H.M. Blalock, op. cit., p. 225, for a fuller discussion of this point.

significant, for all practical purposes the strength of the association may not be. What is needed therefore, in addition to this test, is another test which will indicate the strength of the significant relationships established by the Chi Square test.

Blalock discusses a number of such tests. One denoted as V and defined as follows,

$$V^2 = \frac{\text{Chi Square}}{N \times \text{Min } (r-1,\ c-1)}$$

were r refers to the number of rows and c refers to the number of columns whichever is the smaller, was chosen for this analysis.[24] The upper limit of this test is 1.00 when the association between the variables is perfect.

When the V test was applied to the results of the above Chi Square analysis of the relationship between type of farm and soil zones it appeared to confirm both the results of the regression analysis between type of farm and average size of farm and the doubts about the relationship between type of farm and the soil zones, because its value was only .22. This does not mean that there is no relationship between individual types of farms, as defined above, and the physical resources of Alberta and that the incidence of specific types of farms does not correlate with certain soil areas of Alberta. It is possible, in fact, to indicate the tendency for certain types of farms to occur in specific soil zones by examining the correlation between type of farm and each type of soil expressed as a dummy variable. What the V test does indicate, however is that there is not a strong regionalization by soil zones of all types of farms taken together.

The results of the analysis of the simple correlation between individual farm types and soil zones are not particularly easy to

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[24] *Ibid.*, p. 230.

interpret but they have been, nevertheless entered here in table form (Table IX) to illustrate the nature of the relationship.

Table IX   Relationship Between Individual Types of Farm and Five Soil Groups in Alberta Expressed as a Product Moment Correlation Coefficient.

Type of Farm	Soil Groups				
	A	B	C	D	E
Dairy	-.18	-.24*	+.47*	.00	-.25*
Cattle, Hogs, Sheep	-.03	+.17	+.14	+.08	-.51*
Wheat	+.46*	+.43*	-.37*	-.29*	-.04
Small Grains	-.07	-.08	-.12	+.29*	+.67*
Mixed Farms—Livestock	-.28	-.26*	+.57*	+.19	-.40*
Mixed Farm—Field Crops	+.06	.00	-.12	-.21	+.36
Non-commercial	-.30*	-.49*	-.01	+.52*	+.33*

* Indicates significance at the 5 per cent level of confidence, A.L. Edwards, op.cit., p. 502.

It will be recalled from the previous discussion of dummy variables that the municipality in which a soil is dominant is scored one and the municipality in which the soil is not dominant is zero. It is this scoring procedure which is responsible for the sign of the correlation coefficient in Table IX. What the sign indicates is that large percentages of a specific type of farm are either concentrated or not concentrated in the soil zone under examination. Using wheat farms as an example of the first condition it appears from the data that large percentages are weakly associated with A and B soil zones. The opposite condition is illustrated by Cattle—Hogs—Sheep farms in soil zone E. In this area the correlation coefficient is -0.51 This suggests that in comparison with the other soil zones this type of farming is fairly markedly under represented in this area. Generally, from the results shown in Table IX, Dairy farms tend to be concentrated in zone C, Cattle-Hogs-Sheep are found everywhere with some tendency for this type of farm to be under represented in E, Wheat farms tend to be located in A and B, Small Grains farms are concentrated in E, Mixed Farms-Livestock Emphasis tend to occur more often in C, Mixed Farms—Field Crop Emphasis have a very weak tendency to be more prevalent in E and Non-Commercial farms tend to be under represented in A and B and over represented in soil zones D and E.

From these results it appears fairly obvious that there is a relationship between type of farm and soil zones but, as the results of the V test indicated the overall relationship is weak. What appears to be needed, for any classification of farms which is expected to have universal application across regions of differing physical conditions, is some indication of the relative intensity of agricultural production. The classification of livestock farms is a particular case in point because even if the category is restricted to the production of cattle there is still no indication of the nature of the means of production. In Alberta, for example, the category has been used in both ranching districts and in areas dominated by more intensive forms of livestock production and it fails to distinguish between the two types. This is probably the major reason for the lack of association between this type of farm category and the average size of farm per municipality. What appears to be needed then, is some modification to the basic definition in order that areal variation in the intensity of production may be taken into account.

Summary

In this section a discussion of the preparation and analysis of the data has been carried out. The difficulty of establishing meaningful objective measures for some of the physical variables was also discussed and, as a final solution, soil zones were established and their validity tested. An exploratory weighted analysis of the linear relationship between the dependent and independent variables produced a number of interesting relationships. Soil zones, for example, were highly associated with the areal variation in farm size, whereas the values for average value of lands and buildings per acre and type of farm produced relatively insignificant results, although they did prompt additional observations on the nature of their relationship with other variables and the basic premises upon which the original hypothesized relationship was based.

The analysis of size of farm business also produced interesting results in that the original observation that farm business size varies areally seems to have been confirmed. The underlying reasons for this regional disparity were not thoroughly examined but one of the more basic ones appears to be linked with the differing regional rates of increase in the areal size of farms.

This suggests that if the analysis were extended farther the date of original settlement, or stated more meaningfully, time itself could be an important underlying variable affecting the areal distribution of farm business size. It is not likely that it would completely account for the distribution of farm business size because of the ease with which agriculture could be carried on under certain climatic and soil conditions would also influence the rate at which farm businesses expanded. In southern Alberta for instance, farm businesses also appear to be larger than the average because farmers periodically undergo economic stress as a result of randomly occurring drought years. Under these circumstances the removal of less efficient farmers was in all likelihood accomplished more quickly here than in more favourable locations.

Reasons for the lack of strong association between farm type and farm size were also examined and one of the major causes appeared to be that a definition of farm type based on income gives little indication of the intensity of production of the agricultural commodity specified in the name of the type of farm. It was first assumed that regional variation in intensity would pose few problems because it was also assumed that specific types of agricultural production were highly localized and occupied areas with well defined physical conditions. While this may be true for some speciality crops such as wheat or forage seed it did not appear true for most agricultural commodities because these commodities are produced in widely differing areas under differing levels of intensity. In the next chapter a modification will be made to the type of farm definition for one type to suggest how the type of farm definition might be made more useful in a study of the areal variation of farm size.

CHAPTER IV

MODIFICATION OF THE TYPE OF FARM CATEGORY

The Cattle-Hogs-Sheep type of farm category was chosen for further analysis because it encompasses agricultural products which are produced at a wide range of rates of intensity. Both cattle and sheep, for example, are produced in Alberta under range and feed lot conditions. Some animals of the types in question are also raised under both conditions during their cycle of production. Hogs, however, are normally produced under fairly intensive conditions.

It was decided therefore to establish a number of characteristics which could be used to differentiate between the various levels of intensity of livestock production and at the same time improve the type of farm classification so that it more accurately reflected a homogeneous type of production.

Extensive livestock production or "ranching" was used as the basis for differentiating between other types of livestock production because it represents a well defined or distinguishable type of farming in Alberta and because of the fairly long term interest of the author in it. The emphasis in the chosen characteristics and the numerical scale developed to describe the intensity of livestock production are therefore directed to the description of this type of farming. Other types of livestock farming will be less like ranches and hence by definition less extensive in terms of the criteria used for the analysis, or perhaps more precisely, although less accurately in terms of the analysis, more intensive. Because of this emphasis on "ranching" or extensive livestock production the more extensive (or least intensive) type of farming was given the highest numerical score and the least extensive (or most intensive) the lowest. This might be the reverse of what is normally expected but the reasons for this reversal are now evident.

Some "Ranching" Characteristics

Although dated, the general characteristics of ranching outlined in a 1946 publication entitled "Cattle Ranching in Western Canada"[1], were accepted as still being applicable to this problem. On the basis of this research and the field experience of the author five characteristics were selected to identify extensive livestock production or "ranching". Each of the characteristics or factors were expressed as ratios so that all are in reality relative measures immediately applicable only to Alberta. Two factors, the ratio of potentially extensively grazing animals (beef cattle, horses and sheep) to total animal units[2] and the ratio of income from the sale of these animals to total farm income derived from the sale of agricultural commodities, were used to help identify the type of agricultural production under study. The remaining three, the ratio of livestock to machinery inputs expressed in dollars, the proportion of unimproved land to total land in farms and the gross dollar return from the sale of agricultural commodities per acre of land in farms, were developed to assess the relative intensity with which livestock are produced in Alberta.

It is important to note that the characteristics of individual farms could not be assessed using the five aforementioned characteristics because, as before, mean census values per municipality were the only

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[1] C.W. Vrooman, Cattle Ranching in Western Canada, Technical Bulletin of the Canada Department of Agriculture no. 55, Ottawa, 1946, 80 pp.

[2] The definition of animal units which was used for this study was: J.N. Winburne, A Dictionary of Agricultural and Allied Terminology, Michigan State University Press, East Lansing, 1962, 905 pp.

data available for the study. Each municipality was therefore rated as to the degree to which it possessed the characteristics in question. A spatial pattern which coincided with the generally accepted distributional patterns of extensive livestock production immediately became evident on sketch maps with the possible exception of the gross dollar return from the sale of agricultural commodities per acre of land in farms. What was now needed was some objective technique to combine the various characteristics into a meaningful "ranching" or extensive livestock production index and to reject any factors which did not contribute fruitfully to the analysis of the relationship of this type of farm to average size of farm.

Scalogram Analysis

The scalogram technique was developed by L. Guttman during the Second World War to measure attitudes and opinions about the war effort. It has since been used by sociologists, social psychologists and economists primarily to quantify qualitative data or to examine data in which the errors are not distributed randomly, or which is not normally distributed, and so on. It is then in essence, a non-parametric test, in which it is assumed that it is possible to rank people or areas from high to low in such a fashion that from a person's or area's rank alone it is possible to reproduce the person's response or the area's characteristics to each of the items in the test in a simple fashion. Perhaps the simplest example will suffice to demonstrate the above assumption. If a series of mathematical questions of increasing difficulty were administered to a group so that the ability to answer the second question depended on the ability to answer the first and so on then it would be possible from the individual's rank to predict which questions he successfully answered. If a particular individual out of a group of four ranked last in his ability to respond to four mathematical questions then it could be predicted fairly accurately that the respondent in question managed to answer the first item only.[3] In reality it is often not possible to derive such precise results and consequently it has been the practice to accept a scale which is accurate at the 90 per cent level of reproducibility.

Technique

In this study it was assumed that with the aforementioned five characteristics it would be possible to rank the municipalities of Alberta with respect to all the characteristics taken together and in this way to measure the underlying attribute of "ranching" or extensiveness of livestock production. Each municipality was therefore scored on each of the characteristics, but the actual values derived from the census were not used. It was decided instead to use the technique offered by el-Kammash.[4] The ratios computed from census data were therefore dichotomized by taking the range for each characteristic and scoring the municipality one or zero using the approximate midpoint of the range as the cutting point. Above this value the municipality was, for four out of the five characteristics, scored one, below this value it was scored zero. For the last characteristic shown on Table X the procedure was reversed. All values below the midpoint were scored one because it was assumed dollar return per acre of land in farms would be lower for ranching areas than the average dollar return in the

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3 For a fuller discussion see L. Guttman, "The Cornell Technique for Scale and Intensity Analysis", Educ. and Psych. Meas., Vol. 7, No. 2, summer 1947, pp. 247-279; L. Guttman, "The Problem of Attitude and Opinion Measurement", in S.A. Stouffer et al, Measurement and Prediction, Princeton University Press, Princeton, N.J., 1950, p. 64; M.M. el-Kammash, "On the Measurement of Economic Development Using Scalogram Analysis", Papers and Proceedings, Regional Science Association, Vol. 11, 1963, pp. 309-334.

4 M.M. el-Kammash, op. cit.

remainder of the province. It should also be noted that if a municipality had less than 100 farms or did not have values for all of the five characteristics it was not used in the analysis. In this way a municipality which had well developed "ranching" characteristics was always assigned the value of one. The assigned midpoints for each characteristic or factor are arranged in the following table. The range of values for all municipalities in Alberta from which the midpoints were computed have been placed in Appendix "C" because of the number of municipalities involved.

Table X Cutting Points for Dichotomous Scores

Characteristic	Indicates Ranching	Does Not Indicate Ranching
Ratio of Livestock value to machinery value	above 1.2	below 1.2
Ratio of unimproved land to total land in farms	above 51.0 %	below 51.0 %
Ratio of extensive grazers to total animal units	above 77.0 %	below 77.0 %
Ratio of income from the sale of livestock to total income	above 54.0 %	below 54.0 %
Ratio of dollars per acre	below 12.0 %	above 12.0 %

The dichotomous values derived from the above scoring technique were next entered into table form and the municipalities were then ranked in order of the total number of ranching characteristics possessed by each. Finally the scale of each characteristic was examined for scaling errors using the method outlined by Hagood.[5] These results, again because of length, have been placed in appendix "C"-1.

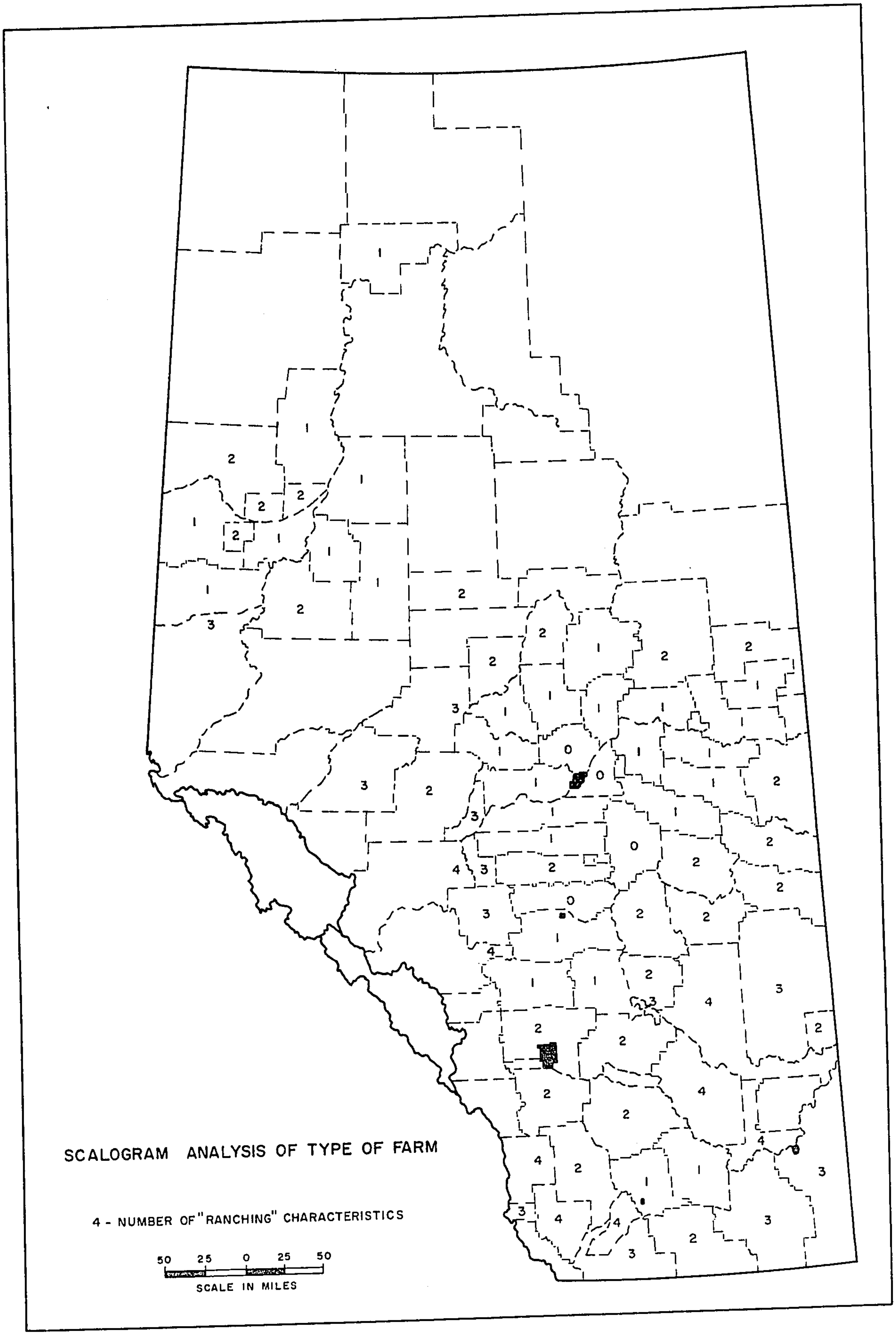
Although the amount of scaling error was acceptable for the five categories under study in terms of the criterion previously established by Guttman one factor, dollar return per acre of land in farms, was found to have more error than non-error in the "Does Not Indicate Ranching" column. This suggests, as was previously anticipated, that this characteristic does not adequately reflect "ranching". The reason appears fairly obvious in retrospect because this characteristic could just as easily apply to other extensive forms of farming, such as dryland wheat production. Another flaw in this characteristic that became evident when the data were entered into Appendix C is that there are a large number of low values from municipalities in all parts of the province whether or not ranching takes place within them. Consequently the midpoint of the data was not a good value to distinguish between the various levels of intensity one often associates with different types of farming. This characteristic was therefore removed from the scalogram analysis and the coefficient of reproducibility computed again with the following formula:

$$\text{Coefficient of Reproducibility} = 1 - \frac{\text{Number of Errors}}{\text{Total No. of Responses}}$$

The resultant value of .91 was above the 90 per cent value mentioned previously and hence the four factor scalogram was accepted as an acceptable approximation to a perfect scale. The areal pattern of scale types has been plotted on Map 17, but the analysis of the relationship between ranching expressed as a scale value and farm size was carried no farther because, in spite of the interesting pattern of values, it

[5] M.J. Hagood and D.O. Price, Statistics for Sociologists, Holt, New York, 1957, pp. 114-152.

Map 17


SCALOGRAM ANALYSIS OF TYPE OF FARM
4 - NUMBER OF "RANCHING" CHARACTERISTICS
50 25 0 25 50
SCALE IN MILES

was observed that the range of values which could be assigned to livestock farming to assess its extensiveness or "ranching" qualities was directly proportional to the number of factors or characteristics used in the scalogram analysis. This means only five values ranging between zero and four could be assigned to each municipality to express the degree to which it could be considered a "ranching" area. Rather than be limited by this condition it was decided instead to employ another technique of index construction which could provide a greater range in index values.

Factor Analysis

Margaret Jarman Hagood demonstrated the value of factor analysis for regional delineation of some agricultural and demographic characteristics in the United States in a paper published in Social Forces in 1943.[6] Using this statistical technique Hagood was able to combine summary statistics such as ratios, percentages, means, etc., into a multivariate index which reflected the relative importance of each value or "component" utilized in its construction. As with the preceeding method of index construction it is possible to have reporting or census units with the same index value even though they may have high measures for the component or factor for which another census unit has low values. This method however minimizes the occurrence of this condition because each of the components are weighted in terms of the degree to which each variable or component correlates with every other factor used in the construction of the index values. These weights are derived from a matrix of intercorrelation by the use of a

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6 M.J. Hagood, "Statistical Methods for Delineation of Regions Applied to Data on Agriculture and Populations" Social Forces, Vol. 21, No. 3, March 1943, pp. 287-297.

principal component solution developed by Hotelling[7] and outlined in an elementary form in Hagood et al.[8] With this technique the variable which shows the largest degree of correlation with every other factor is arbitrarily assigned a weight of 1.000 and every other variable is given a weight less than this value. Negatively correlated variables receive a negative weight.

In summary Hagood noted that,

> There are several methods of performing factor analysis, ... In all of the methods the factor loadings for each characteristic are obtained for one factor at a time; and in all methods the first factor for which loadings are obtained is the most important. Since our use of factor analysis will include only the first factor loadings, we shall not be concerned with any of the further procedures of factor analysis.[9]

Once the weights are computed they are assigned to each value of the component to which they refer and each weighted value is then utilized to construct a composite index, defined by the equation:

$$\text{Index} = a_1 z_1 + a_2 z_2 + \dots a_i z_i$$

where

$$z_i = \frac{x_i - m_i}{s_i}, \quad \text{the standard score on } x_i$$

and

$$a_i = \text{first factor loading for characteristic } i$$

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7 H. Hotelling, "Analysis of a Complex of Statistical Variables into Principal Components", J. of Ed. Psych., Vol. 24, No. 6, September 1933, pp. 417-441.

8 M.J. Hagood, N. Damilevsky and C.O. Beum, "An Examination of the Use of Factor Analysis in the Problem of Subregional Delineation", Rural Sociology, Vol. 6, No. 3, September 1941, pp. 216-233.

9 Ibid., pp. 221-222.

Technique

No component was removed from this investigation on the basis of the findings of the foregoing scalogram analysis because it was assumed that the factor loadings would de-emphasize those variables that contributed little to the ultimate value of the multivariate index. All of the original five components or factors which were judged as describing "ranching" in Alberta were therefore utilized in the principal component solution to index construction.

Each factor was intercorrelated with every other factor and the matrix of intercorrelations for the five factors for 89 municipalities of Alberta was then entered into the Hotelling process for the development of the appropriate weights. These intercorrelations are set out in Table XI. From an examination of the intercorrelations

Table XI Correlation Matrix for Five "Ranching" Characteristics, 89 Municipalities of Alberta, 1961.

Characteristic *	2	3	4	5
1	+0.53	+0.45	+0.79	-0.05
2		+0.42	+0.34	-0.66
3			+0.63	-0.15
4				+0.12

*The characteristics are those mentioned previously, that is, (1) the ratio of livestock inputs to machinery inputs (2) the ratio of unimproved land to total land in farms (3) the ratio of extensive grazers to total animal units (4) the ratio of income from the sale of livestock to total income (5) the ratio of dollars per acre.

above it would appear that the previous conclusions concerning the value of the ratio of dollars per acre component to an analysis of the distribution of extensive livestock production "or ranching" were valid.

This will, however, be accounted for by the weights assigned to each factor in the Hotelling process.

The weighting values which were developed on a hand calculator, are set out in Appendix "C"-2 and in Table XII. These weights were

Table XII First Factor Loadings or Weights for Five "Ranching Characteristics"

	Characteristics*				
	1	2	3	4	5
Weights	.826	.695	.694	.811	-.293

*The characteristics are the same as those defined in Table XI.

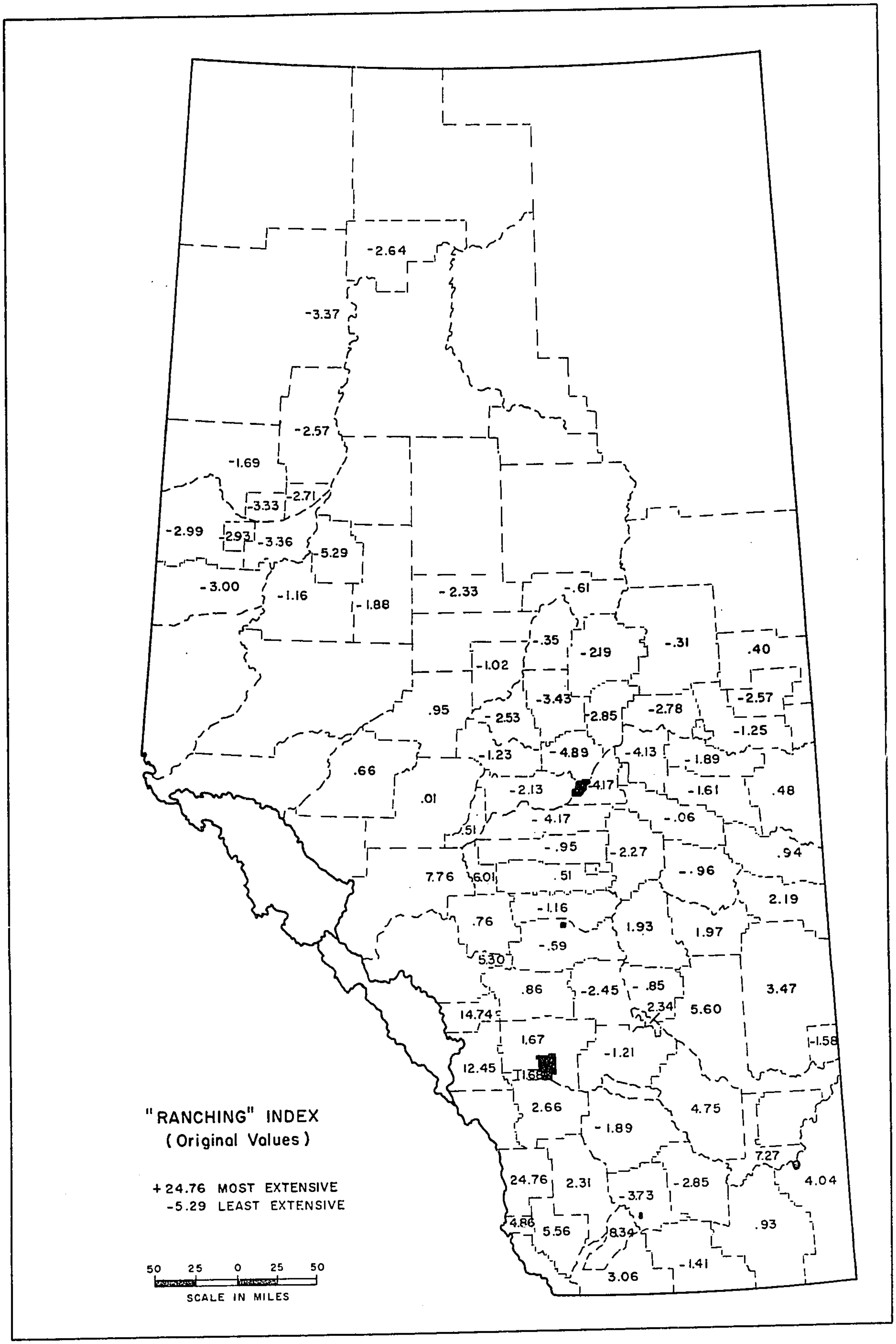
entered into the following index equation:

$$\text{Index} = .826Z_1 + .695Z_2 + .694Z_3 + .811Z_4 - .293Z_5$$

Then the weighted means and standard deviations for each municipality were substituted to compute each standard score, or "Z score" so that all scores were standardized and each factor could therefore be directly compared with every other factor. After collecting the constant terms the equation now reads:

$$\text{Index} = 2.36X_1 + .051X_2 + .056X_3 + .050X_4 - .059X_5 - 10.22$$

Next the values for the five components were entered into this equation for every municipality in Alberta for which five ranching characteristics could be computed. The resultant values ranged between -5.29 and 24.76. The areal pattern of the variables are illustrated on Map 18. After a careful examination of the range of the index values and their location it was decided to remove the extreme values by removing any values which were derived from municipalities in which 100 farms or less were located. This involved removing the values for those municipalities in census division 9 which are dominated by a few extremely extensive

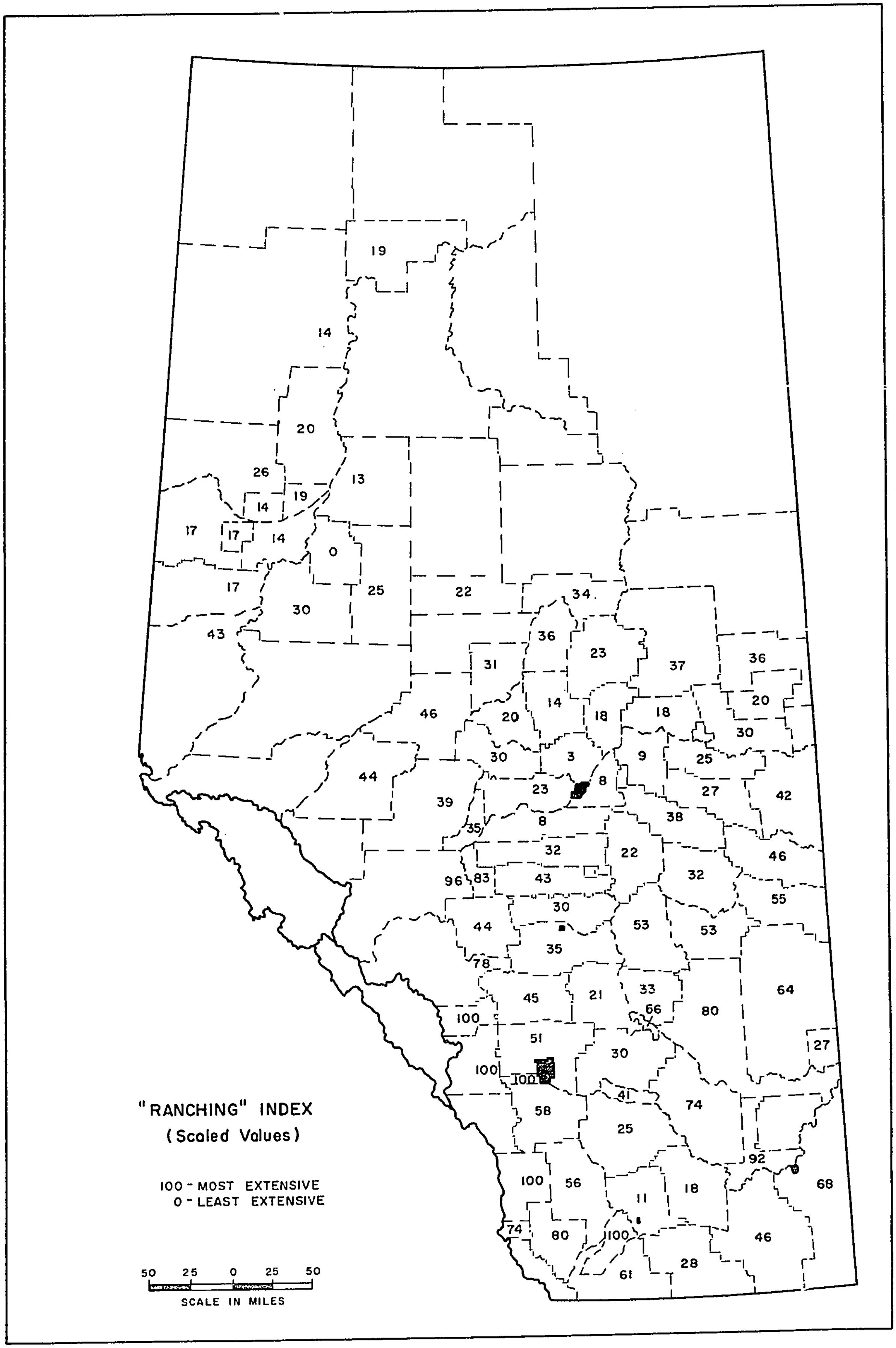

"RANCHING" INDEX
(Original Values)
+24.76 MOST EXTENSIVE
-5.29 LEAST EXTENSIVE
50 25 0 25 50
SCALE IN MILES
-2.64
-3.37
-2.57
-1.69
-2.71
-3.33
-2.99
-2.93
-3.36
-5.29
-3.00
-1.16
-1.88
-2.33
-.61
-.35
-2.19
-.31
.40
-1.02
-3.43
-2.85
-2.78
-2.57
-1.25
.95
-2.53
-1.23
-4.89
-4.13
-1.89
.66
.01
-2.13
-4.17
-1.61
.48
-4.17
-.06
.51
-.95
-2.27
.94
7.76
6.01
.51
-.96
2.19
-1.16
.76
1.93
1.97
-.59
5.30
.86
-2.45
-.85
3.47
2.34
5.60
14.74
1.67
-1.58
-1.21
12.45
1.68
2.66
4.75
-1.89
7.27
24.76
2.31
-2.85
4.04
-3.73
4.86
5.56
8.34
.93
-1.41
3.06

livestock enterprises. The new range of values was then converted to a simple linear scale ranging between 0 and 100. Any previously excluded values were automatically given the highest value on the scale.

It may be of value to draw attention again to the writer's purpose in constructing the scale. As stated previously, the main emphasis is on determining the extensiveness of livestock production or "ranching". A value of 100 was used therefore to designate the most extensive and zero the least extensive (most intensive) livestock production municipality in Alberta.

The values (shown on Map 19) were then correlated with mean farm size per municipality to determine if indeed the type of farm classification had been improved by adding variables which indirectly indicated the intensity of livestock production and by excluding forms of livestock, hogs for example, which are raised intensively everywhere in Alberta. (Hog production does vary in intensity from place to place in Alberta, but not in terms of the areal component of the index constructed for the purposes of this discussion.) The resultant, statistically significant, correlation coefficient and T value are +0.67 and 4.30 respectively for this new classification of livestock type of farm. This would seem to indicate that a reasonable livestock type of farm classification has been established with these five factors. Further analysis suggested however that there are still serious flaws in the farm classification procedure.

If the values are carefully examined in Map 19 it is obvious that the indices of ranching reflect both the extensiveness and the importance of livestock production in any particular municipality. Warner County (municipality number five) in census division 2, for example, is occupied by "ranching" and extensive wheat farms for the most part, but the index value assigned to this unit is lower than that


"RANCHING" INDEX
(Scaled Values)
100 - MOST EXTENSIVE
0 - LEAST EXTENSIVE
50 25 0 25 50
SCALE IN MILES

for municipality 3 in census division 8. It is doubtful that livestock production is as extensive in this municipality as that found farther south in Warner County, although "ranching" is found on the Grey Wooded soils in the western half of municipality 3. It is highly likely therefore that in this instance the ratio of income from the sale of livestock to total income variable "outweighs", in terms of significance, the influence of the other factors which measure the extensiveness of livestock production. There is no apparent or ready solution to this dilemma for the purposes of this study, however, because factors are needed to describe both the type and the intensity of production. If one were willing to overlook type of production altogether and concentrate only on the relationship of intensity of production and average size of farm then the solution would in all likelihood be more apparent.

This raises an interesting and challenging point because it suggests that the type of agricultural commodity produced in Alberta at this time is a poor indicator of the intensity of production and hence average size of farm under present farming practices. This observation along with others will form the concluding remarks to this study in the next chapter.

CHAPTER V

FINAL OBSERVATIONS AND INFERENCES FOR FURTHER RESEARCH

Importance of the Quality of the Physical Site

The foregoing observations suggest that the quality of the physical site for agriculture is one of the most important factors affecting the areal size of farms in Alberta at this scale of analysis. Admittedly, the influence of other factors, such as transportation costs, have been examined using indirect measures only, nevertheless the results of this study appear to be in accord with others conducted at a much larger scale of analysis[1] and they also add additional weight to statements by McCarty and Lindberg[2] concerning the relative importance of transportation costs versus the qualities of the physical site for the production of agricultural commodities.

It has been demonstrated elsewhere[3] that under conditions of primitive and near subsistence agriculture other considerations such as social values and marketing forces exert a greater influence on agricultural activity than variations in the physical resource base. This is understandable, because in all likelihood these conditions

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[1] See for example A.A. Lupton, Some Geographical Aspects of Dairying in Alberta, unpublished M.A. thesis, University of Alberta, Edmonton, 1965, 149 pp. and D.A. McQuillan, Estate Production and Transportation, Dominica, unpublished M.A. thesis, University of Alberta, Edmonton, 1968, 106 pp.

[2] H.H. McCarty and J.B. Lindberg, A Preface to Economic Geography, Prentice-Hall, Englewood Cliffs, N.J., 1966, p. 224.

[3] J.D. Henshall and L.J. King, "Some Structural Characteristics of Peasant Agriculture in Barbados", Econ. Geogr. Vol. 42, No. 1, January 1966, pp. 74-78.

most approximate the assumptions underlying models, such as those proposed by Von Thunen, which stress the importance of transportation costs in areas with an undeveloped transportation technology and unsophisticated marketing mechanisms.

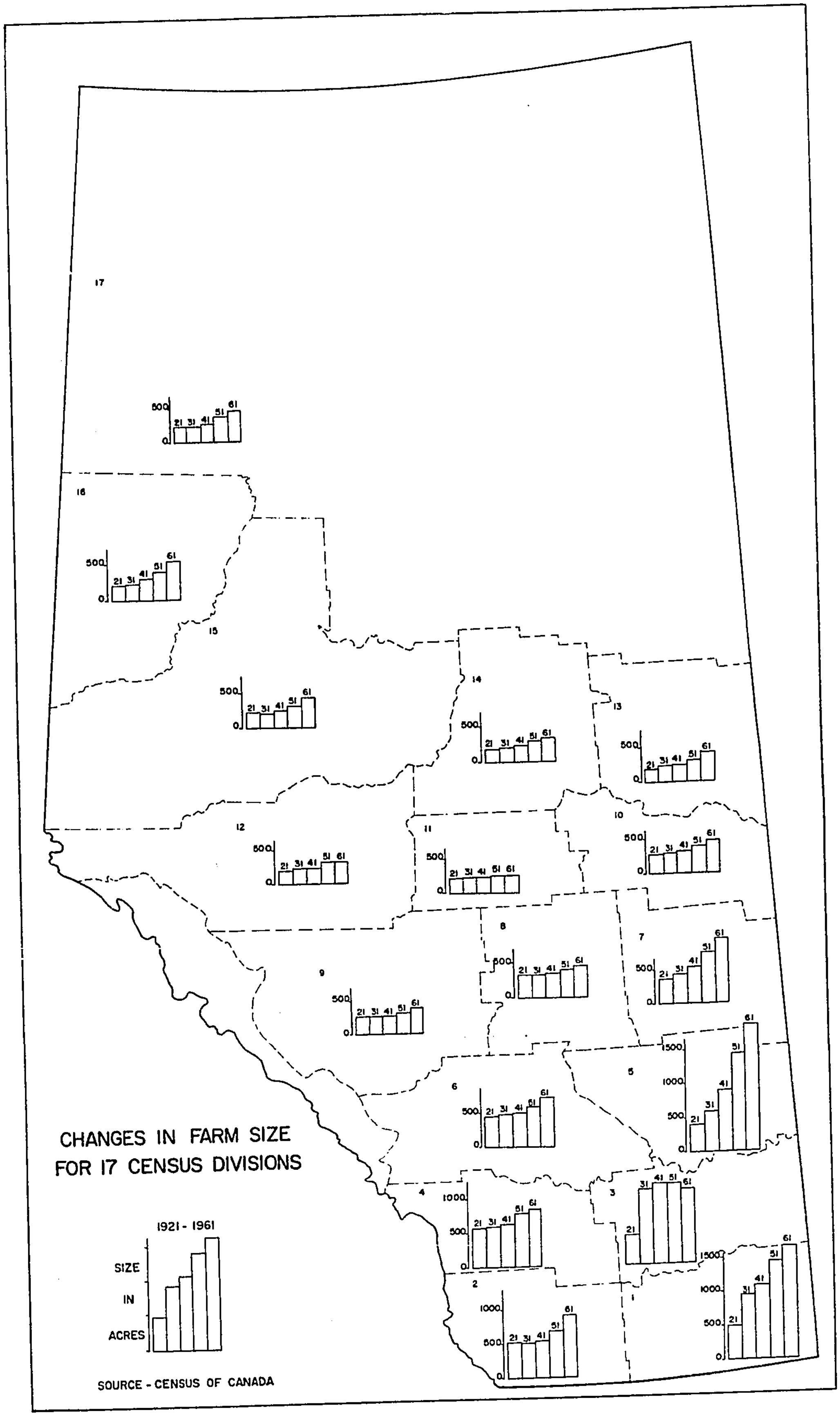
Farmers in Alberta however employ an advanced technology and apparently more readily shift the factors of production so that land is used at rates of intensity which bear a close resemblance to the areal patterns of soil quality.

The underlying reason for this pattern of association is assumed to be the maximization of profit, but how this particular pattern developed and its degree of stability are in themselves difficult problems. For example, are transportation costs relatively unimportant because much of Alberta's agricultural production is exported and therefore shifts of many miles one way or the other to prime agricultural sites relatively unimportant? Do anomalies occur around Edmonton because it is a secondary marketing or trans-shipping centre for this larger national viewpoint, or are physical conditions themselves responsible for the observed pattern of small farm size?

Average rates of growth in farm size have been reconstructed for the original 17 census divisions of Alberta (Map 20) and these figures may provide clues for future lines of research. It is evident from the map that areal growth rates vary markedly over the 1921 - 1961 time period and they do so in such a way that a case may be made for the strong influence that the quality of the physical environment has had on farmers' decisions.

Examination of Map 20 suggests that by 1921 average farm size already covaried in association with the great soil group pattern, although no recognition was given to the areal variation in soil quality when allocating land under the terms of the Homestead Act. It is possible of course that the first settlers in Alberta established

Map 20


CHANGES IN FARM SIZE
FOR 17 CENSUS DIVISIONS
1921 - 1961
SIZE
IN
ACRES
SOURCE - CENSUS OF CANADA

themselves in the southern parts of the province and that they had capital, or acquired it quickly from employment in railway construction in the south, to increase the size of their holdings. It is equally likely that the original ranching economy in southern Alberta provided the basis for the initial development of larger farm sizes. Whatever the factors leading to the development of the 1921 pattern of farm sizes however, a good case can be made for the influence of the physical environment on subsequent rates of farm consolidation.

From time to time southeastern Alberta experienced severe moisture deficiency conditions so that long term yields were generally lower than those in the more westerly or northerly parts of the province. It also is in these areas that rates of increase in farm size were the largest. This suggests that farmers in the south were forced to respond to climatic stress by increasing the size of their holding or by leaving the area and/or the agricultural sector of the economy. They were in all likelihood unable to remain long in this geographic area as near subsistent or "poor" farmers because alternate forms of employment, such as hunting, trapping or forestry which were available in northern areas of climatic stress, were unavailable to them.

In northeastern Alberta farm size was much smaller in 1921 compared to the south even though soils are relatively infertile and the frost free season too short for optimal production of cash grains. Moisture deficiency, however, was rarely as acute, consequently muskeg and slough areas could be grazed and the other aforementioned economic activities could be pursued. It was possible therefore to survive, albeit close to subsistence levels. This is an oversimplification of the reasons for slow growth rates in the northernmost census divisions because other factors, such as the continued influx of homesteaders, have also retarded average farm size growth rates.

In the better areas for farming between these two extremes the rates of increase in farm size are variable but they nevertheless again appear to relate to the quality of the natural resource base for agriculture. For example, census divisions 8 and 11, located in the Black Soil Group, have the lowest rates of growth. Census division 6, located on poorer quality soil groups however has a larger growth rate even though it contains the second major city in Alberta. It may be argued that the reason for the smaller farm sizes in census divisions 8 and 11 is that this part of the province contains the largest proportion of the urban population of Alberta and therefore local market opportunities have exerted their greatest influence here. This may be true, but why are there so many urban market opportunities in this particular part of the province? This is a subject that needs intensive research but it is possible to postulate that the agricultural development on the fertile areas adjacent to Edmonton contributed a powerful impetus to the city's early growth and its continued survival. In all likelihood a feed back mechanism was gradually established that encouraged farmers to intensify their operations or to retain holdings that were not as profitable in terms of the farmer's agricultural activities as they were in terms of their increased land values. This feed back mechanism may have taken many forms. At first it probably was the demand for agricultural commodities produced intensively. Then as transportation technology and structures improved and the milk shed began slipping away to the south, in all likelihood the mechanism became the demand for land or expectation of demand for land itself for non- or pseudo- agricultural activities. The most recent land market has been developed by urbanites seeking rural holdings for land speculation, recreation, tax privileges and similar reasons.

In summary, historically there has been a delicate interplay between agricultural and urban activities in the development of Edmonton and its agricultural hinterland. The initial emphasis on intensive farming, perhaps because of the terms of the Homestead Act, the activities of the Federal Department of Agriculture, the majority of the settler's cultural background or some combination of the above and others resulted in small farm size wherever this type of farming proved to be successful. Although this type of farming may also have been initially undertaken in areas of the province not physically suited to it, a more extensive type of farming appears to have quickly supplanted it. In any case wherever intensive farming did prove successful a powerful force for the maintenance and growth of cities such as Edmonton developed. Later as this particular city took on other economic and administrative functions it is reasonable to expect that Edmonton began to exert increasingly powerful influences on the surrounding rural areas, some possibly related to transportation charges on perishable commodities, others related primarily to the demand for land rather than the agricultural products it produces. It is possible that only behavioral studies will be able to define the impact that the most recent urban force has had on a farmer's attitude towards the physical resource base. It is reasonable to expect however that in an historic period in which communication technology and information transfer has been stressed even the farmer in the most isolated parts of the province has been exposed to developments in the land market in all parts of Canada. It is also reasonable to assume that this information has raised the expectations for increased land values virtually everywhere. The degree of expectation may however be tempered by distance so that it bears an inverse relationship with distance from the source of information or most active and/or closest land market. What the response to this heightened awareness of the value of land in the urban place or the increased urban demand for land far beyond its boundaries may be is difficult to forecast. Its most probable effect has been to suppress increases in farm size in areas adjacent to urban places.

Whether the natural quality of land for agriculture will remain one of the most powerful influences on farm size under these most recent influences is difficult to predict, but the distribution of average farm size in 1961 would indicate that it was a powerful force at that date. The subsequent activities of the Provincial Government in the economic rehabilitation of the northern parts of the province would suggest that it will remain so for some period yet, as least in these geographic areas.

The Problem of Type of Farm

The second finding of major importance arising from the foregoing analyses is that farm classifications based on objective measures of agricultural specialization do not necessarily give a good indication of the intensity of farming at all scales of study.

Geographers have developed classification systems that have been generally accepted as indirect measures of the intensity with which farmers utilize their resources per unit area. This assumption may have initially arisen from Von Thunen's model of the effects of transportation charges on the intensity of agricultural production around the single central market node. For example Von Thunen theorized that if all of his assumed conditions were met then in reality the market centre would be surrounded by rings of land use that ranged from intensive uses typified most often by dairy farming and horticulture in the innermost ring to extensive uses such as extensive livestock production in the outer rings. Many students in the various fields of agricultural research, including the author have taken the converse of Von Thunen's theorized relationship as also being true. They have assumed that one need only identify the type of farm and it will indicate the intensity of production.

This assumption has also been periodically verified in empirical studies executed primarily by agrologists. Research undertaken by the Canada Department of Agriculture during the thirties in the subject area of productive man work units is an example of the observed relationships between a specific crop and the amount of labour expended per unit area to produce it.[4] In view of both theoretical considerations and the empirically established relationships this assumption appears therefore to be reasonable.

Furthermore it was demonstrated earlier that if soils were held constant and types of farm ranked in the order of their average size there does appear to be some tendency for dairy farms to be the smallest type of farm and livestock and wheat farms the largest. Once the analysis of the association of farm type and farm size was extended across soil groups the relationship became less obvious except for specific types of farm. The hypothesised relationship was extended across soil groups because it was also assumed that certain types of agricultural commodities could effectively compete for land in those areas physically best suited for its production. This in turn suggests that farm types would also be regionalized in keeping with the quality of the physical resource base. Under further statistical analysis however even this relationship could not be established, although regional specialties do appear evident on the maps presented in the Atlas of Alberta.

The reasons for this lack of strong association between farm type and either farm size or soil group may be related to the maturity or stability of agricultural crop patterns in Alberta and/or the type of farm classification itself.

In the first case it may be found, after additional study, that

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[4] Canada, Dept. of Agriculture, Economics Division, Types of Farming in Canada, by I.S. McArthur and J. Coke, Ottawa, 1939, 43 pp.

although specialization may have occurred fairly quickly under the conditions of climatic stress in southeastern and east central Alberta it has not yet progressed to the same degree in the more humid parts of the province. In other words time may be a factor in agricultural specialization and the effects of time itself may be modified by the quality of the physical resource base.

In the second case what appears to be needed is a type of farm classification that stresses the intensity of agricultural production on a continuum rather than an identification of farm type based only on the major source of gross income from the sale of agricultural products. It was demonstrated in this study that if intensity factors were added to the livestock farm type then an improved relationship could be established between this type of farm and average farm size. Theoretically there is every likelihood that other types of agricultural production could be categorized in a similar fashion.

Helburn[5] has suggested that such a classification is necessary for a proper understanding of agricultural patterns on a world scale. In research undertaken at a later date[6] he demonstrated that the agricultural labour input reported in the U.S. census could in itself serve as a valuable tool for describing the net productivity per unit area of farm land. The value of the product moment correlation coefficient computed in Helburn's study between labour inputs and net value of agricultural products sold for all counties was +0.87. Although labour inputs correlated well with the average value of lands and buildings per acre of land in farms, another accepted intensity

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[5] N. Helburn, "The Bases for a Classification of World Agriculture", Professional Geographer, Vol. 9, No. 2, March 1957, pp. 2-7.

[6] N. Helburn and A.A. Lupton, "The Density of the Agricultural Labor Force, a Measure of the Intensity of Land Use", Annals, Association of American Geographers, Vol. 53, No. 4, December 1963, p. 596.

measure, (+0.73) surprisingly it did not correlate well with average farm size. Therefore although this finding does not weaken Helburn's case for an agricultural classification system based on intensity factors it does raise some interesting points concerning the relationship of intensity of farming and farm size.

It was demonstrated in this thesis that it is possible to modify the farm classification for at least one type of farm and thereby increase its usefulness for an analysis of the areal variability of farm size. The factors employed in this modification however did not include traditional measures of the intensity of farming, but rather a blend of land use and capital input ratios. Why this approach should be more successful than the more traditional measures of labour and capital used by Helburn appears to be another interesting problem worthy of further research.

Inferences for Further Research

There were many independent variables that could have been chosen or modified to represent more clearly the characteristic they were intended to measure. They were unavailable to the author however because the resources of any one student are clearly limited. Nevertheless this broad approach to the areal variability of farm size in Alberta has provided an overall view of the subject matter and more importantly has raised many questions in the author's mind concerning the explored relationships. For example, if it were economically possible to obtain the data would a more powerful test, such as an analysis of covariance using a stratified random sample of individual farms in Alberta, produce results that indicate the effects of each variable on the dependent variable while holding the effects of soils constant? Will the nature of the problem remain the same if the scale of the study were enlarged so that the effects, if any, of transportation costs could be more accurately isolated? What is the relationship between the progress of farm consolidation and the date of settlement? How has the quality of the physical environment influenced the rate of farm consolidation in Alberta? What is the relationship of time and agricultural specialization? To what degree has agricultural specialization progressed in Alberta? Do well defined agricultural regions exist everywhere in the province? What size of farm is needed in each of the major soil zones to produce a specified level of income? (It has been shown in this study that farms on the Grey Wooded soils are not significantly different in average size than those on the better Black-Dark Grey Wooded-Grey Wooded Soil Zone although they are significantly smaller than those in the Peace River District. In terms of physical conditions alone the average farm size should in all likelihood be larger than that in the Peace River District. Unfortunately this study dealt only with mean farm size. Therefore it is difficult to recommend optimal individual farm sizes.) Lastly, what measures should be incorporated into a type of farm classification based on an intensity continuum so that the relationship between regional variation in farm size and intensity of agricultural production can be accurately portrayed?

Conclusion

The foregoing are interesting and valid questions worthy of further analysis but it should be recognized that the author's ability to formulate them arose primarily from the models which were developed above for the exploratory analysis. In essence however these questions are only inferences for further research. Consequently they may be viewed as no more than a legitimate by-product emmanating from a fruitful methodology which in itself allowed the author to demonstrate some of the factors affecting the areal variability of average farm size.

More specifically this study made contributions in three major subject areas: location theory, methodology, and regional spatial relationships.

The major contribution to location theory is that under present technological and market conditions the quality of the physical environment may be one of the most important determinants of areal size of farms and by inference, intensity of land use. Furthermore this is consistent with Von Thunen's major thesis, that economic rent influences the intensity of land use. It is in the area of product specialization and the importance of transportation costs at the local level that these findings are at variance with Von Thunen's observations.

These observations appear to lead naturally to contributions to methodology. The importance of what is essentially a qualitative variable, the quality of the physical environment, was demonstrated with the use of dummy variables. This spared the author the virtually impossible task of assigning objective measures to soils for all agricultural uses, or affixing ranks to the great soil groups. The latter is a relatively easy process when moving from Light Brown through Dark Brown and Thin Black Soil Groups to the Black or chernozem soils, but the assignment of a rank to the Grey-Wooded soils poses a much more difficult problem. In addition to their use in the foregoing descriptive model dummy variables also allowed the writer to formulate a normative model in which a hypothetical pattern of farm size was postulated as a function of soil moisture deficit and the length of the frost free season. Both of these models in turn proved useful as a framework for the discussion of the areal variation in farm size, but more important they paved the way for further research in this subject field.

The other major contribution to methodology lies in the field of type of farm classification. By employing a scalogram and a modified factor analysis the author was able to demonstrate that classifications based on intensity have more utility for this type of study than broad classifications based on major sources of income. Using the example of livestock farms the original correlation of + 0.11 was improved to + 0.67 when blends of land use characteristics and capital inputs expressed as rates were employed.

The dubious nature of census data for manipulation in parametric tests remains however, particularly when the values used are abstractions from areal units which vary in size and in terms of the numbers of farms that they contain. Attempts to circumvent this problem were made by treating the population as a sample of a larger universe of events that could have occurred except for the random shocks. Also the mean values were accepted as samples drawn from each census unit which could be weighted in terms of the total number of farms from which they were drawn. This whole subject area needs further research however to either modify the traditional correlation tests for areally distributed data or to show conclusively that census data do not lend themselves to sophisticated statistical manipulation.

Lastly, this study may be regarded as a legitimate contribution to the geographic body of knowledge pertaining to the regional patterns of agriculture in Alberta. It provides an overview to the areal distribution of farm size and some of the factors affecting the variability of this aspect of farming. Moreover the anomalies in the general distributional patterns pose in themselves interesting subject matter for further analysis. They focus attention on those areas in which the areal size of farm is obviously too small in terms of the commodities grown and the level of inputs employed.

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APPENDIX "A"

Table XIII Average Farm Size in Acres and Frequency of Farms in Each Size Group Expressed as a Percentage of Total Numbers of Farms in Each Municipality - 1961.*

			Size Groups							
		Average Size	0-69	70-239	240-399	400-559	560-759	760-1119	1120-1599	Over 1600
Division One										
Municipality	11	1858	3	7	13	10	12	18	17	21
	22	3350	5	3	6	7	4	10	15	50
	8	1889	0	5	9	10	11	19	18	28
Division Two										
Municipality	14	741	5	29	20	12	9	9	7	9
	25	488	11	35	19	9	8	9	5	5
	4	1109	5	33	26	11	7	6	2	11
	5	1360	5	7	11	8	14	17	17	21
Division Three										
Municipality	6	940	11	16	14	14	14	13	8	11
	9	1080	2	9	16	14	14	20	13	14
	26	1047	3	7	18	13	16	21	12	12
Indian Reserves		2563	2	32	4	10	13	5	6	8
Division Four										
Municipality	34	1605		2	9	8	10	17	21	32
	2	2520	1	4	7	6	9	16	14	43
	3	2291		2	6	6	7	13	17	50
Division Five										
Municipality	42	1134	25	13	16	16	9		3	19
	47	845	1	6	17	14	19	22	14	8
	48	641	3	11	19	19	17	19	8	4
	2	1093	2	4	10	13	16	24	18	14
	16	1094	2	4	10	12	20	22	14	16
Indian Reserves		482	4	46	29	7	8	4		4
Division Six										
Municipality	31	749	7	15	19	15	16	11	9	7
	44	755	13	13	18	13	17	13	6	7
	17	451	3	23	29	18	12	10	3	2
Indian Reserves		775		28	17	11	11	11	6	17

APPENDIX "A", cont'd

		Average Size	0-69	70-239	240-399	400-559	560-759	760-1119	1120-1599	Over 1600
Division Seven										
Municipality	52	1121		5	12	10	15	22	17	19
	53	1029		5	9	11	14	24	22	16
	61	904		8	14	14	17	21	14	12
	62	642	1	9	22	20	18	18	9	4
	6	798	2	8	17	17	17	20	10	9
Division Eight										
Municipality	55	422	6	25	28	17	10	8	4	1
	65	369	3	29	35	19	9	5	2	
	68	367		57		29		14		
	3	409	4	23	33	20	11	8	2	1
	14	397	5	26	32	19	10	6	3	1
Indian Reserves		163		98	2					
Division Nine										
Municipality	10	363	25	30	20	5		10	10	
	27	6361			6			13	6	75
	50	2133			14			14	14	57
	58	573	4	22	26	21	9	9	4	6
	946	1677	5	5	14	10	5	19	5	38
Division Ten										
Municipality	63	424	3	20	35	19	11	8	2	1
	71	677	1	11	21	19	16	17	9	6
	72	499	2	16	32	20	14	10	5	2
	81	396	2	24	35	21	10	6	2	
	82	327	4	33	33	18	8	4	1	
	9	517	2	17	31	21	13	9	5	2
Division Eleven										
Municipality	75	281	4	45	32	12	5	2		
	77	327	1	37	36	15	7	3		
	83	289	12	40	26	12	6	3	1	1
	84	313	9	34	31	14	7	4		
	10	339	4	34	33	16	7	4	1	
	15	324	12	29	32	14	7	5	2	
Indian Reserves		204	2	75	17	7				
Division Twelve										
Municipality	85	2699	5	37	11	5	5	5		32
	86	438	3	20	33	19	14	9	2	1
	87	401	3	22	34	22	12	7	1	
	101	446	2	20	29	23	12	9	3	1
	102	413	8	23	25	22	11	8	3	1
	13	354	3	30	35	29	8	4	1	
Indian Reserves		397	32	43	10	6	6	1	1	1

APPENDIX "A", cont'd

	Average Size	0-69	70-239	240-399	400-559	560-759	760-1119	1120-1599	Over 1600
<u>Division Thirteen</u>									
Municipality 92	380	2	29	34	19	9	6	1	1
93	380	3	27	35	19	10	6		
107	381	1	30	37	16	9	4	3	1
108	428	2	26	32	18	10	7	4	1
122	276	22	27	19	19	8	4		
7	322	3	36	35	16	7	3	1	
11	365	1	28	39	17	10	4	1	
12	400	1	24	35	21	10	8	1	1
<u>Division Fourteen</u>									
Municipality 78	323	2	39	37	13	6	3	1	1
95	357	3	34	29	19	7	7	1	1
96	7098						50		50
109	477	1	21	29	19	15	10	5	1
<u>Division Fifteen</u>									
Municipality 110	402			67	17	17			
111	450		21	40	11	4	19	4	
124	236	40	22	20	7	3	5	1	1
125	418	1	26	36	18	8	8	3	1
126	449	2	21	40	16	9	8	3	1
129	358		40	20	20		20		
130	495	1	17	36	17	13	10	6	1
131	489		17	32	20	14	12	3	2
132	552		13	36	17	15	11	4	3
133	530	1	19	27	21	12	16	4	2
134	434	1	17	40	18	16	8	1	1
135	577	2	17	21	21	15	16	6	3
136	595	1	16	20	19	19	17	6	3
138	492	1	15	34	21	14	11	4	2
139	539		12	32	19	18	12	5	2
145	509		14	29	29		29		
146	410		18	43	21	13	3	3	
147	378	2	26	44	11	10	5	3	
1	480	1	18	30	21	14	11	4	1
Indian Reserves	260	25	33	17	11	11	3		

* Note municipal percentages may not add to 100 due to errors in rounding.

Source: Canada, Dominion Bureau of Statistics, <u>Census of Canada</u>, Vol. 5, Pt. 3, No. 3, Agriculture: Alberta, Ottawa, 1961, Table 29.

APPENDIX "B"

DISCUSSION OF WEAVER'S CROP COMBINATION TECHNIQUE

J.C. Weaver has developed a technique which provides an objective measure of the most important crops in any municipality. His technique has been extended in this study to the identification of the most commonly occuring farm size group or combination of groups. One important difference however, between the type of data Weaver used and those used in this study is Weaver used areas of specific types of land use whereas frequencies of farm expressed as percentages of the total number of farms in each municipality were used here. Theoretically it should be possible to convert these frequencies to area. In actual practice it was found not possible due to the nature of the census data. In any case it was not the author's purpose to determine the land occupancy strength of specific size groups but rather, as stated in the text, to ascertain the variability of the data associated with each municipal mean. Weaver was himself aware that there was more than one type of data that could be examined with his technique. He stated, for example:

> Any one of several bases of definition might be effectively used to determine the identity of critical crop combinations. One approach might be to examine the crops of a given complex for their relative land-occupancy strength. Another might be to weigh them comparatively for production volume or value.[1]

It would appear then, that no error has been committed by substituting frequency values for area data.

Weaver was able to make statements about the importance of any

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[1] J.C. Weaver, "Crop Combination Regions in the Middle West", Georgr. Rev., Vol. 44, No. 2, April 1954, p. 17.

crop or combination of crops in any municipality because he assumed that the basis for establishing the importance of the crop was the area of the municipality in question, not some mean value derived from a synthetically defined "average municipality". If he had accepted the latter values as his standard of comparison then he would have been forced to express the crop combination in the study municipality in terms of the degree to which it deviated from the "average municipality". This means that the values could not be readily understood except by referring to an average municipality which exists only as an empirically derived value. What Weaver chose instead was a theoretical curve that had universal application. He derived this theoretical curve by assuming that if a single crop were the most important in terms of the area it occupied in the municipality then the value of the curve or model against which it should be compared would be 100 per cent of the cropland in the municipality. If a two crop combination were the most important then the area occupied by each crop should be compared with 50 per cent of the total cropland available in the municipality. Stated in terms of probabilities what this means is that if the municipality under investigation was characterized by monoculture then we would expect 100 per cent of the total harvested cropland to be in one crop. If the municipality in question was characterized by a two, three, four, etc. crop combination then we would expect 50 per cent of the cropland in each of two crops, 33.3 per cent of the cropland in each of three crops or 25 per cent of the cropland in each of four crops, and so on.

Once Weaver had established the foregoing curves, or models, as the standard reference against which all municipalities could be compared, he then tested all combinations to see which deviated least from the theoretical model. The crop combination that deviated least was, of course, adjudged the combination which best represented the land use in that particular municipality. The statistical test he used to measure the degree to which each possible combination deviated from the theoretical curve was the variance of each crop combination from the theoretical curve. This variance was computed by the standard variance formula with an important difference. Instead of subtracting each actual score from the mean of the distribution, the scores were subtracted from the mean of the hypothetical curve. In other words if Weaver was testing for a two crop combination he did not compute a mean from the empirically observed values which might have been 55 per cent, for example, rather he used the means of the theoretical curve which would be 50 per cent in each crop divided by two, or 50.

The computations for determining the best size combination to describe municipality 11 in census division 1 have been placed in the Table below. First the size groups were ranked in order of their importance. If a size group in any municipality had the largest number of farms in it then it was called number one. After the size groups had been ranked, the frequency of farms occuring in each group were expressed as percentages of the total number of farms in the municipality. (These percentage values are recorded in Appendix "A".) Then these values were used in Weaver's technique.

It should be strongly emphasized that the size group with the greatest number of farms in it was called number one. This means that municipalities with the same number of groups that best describe the actual distribution of most farm sizes may not have the same groups represented in its combination. It is possible, although in actual practice it did not occur, that municipalities with the same number may be composed of farms in the smallest size group categories in one case and the largest size group categories in another. This was not considered important by the author however, because this technique was not employed to determine which size groups best describe the actual variation in farm size but rather the degree to which farm sizes varied around the municipality mean.

Table XIV Size Group Combinations for Municipality 22, Census Division One, Using Weaver's Technique For Determing the Best Combination

Number of Size Groups

	1	2		3			4			
Per Cent of Farms in each Group	50.4	50.4	15.0	50.4	15.0	9.7	50.4	15.0	9.7	7.1
Per Cent of Theoretical Curve	100.0	50.0	50.0	33.3	33.3	33.3	25.0	25.0	25.0	25.0
Difference	49.6	4.0	35.0	17.1	18.3	23.6	25.4	10.0	15.3	17.9
Sum of Squared Differences	2460.0	1225.2		1204.3			1299.7			
Sum Divided by No. of Size Groups	2460.0	612.6		401.4			324.9			

	5					6					
Per Cent of Farms in each Group	50.4	15.0	9.7	7.1	6.2	50.4	15.0	9.7	7.1	6.2	4.5
Per Cent of Theoretical Curve	20.0 in each					16.6 in each					
Difference	30.4	5.0	10.3	12.9	13.8	33.8	1.6	6.9	9.5	10.4	12.1
Sum of Squared Differences	1412.1					1537.1					
Sum Divided by No. of Size Groups	282.4					256.1					

	7							8							
Per Cent of Farms in each Group	50.4	15.0	9.7	7.1	6.2	4.5	4.4	50.4	15.0	9.7	7.1	6.2	4.5	4.4	2.7
Per Cent of Theoretical Curve	14.3 in each							12.5 in each							
Difference	36.1	.7	4.6	7.2	8.1	9.8	9.9	37.9	2.5	2.8	5.4	6.3	8.0	8.1	9.8
Sum of Squared Differences	1636.1							1745.0							
Sum Divided by No. of Size Groups	233.7							218.1							

Table XV Size Group Combinations

Divisions		Combinations
Division One		
Municipality	11	6
	22	8
	8	7
Division Two		
Municipality	14	8
	25	8
	4	7
	5	7
Division Three		
Municipality	6	7
	9	6
	26	7
Division Four		
Municipality	34	6
	2	7
	3	8
Division Five		
Municipality	42	6
	47	6
	48	6
	2	6
	16	6
Division Six		
Municipality	31	6
	44	6
	17	5
Division Seven		
Municipality	52	6
	53	6
	61	6
	62	5
	6	6

Divisions		Combinations
Division Eight		
Municipality	55	5
	65	3
	68	2
	3	4
	14	4
Division Nine		
Municipality	10	5
	27	1
	50	4
	58	3
	69	3
	946	8
Division Ten		
Municipality	63	5
	71	6
	72	5
	81	3
	82	3
	9	5
Division Eleven		
Municipality	75	2
	77	3
	83	2
	84	3
	10	3
	15	4
Division Twelve		
Municipality	85	6
	86	4
	87	4
	101	4
	102	5
	13	3
Division Thirteen		
Municipality	92	3
	93	3
	107	3
	108	4
	122	4
	7	3
	11	3
	12	3

Divisions	Combinations
Division Fourteen	
Municipality 78	3
95	3
109	5
Division Fifteen	
Municipality 110	3
111	4
124	3
125	3
126	5
129	4
130	5
131	5
132	6
133	5
134	6
135	5
136	5
137	5
138	5
146	4
147	4
1	5

APPENDIX "C"

Table XVI

Five Ranching Characteristics

		Ratio of Livestock Inputs to Machinery Inputs	Ratio of Unimproved Land to Total Land in Farms	Ratio of Extensive Graziers to Total Animal Units	Ratio of Livestock Income to Total Income	Ratio of Dollars to Acres
Division One						
Municipality	11	1.1	71.0	95.0	59.0	5.0
	22	2.0	87.0	98.0	74.0	3.0
	8	0.5	55.0	94.0	27.0	6.0
Division Two						
Municipality	14	0.5	37.0	87.0	05.0	15.0
	25	0.5	17.0	80.0	31.0	27.0
	4	1.5	75.0	91.0	59.0	8.0
	5	0.5	35.0	90.0	30.0	13.0
Division Three						
Municipality	6	1.4	51.0	93.0	56.0	11.0
	9	1.7	66.0	95.0	67.0	7.0
	26	1.1	45.0	94.0	55.0	11.0
Indian Reserves		2.4	89.0	99.0	60.0	2.0
Division Four						
Municipality	34	0.4	43.0	93.0	13.0	6.0
	2	1.5	78.0	97.0	60.0	3.0
	3	1.1	68.0	97.0	55.0	3.0
Division Five						
Municipality	42	1.0	58.0	91.0	50.0	7.0
	47	0.6	30.0	91.0	38.0	11.0
	48	0.6	20.0	83.0	30.0	15.0
	2	0.4	27.0	91.0	29.0	11.0
	16	0.7	25.0	89.0	35.0	13.0
Indian Reserves						
Division Six						
Municipality	31	1.4	44.0	91.0	60.0	14.0
	44	1.3	45.0	87.0	54.0	18.0
	17	1.1	34.0	85.0	55.0	15.0
Indian Reserves						

APPENDIX "C", cont'd.

		Ratio of Livestock Inputs to Machinery Inputs	Ratio of Unimproved Land to Total Land in Farms	Ratio of Extensive Graziers to Total Animal Units	Ratio of Livestock Income to Total Income	Ratio of Dollars to Acres
Division Seven						
Municipality	52	1.0	48.0	94.0	52.0	6.0
	53	1.1	49.0	92.0	45.0	6.0
	61	0.9	46.0	89.0	39.0	6.0
	62	0.7	33.0	82.0	38.0	10.0
	6	1.1	49.0	88.0	51.0	8.0
Division Eight						
Municipality	55	0.9	34.0	79.0	45.0	16.0
	65	1.0	53.0	78.0	35.0	7.0
	3	1.1	38.0	77.0	50.0	12.0
	14	0.8	28.0	76.0	49.0	18.0
Division Nine						
Municipality	10	1.5	83.0	91.0	50.0	6.0
	58	1.6	70.0	89.0	70.0	7.0
	69	2.2	61.0	85.0	100.0	5.0
Division Ten						
Municipality	63	0.7	25.0	70.0	37.0	14.0
	71	0.9	43.0	87.0	40.0	8.0
	72	0.7	34.0	74.0	27.0	9.0
	81	0.7	34.0	77.0	20.0	8.0
	82	0.6	25.0	55.0	16.0	10.0
	9	0.9	43.0	77.0	39.0	8.0
Division Eleven						
Municipality	75	0.6	33.0	56.0	8.0	13.0
	77	0.6	64.0	78.0	40.0	4.0
	83	0.7	29.0	57.0	22.0	24.0
	84	0.8	42.0	63.0	23.0	12.0
	10	1.0	37.0	68.0	39.0	14.0
	15	0.5	16.0	58.0	25.0	20.0
Division Twelve						
Municipality	86	0.9	47.0	65.0	23.0	7.0
	87	0.8	46.0	59.0	9.0	7.0
	101	0.9	59.0	68.0	36.0	5.0
	102	0.8	60.0	72.0	22.0	6.0
	13	0.7	37.0	60.0	18.0	8.0

APPENDIX "C", cont'd.

	Ratio of Livestock Inputs to Machinery Inputs	Ratio of Unimproved Land to Total Land in Farms	Ratio of Extensive Graziers to Total Animal Units	Ratio of Livestock Income to Total Income	Ratio of Dollars to Acres
<u>Division Thirteen</u>					
Municipality 92	0.5	30.0	63.0	22.0	11.0
93	0.8	49.0	73.0	16.0	7.0
107	0.6	63.0	69.0	27.0	4.0
7	0.6	36.0	62.0	21.0	8.0
11	0.7	41.0	59.0	22.0	10.0
12	0.5	47.0	64.0	21.0	6.0
<u>Division Fourteen</u>					
Municipality 78	0.8	58.0	70.0	36.0	5.0
95	0.7	70.0	81.0	27.0	6.0
109	0.8	62.0	80.0	37.0	5.0
<u>Division Fifteen</u>					
Municipality 110	0.4	54.0		22.0	3.0
124	0.5	58.0	78.0	8.0	17.0
125	0.4	50.0	77.0	17.0	6.0
126	0.4	59.0	76.0	22.0	5.0
130	0.1	31.0	56.0	5.0	7.0
131	0.2	43.0	65.0	11.0	5.0
132	0.2	40.0	72.0	10.0	5.0
133	0.3	36.0	78.0	14.0	6.0
134	0.2	44.0	74.0	13.0	6.0
135	0.3	34.0	78.0	18.0	7.0
136	0.2	32.0	78.0	13.0	7.0
138	0.3	42.0	76.0	14.0	5.0
139	0.4	53.0	75.0	18.0	5.0
145		47.0	84.0		8.0
146	0.3	49.0	61.0	7.0	5.0
147	0.6	40.0	62.0	18.0	4.0
1	0.4	37.0	79.0	9.0	8.0

Source: Canada, Dominion Bureau of Statistics, <u>Census of Canada</u>, Vol. 5, Pt. 3, No. 3, Agriculture: Alberta, Ottawa, 1961, 1 vol. (unpaged)

DISCUSSION OF SCALOGRAM ANALYSIS

The components for scalogram analysis are treated as dichotomous variables in this study and each municipality is therefore scored as either possessing the characteristic in question or not possessing it. The cutting point for each characteristic or component was determined by accepting the midpoint of the range of values for each factor as the point at which farms in the municipality could be characterized as extensive livestock producers. Above this value the municipality was scored in the "yes" column with the exception of one characteristic, Dollars per Acre. If the score for the characteristics were less than the cutting point then the municipality was scored "no".

When all municipalities had been assigned a score on every characteristic they were then ranked in terms of the value of their total "yes" scores from the highest to the lowest. Then the "yes" and "no" columns were examined for each of the factors to ascertain the amount of error in the individual components. This was determined by assuming that it would be possible to predict the municipal scores for individual components knowing only the total score or rank for each municipality. The degree to which each municipality failed to hold the same rank for individual components is the error for that component.

All errors for every component are summed and entered into a formula for determining the coefficient of reproducibility. The coefficient is really a statement of the ability of this scale of components to measure the quality in question. A perfect scale would measure the quality in such a way that the position of every municipality or scoring unit would be predicted knowing only the total score or rank for all components for a particular municipality.

In practice if a scale is reproducible at the 90 per cent level of accuracy, it is accepted as a "perfect" scale.

If a particular component possesses more error than non-error, then its utility as a measure of a quality in question is in doubt. Error is determined by dividing the "yes" and "no" scores in such a way that the smallest possible number of "yes" and "no" scores are located below and above the dividing line in the adjoining "yes" and "no" columns. If a component has more error than non-error, the usual practice is to remove it from the scale. Component five, Dollars per Acre, was left in this scale to illustrate the nature of the problem.

It may be seen from the following table that component five must be divided between census division 15, municipality 1 and census division 8, municipality 14 to produce the smallest number of errors. Unfortunately this division results in more "no" scores above the dividing line than below it. Therefore this component has more error than non-error.

APPENDIX "C" - 1

Table XVII

Scale of Degree of "Ranching"

Scoring Unit 1961		Factors									
		1		2		3		4		5	
Census Division	Municipality	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
1	22	1		1		1		1		1	
2	4	1		1		1		1		1	
3	9	1		1		1		1		1	
3	Indian Reserve	1		1		1		1		1	
4	2	1		1		1		1		1	
9	58	1		1		1		1		1	
9	69	1		1		1		1		1	
1	11		1	1		1		1		1	
9	10	1		1		1			1	1	
4	3		1	1		1		1		1	
1	8		1	1		1			1	1	
3	6	1			1	1			1	1	
3	26		1		1	1		1		1	
5	42		1	1		1			1	1	
6	31	1			1	1		1			1
6	44	1			1	1		1			1
8	65		1	1		1			1	1	
11	77		1	1		1			1	1	
14	95		1	1		1			1	1	
14	109		1	1		1			1	1	
15	111		1	1		1			1	1	
2	5		1		1	1			1	1	
4	34		1		1	1			1	1	
5	47		1		1	1			1	1	
2	2		1		1	1			1	1	
5	16		1		1	1			1	1	
6	17		1		1	1		1			1
7	52		1		1	1			1	1	
7	53		1		1	1			1	1	
7	61		1		1	1			1	1	
7	62		1		1	1			1	1	
7	6		1		1	1			1	1	
8	3		1		1	1			1	1	
10	71		1		1	1			1	1	
12	101		1	1			1		1	1	
12	102		1	1			1		1	1	
13	107		1	1			1		1	1	
13	108		1	1			1		1	1	
13	122		1	1			1		1	1	
14	78		1	1			1		1	1	
15	124		1	1		1			1		1
15	126		1	1			1		1		1
15	133		1		1	1			1	1	
15	135		1		1	1			1	1	
15	136		1		1	1			1	1	
15	139		1	1			1		1	1	
2	14		1		1	1			1		1

APPENDIX "C" - 1, cont'd.

Scoring Unit 1961		Factors									
		1		2		3		4		5	
Census Division	Municipality	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
2	25		1		1	1			1		1
5	48		1		1	1			1		1
8	55		1		1	1			1		1
10	72		1		1		1		1	1	
10	81		1		1		1		1	1	
10	82		1		1		1		1	1	
10	9		1		1		1		1	1	
11	75		1		1		1		1	1	
11	84		1		1		1		1	1	
11	10		1		1		1		1	1	
12	86		1		1		1		1	1	
12	87		1		1		1		1	1	
12	13		1		1		1		1	1	
13	92		1		1		1		1	1	
13	93		1		1		1		1	1	
13	7		1		1		1		1	1	
13	11		1		1		1		1	1	
13	12		1		1		1		1	1	
15	125		1		1		1		1	1	
15	130		1		1		1		1	1	
15	131		1		1		1		1	1	
15	132		1		1		1		1	1	
15	138		1		1		1		1	1	
15	146		1		1		1		1	1	
15	137		1		1		1		1	1	
15	1		1		1		1		1	1	
8	14		1		1		1		1		1
10	63		1		1		1		1		1
11	83		1		1		1		1		1
11	15		1		1		1		1		1
Scaling Errors		4		13		8		5		9*	

Co-efficient of reproducibility $1 - \frac{39}{5x77} = .9$

* More error than non-error i.e. more "no" scores above the line than below.

APPENDIX "C" - 1, cont'd.

The factors used in this analysis are defined below in the order in which they occur.

1. Ratio of Livestock Value to Machinery Value.
2. Ratio of Unimproved Land to Total Land in Farms.
3. Ratio of Extensive Grazers to Total Animal Units.
4. Ratio of Income from the Sale of Livestock to Total Income.
5. Ratio of Dollars per Acre.

APPENDIX "C" - 2

COMPUTATIONS FOR DETERMINING FIRST FACTOR LOADINGS BY THE HOTELLING METHOD OF ITERATION

Discussion

An elementary exposition of the Hotelling Method is found in the Appendix of an article by M. J. Hagood.[1.] It was this exposition that was used to execute the following computations which in turn led to the development of the weights used in formulating a "ranching" index for Alberta.

The method is based on the assumption that the generalized variance for all municipalities assigned the same composite of multivariate index should be minimized. To have it otherwise would permit the assignment of the same index score to many municipalities which differed radically on the scores assigned to the various categories. Under this opposite condition, it would be possible for example to assign individuals with high scores in one category and low scores in another the same multivariate index number as another municipality with the opposite range of scores in the same categories. The Hotelling Method therefore determines the weights in such a way that all municipalities with comparable index values will have minimum variance in their measures on each of the five characteristics. This suggests that all municipalities with similar index values within a certain range will have similar values for each of the five "ranching" characteristics.[2.]

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[1] M.J. Hagood and N. Damilevsky and C.O. Beum, "An Examination of the Use of Factor Analysis in the Problem of Subregional Delineation", Rural Sociology, Vol. 6, No.3, Sept.1941, pp. 216-233.

[2] Ibid, p. 230.

APPENDIX "C" - 2, cont'd.

Computations:

Table XVIII

Original Matrix

	1	2	3	4	5
1		.53	.45	.79	-.05
2	.53		.42	.34	-.66
3	.45	.42		.63	-.15
4	.79	.34	.63		.12
5	-.05	-.66	-.15	.12	
Sums	1.72	.63	1.35	1.88	-.74

Reflection One

	1	2	3	4	5
1		.53	.45	.79	.05
2	.53		.42	.34	.66
3	.45	.42		.63	.15
4	.79	.34	.63		-.12
5	.05	.66	.15	-.12	
Sums	1.82	1.95	1.65	1.64	.74

Iteration One

	1	2	3	4	5
1	.79	.53	.45	.79	.05
2	.53	.66	.42	.34	.66
3	.45	.42	.63	.63	.15
4	.79	.34	.63	.79	-.12
5	.05	.66	.15	-.12	.66
Sums	2.61	2.61	2.28	2.42	1.40
Weights	1.000	1.000	.874	.927	.536

APPENDIX "C" - 2, cont'd.

Computations:

Iteration Two

	1	2	3	4	5
1	.79	.53	.45	.79	.05
2	.53	.66	.42	.34	.66
3	.39	.37	.55	.55	.13
4	.73	.32	.58	.73	.11
5	.03	.35	.08	.06	.35
Sums	2.47	2.23	2.09	2.35	1.08*
Weights	1.000	.900	.843	.950	.439

* May not add precisely due to errors in rounding illustration data.

Proceed to Iteration Eight

1	.79	.53	.45	.79	.05
2	.44	.55	.35	.28	.55
3	.37	.35	.52	.52	.13
4	.77	.33	.61	.77	.12
5	.02	.23	.05	.04	.23
Sums	2.39	1.99	1.99	2.32	.84
Weights	1.000	.833	.832	.972	.351
Weights Squared	1.000	.694	.692	.945	.123
Factor Loadings (.834 x Weights)	.826	.695	.694	.811	.293

The weights obtained from the final iteration are proportional to the first factor loadings which are obtained from them in the following manner.

1. Sum of squared weights = 3.454

2. $\sqrt{\frac{\text{Largest sum}}{\text{Sum of squared weights}}} = \sqrt{\frac{2.391}{3.454}} = .834$

Index $= .826Z_1 + .695Z_2 + .694Z_3 + .811Z_4 - .293Z_5$

APPENDIX "C" - 2, cont'd.

Weighted means and standard deviations for standard scores (Z)

Z1	1.22	.35
Z2	40.62	13.53
Z3	76.68	12.36
Z4	31.92	16.28
Z5	10.45	4.97

Computation of Z scores, substitutes in original equation and collection of constant terms gives,

$$\text{Index} = 2.36X_1 + .951X_2 + .056X_3 + .050X_4 - .059X_5 - 10.22$$