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DISCUSSION PAPER NO. 353



# Weather and Crop Yields in the Prairie Provinces, 1961-1986

by

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## RÉSUMÉ

Le rendement des cultures et la superficie récoltée sont les deux déterminants de la production céréalière et ont donc un important effet sur le revenu des fermiers. Contrairement au facteur superficie, celui du rendement est grandement marqué par diverses variables non contrôlables, notamment les conditions météorologiques, un fait dont l'analyse de la production et du revenu agricoles doit tenir compte. Cette étude examine donc les niveaux, les tendances et le taux de variation du rendement des cultures de blé, d'orge et d'avoine dans les provinces des Prairies entre 1961 et 1986, en accordant une attention particulière à l'effet des conditions météorologiques. Les cycles longs de la production de blé canadien y sont également notés et reliés à l'évolution cyclique du rendement des cultures de blé au cours de la période de 1908 à 1984.

L'analyse porte sur les provinces et sur les régions infraprovinciales. Elle repose sur un "indice généralisé de croissance des cultures" qui permet de mesurer comment, dans une région donnée, les conditions météorologiques font varier le rendement des cultures autour de sa tendance à long terme.

Au début de son analyse empirique, l'auteur identifie les régions infraprovinciales ayant les rendements les plus élevés et les plus bas, et il examine les tendances du rendement des cultures de 1961 à 1986.

Il présente ensuite des indices de la variation du rendement des cultures due aux conditions météorologiques pour chaque province et pour tous les districts agricoles consolidés. Enfin, il compare ces indices avec des mesures équivalentes de la variation totale des rendements autour de leur tendance.

## ABSTRACT


Crop yields and harvested acreage are the two components of grain production and therefore have an important impact on farm income. Unlike acreage however, yields are greatly affected by random non-policy variables such as weather, a fact which must be taken into account in the analysis of farm production and income. This study therefore examines the levels, trends and variability of wheat, barley and oat yields in the Prairie provinces between 1961 and 1986 with particular attention devoted to the impact of weather conditions. The long-run cycles of Canadian wheat production are also noted and attributed to a cyclical pattern of wheat yields over the 1908-1984 period.

The analysis is carried out at both the provincial and the sub-provincial level. It uses a weather-based "generalized crop growth index" to quantify the effect of weather on the regional variability of yields around their long run trends.

The empirical analysis begins by identifying sub-provincial regions with the highest and lowest yields and by examining the trends of the crop yields over the period 1961-86.

Indices of the yield variability due to the weather effect are then developed for each province and for all consolidated crop districts. These indices are then compared with equivalent measures of the total variability of the yields around their trends.

CONTENTS

# FOREWORD

This study is part of the Economic Council of Canada's project on the future of Prairie agriculture. It examines the variations of yield trends of wheat, oats and barley across the Prairies and the impact which weather conditions have had on the variability of the yields around the trend.

In particular, this paper discusses a method for quantifying these weather effects and produces a series of indices which do so. These indices are useful for studies of farm production and income stability at both the provincial and sub-provincial level. Some have already been used successfully in another study in this project.

Robert Wisner is a student of economics at the University of Ottawa. This paper was written while he was working at the Council during the summer of 1987.

Judith Maxwell
Chairman

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# 1 INTRODUCTION

In the broader context of the Economic Council of Canada's research project on the future of the Prairie grain economy, it is necessary to examine the instability of farm income, which may be a key factor determining a farmer's chances of survival. However, any such study of instability must take into consideration the random effects of weather on crop yields, and hence on production and income. Since these effects are non-policy variables, they must be singled out and the analysis should be adjusted for them.

## 1.1 A Historical Perspective

The importance of weather-related instability may be illustrated by briefly examining the long-run variability of the value of wheat production in each of the Prairie provinces. The value of production is defined as the price of wheat multiplied by the acreage multiplied by the wheat yield per acre. Table 1 shows the extent to which each of these elements contributed to the variability of the value of wheat production around its trend between 1908 and 1984. We see that although price was the dominant contributor to instability in each province, the contribution of yield was by no means insignificant, weighing almost as much as that of acreage. In Saskatchewan, one third of the variability of value of wheat production was attributable to yield variability as compared with 60 per cent for the price and less than 10 per cent for the acreage. In Manitoba and Alberta, the impact of yield variability was less significant, amounting to one sixth and less than one tenth of the total, respectively. These results show that yield instability is an important factor contributing to value of production instability. A description of the procedure used for calculating the share of overall instability is offered in Appendix A.

## 1.2 The Scope of the Analysis

This study examines the variability of wheat, oat and barley yields in the Prairie provinces over the 1961 to 1985 time period and attempts to quantify the impact which weather conditions may have had on them. Indices of crop yield variability and of weather effects are calculated for the purpose of both provincial and sub-provincial analysis.

# 2 METHODOLOGY

## 2.1 A Review of the Relevant Literature

Previous studies of agricultural productivity have used a variety of methods to adjust for weather effects. An Economic Council study (Auer, 1970) adjusted farm production by adding or subtracting the differences between observed yields and trend yields, weighted by their respective acreages and prices. This procedure is simple and reliable, but it does not distinguish between the effects of weather on yield variability and those of other influential factors, such as pests, disease and farm management skills.

Other studies have incorporated meteorological data for the purpose of estimating weather conditions. For example, the percentage variation in precipitation from the norm during the months of April to September was used as a weather variable (Sampson and Gerrard, 1987). An average rainfall was defined as having no impact on the yield. Although that approach helps to distinguish between weather and non-weather factors, precipitation alone is only a partial indicator of weather conditions since the actual moisture use of the crop is not estimated.

Another method (Brinkman, 1984) uses a weather-based generalized crop growth index (GRODEX) developed by Agriculture Canada (Dyer et al, 1984) to circumvent this problem. GRODEX reflects not only moisture use, but also factors such as temperature stress and length of growing season making it more suitable than the precipitation-based weather variable. Furthermore, by monitoring the stages of crop growth, GRODEX may have some predictive value for mid-season forecasts.

For the purposes of this study, it was decided that a weather index based on GRODEX should be calculated and that it should be compared with an index obtained by using the differences between observed yields and trend yields. Thus it would be possible to contrast an index based on meteorological data with an index of crop yield variability.

It was originally intended to incorporate some data concerning the impact of pests on crop yields, but the estimates of crop losses from insects on wheat are not well documented in the scientific literature as was pointed out in a study by the Entomological Society of Canada (Madder and Stemroff, 1986). Information from a wide variety of sources yielded some estimates of the per cent crop losses due to insects for the years 1980-85 on a provincial basis and 1984-85 on a crop district basis. These data were not used however because similar figures for earlier years could not be found.

## 2.2 The Degree of Disaggregation

A brief glance at the regional breakdown of crop yield data within each province for selected years reveals wide disparities of yields. As Table 2 illustrates, in the province of Alberta in 1986, yields of wheat ranged from 27.1 bu/ac. in crop District 7 to 47.0 bu/ac. in District 5. To take these differences into account, it was necessary to calculate indices on both a provincial and a sub-provincial level.

To perform the sub-provincial analysis, the agricultural regions of the Prairie provinces were divided into 40 crop districts (including the sub-divisions of "single-digit" crop districts) of which eight are in Alberta, twenty are in Saskatchewan and twelve are in Manitoba (Figure 1). The data series for yield and seeded acreage of wheat, oats and barley go back from 1986 to 1961, with the exception of Manitoba for which the crop district data only go back to 1977. Prior to this date, Manitoba had 14 crop districts (Figure 2) which do not correspond in any way to the subsequent arrangement, thus making it necessary to obtain two series of indices for that province: one extending from 1961 to 1976, the other from 1977 to 1984.

Although the yield and acreage data for crop districts were adequate, it was necessary for other studies in the project to aggregate them into larger "consolidated" crop districts whenever possible.

Two or more crop districts were aggregated into one consolidated district, on the basis of two criteria. First, the per-acre crop yields of the crop districts should correlate strongly with each other. No two districts were to be aggregated unless they shared a correlation coefficient whose value was equal to or greater than 0.8. If a particular district had no neighbouring districts meeting this requirement, then it was defined as constituting a separate "consolidated" crop district by itself. Second, no two crop districts were to be aggregated if there was a statistically significant difference between their yield trend levels.

Using this procedure, twenty-two "consolidated" crop districts were created. Of these, seven were located in Alberta, nine in Saskatchewan, and six in Manitoba (prior to 1977 there were five in Manitoba). However the boundaries of these consolidated crop districts did not correspond to the soil zone boundaries making it necessary to adjust the latter accordingly (Figures 3 and 4-A). The final boundaries of consolidated crop districts and adjusted soil zones are shown on Figure 4-A and a description of the empirical results of the procedure for obtaining them is given in Section 3.3.

## 2.3 An Index of the Weather Effect Based on GRODEX

Ideally, an index of the effect of weather on crop yields should provide an input variable which accurately represents weather conditions by integrating different types of weather data. It was for this purpose that "a simple weather-based crop growth index (GRODEX) was developed on the basis of daily soil water budgeting principles and assumed generalized plant water use characteristics" by Agriculture Canada (Dyer et al, 1984). GRODEX integrates "day-to-day weather and soil moisture availability for biomass growth, field trafficability and weather-induced product losses during the growing season" (Narayanan and Dyer, 1983). A series of GRODEX values from 1961 to 1985 was available for each of 28 weather stations scattered across the Prairies.

The model for our analysis is a log-linear regression with the crop yield of a province or a consolidated district as the dependent variable and the GRODEX values of a representative weather station and a time trend as the independent variables. This is illustrated by equation 1:

$$\ln Y_i = a + b \ln G + ct + u, \qquad (1)$$

where $Y_i$ represents the observed yield of crop i, a represents a constant term, b is the weather coefficient, G is the GRODEX value of the representative weather station in a particular year divided by the average of the GRODEX values over the 25-year period (i.e., a value of 1 represents "normal" weather), c is the coefficient of the time trend t, and u is an error term. In exponential form, equation (1) corresponds to (2).

$$Y_i = a\, G^b\, e^{ct} e^u \qquad (2)$$

The impact of weather, i.e., the deviation from the trend yield due to weather (Wi), can be expressed as the difference between the observed yield and what the yield would have been with normal weather (i.e., when G = 1.0) as in (3):

$$W_i = a\, G^b e^{ct} e^u - a\, e^{ct} e^u = a\, e^{ct} e^u (G^b - 1.0) \qquad (3)$$

Both the impact of weather on the crop yield and the observed yield of the crop are then weighted by their respective prices and acreages to obtain the index of the weather effect (W1) in (4):

$$W1 = \frac{\sum_i Y_i P_i A_i}{\sum_i (Y_i - W_i) P_i A_i} \qquad (4)$$

where $P_i$ is the price of the $i^{th}$ crop and $A_i$ is the seeded acreage of the $i^{th}$ crop. In this study, wheat, oats and barley are used, meaning that equation (4) can also be written as:

$$W1 = \frac{Y_w P_w A_w + Y_o P_o A_o + Y_b P_b A_b}{(Y_w P_w A_w + Y_o P_o A_o + Y_b P_b A_b) - (W_w P_w A_w + W_o P_o A_o + W_b P_b A_b)} \quad (5)$$

The weather index Wl is therefore a multiplicative index for which a value of 1 would represent the impact of "normal" weather. It is assumed that the weather conditions observed at a specific weather station apply to the surrounding region. Furthermore, it is important to note that although such an index is useful for comparing the variability of weather conditions of two regions, it does not indicate whether or not the yield conditions are consistently better or worse in one region than in another. The trend yields of crop districts would be one such indicator of interregional disparities of growing conditions, which are combinations of both soil and weather or climatic conditions.

## 2.4 An Index of Yield Variability

Weather is not the only factor influencing the variability of crop yields. Disease, pests as well as expansions of acreage or reduction of summer-fallow, can all affect crop yields significantly. The farmer's choice of herbicides and fertilizers, which may vary with economic conditions, will also contribute to the variability of the yield. For these reasons, weather may explain only part of the variability of yield and it may be desirable to use an index of total variability.

Crop yield variability can be expressed as the total deviation of the observed yield from its trend. Referring to equation (2) above, we can write (6):

$$V_i = a\,G^b e^{ct} e^u - a\,e^{ct} \tag{6}$$

This deviation from the trend is again weighted by the respective acreages and prices to give us the index of total yield variability (W2) which is:

$$W2 = \frac{\sum_i Y_i P_i A_i}{\sum_i (Y_i - V_i) P_i A_i} \tag{7}$$

Again, it should be emphasized that such an index is appropriate for comparing the variability of crop yields in two different regions but not the differences in yield levels between them.

# 3 EMPIRICAL ANALYSIS OF YIELD TRENDS

## 3.1 Regional Differences of Yield Levels

The indices of weather-effect and yield variability can provide an indication of the overall instability of weather and growing conditions. It may also be of interest to examine the yield trends of each crop. For this purpose, a simple log-linear regression model of the form (8)

$$\ln Y_i = a + bt + u \qquad (8)$$

was chosen, where Yi is the yield of the $i^{th}$ crop, a is the base yield in year t=0, and b is the coefficient of the yield trend. This regression was run for wheat, oat, and barley yields in each crop district of the three Prairie provinces using 1971 as the base year. The results, along with a Durbin-Watson test for each regression, are given in Tables 3-A to 3-D.

In Alberta, crop District 1 has the lowest base yields (17.3, 28.9, and 33.9 bu./ac. for wheat, barley, and oats respectively) but the highest yield-trend coefficients. Crop District 5 has the highest base yields for wheat and oats (32.4 and 58.1 bu./ac.), while District 2 has the highest base yield for barley (45 bu./ac. in 1971).

In the province of Saskatchewan, yields for wheat and barley are lowest in District 4A (16.3 and 28.2 bu./ac.). The most productive region in Saskatchewan is the northwestern District 9-B, which has yields of 26.6, 41.2, and 47.7 bu./ac. for wheat, barley, and oats, respectively.

In Manitoba, using data which run from 1961 to 1976, District 14 and 10 were found to have, respectively, the lowest (29.9 and 37.2 bu./ac.) and the highest (41.8 and 51.6 bu./ac.) yields for barley and oats. Districts 6 and 13 had the lowest (22.2 bu./ac.) and highest (29 bu./ac.) yields for wheat, respectively. The data for the more recent Manitoba crop district arrangement, which extend from 1977 to 1986, reveal that District 9 was the least productive region for all three crops with yields of 20.2, 28.9 and 36.2 bu./ac. for wheat, oats and barley, respectively. District 12 had the highest wheat yield (28.5 bu./ac.) whereas District 3 had the highest oat and barley yields (44.6 and 50.4 bu./ac.).

### 3.2 A Note on Production Cycles

By examining only the short-run yield trends on a crop district basis however, a notable aspect of the long-run trends is missed. This is the tendency of wheat production to increase in a cyclical pattern around the long-run trend. Chart 1 shows the production of six major field crops in Canada between 1923 and 1983. Of these six, only wheat seems to exhibit a consistent cyclical pattern. Beginning in 1928, the production of wheat peaks at regular intervals of 12 to 14 years, ending in 1979 when the cycle is broken and production continues to increase instead of falling to a lower level.

This holds true for the combined production of the Prairie provinces as well, but not for the production of every single province within the Prairies. For the Prairies as a whole, the positive deviations from the trend (i.e., the peaks of the cycle) increase and peak in the years 1928, 1940, 1952 and 1966. This cyclical pattern is broken in the 1980s, when yields continued to increase. In Saskatchewan and Alberta, there is a highly similar pattern with three cycles between 1928 and 1966. In Manitoba, however, there is no similar consistent pattern holding over the studied time period (see Charts 2, 3, and 4).

If we now analyze the two components of production, yield and acreage, we see that wheat yields follow a ten- to fourteen-year cyclical pattern around its long-run trend in Saskatchewan and Alberta. The peaks of the cycle are very close to those of the production cycle, but not quite identical. In Saskatchewan, they occur in 1928, 1942, 1952 and 1962 for yield and in 1928, 1942, 1952 and 1966 for production whereas in Alberta they occur in 1927, 1942, 1952 and 1966 for yield and in 1927, 1940, 1952 and 1966 for production (see Charts 5, 6, and 7). Since no such cycle is visible for acreage, we may conclude that the ten to fourteen cycle of production shown in Chart 1 is directly attributable to variations in wheat yields. It also appears that in both Alberta and Saskatchewan, yields increased from 1980 to 1983 instead of falling as the cycle would lead us to expect.

## 3.3 Correlations of Crop Yield Trends and Consolidation of Crop Districts

As specified in Section 2.2, crop districts which are to be aggregated, should share high correlations in yield trends and should have no significant differences in crop yields. The first step of the aggregation procedure should therefore be the estimation of correlation coefficients. Three tables of correlation coefficients are produced for each province (one for each crop) with an additional three tables corresponding to the old crop-district arrangement in Manitoba. These tables show how strongly the crop yields of each district correlate with the yields of all the other districts in a province (see Tables 4, 5, 6, and 7).

Given that a correlation coefficient (or 'r' value) of 1.0 or unity represents a perfect correlation of time trends, it was decided that only districts which share a coefficient equal to or greater than 0.8 for each crop would be considered for aggregation. Although all coefficients greater than 0.6 test significantly at the 1 per cent level, the figure of 0.8 was chosen so as to ensure an adequate degree of disaggregation while choosing only those districts whose yield trends correlate very highly.

Neighboring districts whose crop yields correlated well were then aggregated into consolidated districts if the difference between their yield levels was not significant. If the intercept value of the trend line given by the differences between the yields of two districts tested at the 5 per cent level of significance, the two districts were not aggregated regardless of the correlation between their yield trends.

However, these two criteria had to be suspended in the case of the province of Saskatchewan because the Census data dictated that we choose "single-digit" crop districts as our level of analysis. Thus all districts with the same first digit were aggregated together in Saskatchewan, regardless of their yield trend patterns or the differences of their yield levels. It later turned out that such a constraint did not seriously affect the results in an adverse manner (see Appendix B).

The final configuration of the consolidated crop districts is shown in Figure 4-A. As can be seen, the consolidated districts share the boundaries of the "single-digit" crop districts in Alberta and Saskatchewan. In Manitoba, consolidated Districts 1+7, 2+8+9+14, 3+4+5+6, and 10+11+13 were created from the 1961-1976 crop districts (see Figure 4-B) while consolidated Districts 1+2+3, 5+6, and 7+8+9+11 were created from the 1977-1986 districts.

The boundaries of the consolidated districts however, do not perfectly match those of the soil zones shown in Figure 3. There are four consolidated districts which straddle two different soil zones therefore making it necessary to adjust soil-zone boundaries when insignificant differences of yield levels permit us to do so. Districts 11 and 9 in Manitoba are thus included as part of the black soil zone though they are actually on the grey soil zone. Similarly, black-soil-zone Districts 16 of Saskatchewan and 4-B of Alberta as well as brown soil District 7-A of Saskatchewan are included in the dark brown zone. These changes are illustrated in Figure 4-A.

Before the weather indices could be calculated for each consolidated district, it was necessary to obtain new yield values for the latter. These were simply the mean of the yields of crop districts within a consolidated district, weighted by their respective acreages such that:

$$\bar{Y}_j = \frac{\sum_i Y_{ij} A_{ij}}{\sum_i A_{ij}}$$

where $\bar{Y}$ is the weighted mean of the crop yields, $Y_{ij}$ and $A_{ij}$ are the yield and seeded acreage of the $i^{th}$ crop district within the $j^{th}$ consolidated district. Table 9 shows the basic yields (1971) of wheat, barley, and oats for all consolidated crop districts which were calculated by using the regression model of equation (1), which is discussed in the following section.

## 4 EMPIRICAL ANALYSIS OF WEATHER EFFECTS AND YIELD VARIABILITY

### 4.1 Computation of the Weather and Variability Indices

As mentioned in Section 2.3, the regression model used for calculating the indices was of the form:

$$\ln Y_i = a + b \ln G + ct + u \qquad (1)$$

One of the preliminary tasks of the statistical analysis was thus to decide which weather station's GRODEX values were to be used for a particular consolidated district. This posed two problems. The first was that although there are 28 weather stations across the Prairies, not every district had a weather station within its borders. Specificly, District 6 in Alberta, District 4 in Saskatchewan, 1961-76 Districts 1+7, and 1977-85 Districts 4 and 10 in Manitoba lacked weather stations. This made it necessary to choose one of, or an average of, the neighbouring weather stations.

Second, even when a crop district had one or more weather stations located within its borders, it would often give poor results nonetheless. Out of 18 regressions of crop district yields against their own weather stations, six produced coefficients of weather effects which didn't test significantly at the 5 % level. These were for Districts 4, 5, and 7 in Alberta, and for the 1977-85 Districts 1+2+3, 5+6, and 12 in Manitoba. It should be noted, however, that the sample size of the new Manitoba districts comprised only nine observations (1977-85), as opposed to 25 observations (1961-85) for the other provinces' districts.

To resolve these problems, it was decided that for the eleven cases in which either there were no weather stations within consolidated district borders or those weather stations didn't give results which tested statistically significant, the GRODEX values would then be those of the best testing station or the average of stations in the neighboring districts. Table 8 shows which weather station or which average of weather stations GRODEX values were chosen for each consolidated crop district. For estimates of the provincial indexes, the average of the GRODEX values of all provincial weather stations was chosen.

Regression estimates, showing the 1971 trend yield or base yield, the weather effect estimated from GRODEX, the trend yield coefficient, and the coefficient of determination ($R^2$) are listed in Table 9. The 1971 base yield is defined as the antilog of the intercept value obtained by the regression using a time trend in which 1971 = 0. The weather effect is simply the coefficient of the GRODEX variable and the yield trend in per cent is the coefficient of the time trend multiplied by 100. The coefficients of determination vary significantly from one district to another but most are in the .30 to .70 range. The $R^2$ for Saskatchewan of 0.8 compares favorably with that of .33 obtained using the precipitation weather variable in the study by Sampson and Gerrard (1987).

The weather indices for all consolidated districts and all provinces, as well as the indices of yield variability, were obtained using the procedure described in Sections 2.3 and 2.4. They extend only until the year 1985 since no more recent data for prices were available. The six provincial indices are shown separately in Table 10 and are also in Appendix C, along with all the indices for the consolidated crop districts.

### 4.2 A Comparison and Analysis of the Weather and Variability Indices

In summary, the weather indices obtained for those districts whose coefficient of weather effects didn't test significantly, tend to be quite poor. In some cases, the weather effect is underestimated as the index will only show values which are very close to one. An example of this is the index for consolidated crop district #6 in Alberta, which is shown in Table 3 of Appendix C.

Even when the coefficients test significantly and the correlation coefficient is high, a comparison of the index of weather with that of yield variability reveals important discrepancies. First, in several years, the adjustment for the effect of weather alone on crop yields is greater than that for total yield variability, i.e., the difference between the value of the weather index and unity in a given year may be greater than that of the variability index and unity. For example, in consolidated District 1 in Alberta, for the year 1963, the weather index is 1.21 and the variability index is 1.09. Such instances might be explained by other factors having an effect on the yield that is opposite to the weather effect.

Second, there are years in which the adjustment to be made for the weather effect is opposite to that which should be made for yield variability, i.e., the weather index may be greater than unity when the variability index is less than unity or vice-versa. In District 1 in Alberta for example, the 1968 weather index is 0.89 and the variability index is 1.32. Once again, such a contradiction might be explained by other factors having an effect on the yield which is not only opposite to, but also greater than the weather effect.

Unfortunately, the number of such occurrences and the years in which they happen differ among districts, making it difficult to tell which factors are at work. Furthermore, other environmental factors affecting yield, such as pests and disease, are difficult to quantify. An attempt was made however, to assess the impact of two quantifiable factors on crop yields, namely, acreage and summerfallow. A large expansion of acreage may at times reduce the average yield while conversely, an expansion of summerfallow in one year may increase the yield in the next year. An index of acreage was obtained by taking the ratio of the actual wheat acreage. A corresponding variable was incorporated in the regression analysis.

The regression results show that in all three provinces, there was no significant acreage effect. Nor was there a significant summerfallow effect.

## 5 CONCLUSION

In this study, we examined the levels, trends and variability of wheat, oat and barley yields across the Prairies, on both a provincial and a subprovincial basis. Regions with the highest yields were identified and indices of the yield variability were calculated. These indices allowed us to differentiate between the variability of crop yields due to weather conditions and total yield variability that may be due to the combined effects of weather and other factors.

This study revealed some of the difficulties of quantifying the effects of random non-policy variables on crop yields. First, it was necessary to aggregate yield data representative of crop districts into broader measurements of consolidated crop district yields, so that the results could be used along with Census data. Second, not all weather station values could be used because some did not give meaningful results. Third, the index of variability due to weather differed frequently from that of total yield variability. And finally, acreage and summerfallow data did not explain these discrepencies.

Future improvements to the index should, if at all possible, take into account estimates of crop losses due to insects and disease as well as other environmental factors.

Table 1

**The Contribution of Price, Acreage and Yield to the Variability of the Annual Value of Wheat Production, 1908-84**[1]

| | Price | Acreage | Yield |
|---|---|---|---|
| | | (Per cent) | |
| Manitoba | 64.19 | 19.25 | 16.56 |
| Saskatchewan | 60.41 | 7.48 | 32.11 |
| Alberta | 57.20 | 35.04 | 7.76 |

1 The estimation procedures are described in Appendix A.

Table 2

Wheat Yields By Crop District, 1961, 1971, 1981, 1986 (In BU/AC.)

| | 1961 | 1971 | 1981 | 1986 |
|---|---|---|---|---|
| **Manitoba** | | | | |
| c.d. # 1* | 8.3 | 28.6 | 30.0 | 33.1 |
| 2 | 11.6 | 31.0 | 29.7 | 35.3 |
| 3 | 14.5 | 29.2 | 32.1 | 36.0 |
| 4 | 12.9 | 30.2 | 34.0 | 32.1 |
| 5 | 16.8 | 27.4 | 33.0 | 32.3 |
| 6 | 11.4 | 28.4 | 31.7 | 30.7 |
| 7 | 12.5 | 27.9 | 31.9 | 34.9 |
| 8 | 11.1 | 31.6 | 32.3 | 34.7 |
| 9 | 12.2 | 25.2 | 30.6 | 33.0 |
| 10 | 9.2 | 32.7 | 28.1 | 27.8 |
| 11 | 7.7 | 29.9 | 30.9 | 32.3 |
| 12 | 10.6 | 32.7 | 28.5 | 30.0 |
| 13 | 12.5 | 33.0 | - | - |
| 14 | 5.9 | 24.1 | - | - |
| **Saskatchewan** | | | | |
| c.d. # 1a | 3.7 | 27.8 | 24.9 | 34.6 |
| 1b | 5.7 | 29.3 | 28.1 | 34.4 |
| 2a | 7.9 | 26.2 | 23.6 | 35.4 |
| 2b | 11.6 | 28.4 | 26.5 | 38.1 |
| 3as | 3.5 | 18.6 | 20.9 | 28.5 |
| 3an | 5.9 | 23.4 | 23.2 | 27.4 |
| 3bs | 3.3 | 20.0 | 25.4 | 27.0 |
| 3bn | 7.3 | 25.1 | 26.4 | 29.3 |
| 4a | 4.9 | 14.0 | 23.8 | 29.6 |
| 4b | 6.1 | 23.8 | 26.9 | 28.8 |
| 5a | 6.3 | 30.0 | 33.2 | 32.6 |
| 5b | 8.6 | 31.0 | 35.5 | 28.8 |
| 6a | 7.9 | 29.2 | 26.3 | 29.7 |
| 6b | 7.4 | 30.0 | 24.7 | 31.8 |
| 7a | 11.1 | 27.6 | 26.9 | 36.1 |
| 7b | 13.6 | 28.6 | 31.1 | 38.1 |
| 8a | 14.1 | 31.1 | 30.4 | 27.8 |
| 8b | 12.8 | 31.6 | 26.0 | 26.9 |
| 9a | 10.1 | 29.8 | 28.5 | 29.2 |
| 9b | 23.3 | 30.4 | 25.4 | 32.9 |
| **Alberta** | | | | |
| c.d. # 1 | 3.5 | 19.3 | 28.9 | 29.2 |
| 2 | 13.2 | 28.8 | 42.1 | 40.1 |
| 3 | 16.5 | 26.8 | 41.0 | 40.2 |
| 4a | 17.2 | 27.4 | 26.7 | 36.3 |
| 4b | 23.2 | 31.0 | 30.2 | 37.5 |
| 5 | 21.1 | 32.6 | 41.0 | 47.0 |
| 6 | 24.5 | 25.3 | 35.4 | 35.7 |
| 7 | 26.6 | 27.8 | 28.6 | 27.1 |

* Data for Manitoba crop districts after 1977 do not correspond to data before 1977.

Table 3-A

**Base Yield and Yield Trend for All Crop Districts in Alberta (1961-86)**

| Alberta | Wheat | | | Barley | | | Oats | | |
|---|---|---|---|---|---|---|---|---|---|
| | Base yield (1971) (bu./ac.) | Yield trend (%) | Durbin Watson | Base yield (1971) (bu./ac.) | Yield trend (%) | Durbin Watson | Base yield (1971) (bu./ac.) | Yield trend (%) | Durbin Watson |
| #1 | 17.28 | 3.77 | 0.78 | 28.89 | 3.62 | 0.69 | 33.89 | 2.45 | 1.18 |
| #2 | 27.94 | 1.56 | 1.09 | 45.07 | 1.52 | 1.10 | 54.33 | 1.08 | 1.15 |
| #3 | 27.40 | 0.73 | 1.47 | 43.50 | 0.33 | 1.35 | 53.75 | 0.36 | 1.49 |
| #4A | 25.97 | 1.44 | 2.12 | 38.37 | 1.82 | 2.13 | 47.23 | 1.61 | 2.05 |
| #4B | 27.91 | 1.40 | 2.05 | 36.19 | 2.34 | 2.20 | 48.33 | 1.77 | 2.23 |
| #5 | 32.40 | 1.84 | 1.60 | 40.17 | 2.57 | 1.89 | 58.11 | 1.72 | 1.68 |
| #6 | 25.46 | 2.16 | 1.95 | 33.85 | 2.85 | 2.04 | 47.93 | 2.39 | 1.87 |
| #7 | 23.61 | 1.79 | 2.18 | 31.69 | 1.94 | 2.53 | 45.06 | 1.83 | 2.36 |

Table 3-B

**Base Yield and Yield Trend for All Crop Districts in Saskatchewan (1961-86)**

| Saskatchewan | Wheat | | | Barley | | | Oats | | |
|---|---|---|---|---|---|---|---|---|---|
| | Base yield (1971) (bu./ac.) | Yield trend (%) | Durbin Watson | Base yield (1971) (bu./ac.) | Yield trend (%) | Durbin Watson | Base yield (1971) (bu./ac.) | Yield trend (%) | Durbin Watson |
| #1A | 21.00 | 1.87 | 1.54 | 30.64 | 2.37 | 1.37 | 38.36 | 1.69 | 1.34 |
| #1B | 22.72 | 1.24 | 1.43 | 32.67 | 1.74 | 1.22 | 41.36 | 0.90 | 1.19 |
| #2A | 20.43 | 0.95 | 1.48 | 29.37 | 0.82 | 1.34 | 36.14 | 0.80 | 1.36 |
| #2B | 24.74 | 1.00 | 1.59 | 36.62 | 1.38 | 1.46 | 43.38 | 1.08 | 1.47 |
| #3AS | 18.94 | 1.58 | 1.42 | 28.95 | 1.84 | 1.35 | 34.81 | 1.52 | 1.33 |
| #3AN | 19.48 | 1.57 | 1.42 | 29.52 | 1.34 | 1.39 | 36.46 | 1.24 | 1.22 |
| #3BS | 18.20 | 1.83 | 1.26 | 28.31 | 1.47 | 1.22 | 34.77 | 1.64 | 1.17 |
| #3BN | 20.19 | 2.14 | 1.48 | 30.83 | 1.94 | 1.48 | 37.15 | 1.94 | 1.37 |
| #4A | 16.33 | 2.04 | 1.66 | 28.24 | 1.53 | 1.33 | 36.22 | 0.79 | 1.30 |
| #4B | 19.83 | 2.27 | 1.25 | 30.85 | 2.29 | 1.14 | 36.76 | 2.32 | 1.21 |
| #5A | 23.81 | 1.60 | 1.41 | 35.28 | 2.01 | 1.30 | 41.97 | 1.86 | 1.27 |
| #5B | 24.91 | 1.60 | 1.57 | 35.17 | 2.16 | 1.32 | 43.55 | 1.98 | 1.40 |
| #6A | 22.07 | 1.91 | 1.58 | 33.05 | 2.18 | 1.45 | 40.57 | 1.82 | 1.41 |
| #6B | 21.30 | 2.60 | 1.36 | 30.82 | 2.97 | 1.30 | 37.40 | 2.65 | 1.18 |
| #7A | 23.88 | 1.82 | 1.63 | 35.95 | 2.20 | 1.61 | 43.37 | 1.57 | 1.65 |
| #7B | 24.42 | 2.06 | 1.91 | 35.53 | 2.22 | 1.72 | 44.03 | 1.86 | 1.61 |
| #8A | 25.53 | 0.97 | 1.86 | 35.72 | 3.25 | 1.48 | 45.39 | 1.92 | 1.38 |
| #8B | 25.88 | 1.72 | 1.74 | 38.82 | 4.62 | 0.94 | 44.87 | 2.04 | 1.38 |
| #9A | 22.97 | 2.48 | 1.89 | 37.11 | 5.23 | 1.07 | 42.29 | 2.59 | 1.52 |
| #9B | 26.57 | 1.00 | 2.11 | 41.25 | 2.84 | 1.30 | 47.69 | 1.26 | 2.23 |

Table 3-C

**Base Yield and Yield Trend for All Crop Districts in Manitoba (1961-76)**

| | Wheat | | | Barley | | | Oats | | |
|---|---|---|---|---|---|---|---|---|---|
| Manitoba | Base yield (1971) (bu./ac.) | Yield trend (%) | Durbin Watson | Base yield (1971) (bu./ac.) | Yield trend (%) | Durbin Watson | Base yield (1971) (bu./ac.) | Yield trend (%) | Durbin Watson |
| #1 | 23.83 | 2.84 | 1.89 | 35.95 | 3.94 | 1.56 | 44.46 | 3.18 | 1.64 |
| #2 | 25.54 | 2.10 | 1.84 | 37.08 | 3.44 | 1.57 | 47.51 | 2.53 | 1.69 |
| #3 | 24.24 | 2.54 | 2.43 | 35.30 | 4.03 | 2.19 | 47.15 | 2.26 | 2.17 |
| #4 | 25.31 | 3.08 | 2.23 | 33.39 | 3.80 | 1.71 | 44.09 | 2.60 | 2.16 |
| #5 | 22.39 | 1.94 | 2.44 | 30.78 | 2.82 | 2.20 | 41.74 | 2.17 | 2.58 |
| #6 | 22.15 | 2.99 | 2.20 | 31.75 | 5.11 | 1.80 | 38.03 | 2.67 | 1.99 |
| #7 | 24.34 | 1.75 | 1.90 | 36.73 | 2.82 | 1.72 | 45.22 | 2.51 | 1.58 |
| #8 | 26.46 | 2.54 | 1.78 | 39.82 | 4.29 | 1.52 | 48.84 | 3.22 | 1.66 |
| #9 | 23.85 | 1.28 | 1.74 | 34.20 | 2.81 | 1.54 | 42.39 | 1.59 | 1.79 |
| #10 | 27.62 | 2.19 | 1.33 | 41.78 | 3.80 | 1.38 | 51.58 | 2.87 | 1.28 |
| #11 | 24.78 | 1.86 | 1.37 | 32.74 | 3.08 | 1.38 | 43.07 | 2.49 | 1.31 |
| #12 | 23.22 | 2.04 | 1.66 | 30.94 | 2.45 | 1.52 | 40.88 | 1.80 | 1.36 |
| #13 | 28.99 | 1.60 | 1.38 | 34.61 | 1.59 | 1.37 | 46.18 | 1.29 | 1.56 |
| #14 | 22.65 | 3.55 | 1.67 | 29.94 | 4.09 | 1.56 | 37.19 | 3.09 | 1.52 |

Table 3-D

**Base Yield and Yield Trend for All Crop Districts in Manitoba (1977-86)**

| | Wheat | | | Barley | | | Oats | | |
|---|---|---|---|---|---|---|---|---|---|
| Manitoba | Base yield (1971) | Yield, trend | Durbin, Watson | Base yield (1971) | Yield, trend | Durbin, Watson | Base yield (1971) | Yield, trend | Durbin, Watson |
| #1 | 20.57 | 2.96 | 1.70 | 32.40 | 3.34 | 1.62 | 37.12 | 2.85 | 1.61 |
| #2 | 22.76 | 2.32 | 1.45 | 37.67 | 2.10 | 1.37 | 42.18 | 1.77 | 1.43 |
| #3 | 25.87 | 1.69 | 1.65 | 44.57 | 1.03 | 1.71 | 50.40 | 0.77 | 1.79 |
| #4 | 24.00 | 2.02 | 1.93 | 35.60 | 1.91 | 1.79 | 46.50 | 1.01 | 1.82 |
| #5 | 26.69 | 1.21 | 2.04 | 36.55 | 1.69 | 1.86 | 42.22 | 1.77 | 2.00 |
| #6 | 22.83 | 2.27 | 1.78 | 31.43 | 3.12 | 1.86 | 41.77 | 2.01 | 1.32 |
| #7 | 21.95 | 3.18 | 2.04 | 34.84 | 3.32 | 2.04 | 37.38 | 3.69 | 1.97 |
| #8 | 21.33 | 3.84 | 2.09 | 34.10 | 4.14 | 2.25 | 38.10 | 4.07 | 1.99 |
| #9 | 20.25 | 3.87 | 2.16 | 28.95 | 4.84 | 2.30 | 36.20 | 3.86 | 2.19 |
| #10 | 26.03 | 0.37 | 1.81 | 44.49 | -0.74 | 1.90 | 41.32 | 1.56 | 2.37 |
| #11 | 26.20 | 1.47 | 2.23 | 34.45 | 2.80 | 2.62 | 38.57 | 3.14 | 2.20 |
| #12 | 28.46 | 0.03 | 1.78 | 34.95 | 1.36 | 1.95 | 44.05 | 1.30 | 1.77 |

Table 4-A

Correlation Coefficients of Wheat Yields in Alberta (1961-86)

| | Correlation coefficients | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Crop district | 1 | 2 | 3 | 4a | 4b | 5 | 6 | 7 |
| #1 | 1.00 | 0.92 | 0.81 | 0.66 | 0.38 | 0.64 | 0.59 | 0.35 |
| #2 | | 1.00 | 0.93 | 0.55 | 0.20 | 0.58 | 0.45 | 0.20 |
| #3 | | | 1.00 | 0.52 | 0.18 | 0.46 | 0.32 | 0.13 |
| #4a | | | | 1.00 | 0.80 | 0.71 | 0.61 | 0.18 |
| #4b | | | | | 1.00 | 0.76 | 0.74 | 0.35 |
| #5 | | | | | | 1.00 | 0.84 | 0.47 |
| #6 | | | | | | | 1.00 | 0.64 |
| #7 | | | | | | | | 1.00 |

Table 4-B

Correlation Coefficients of Barley Yields in Alberta (1961-86)

| | Correlation coefficients | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Crop district | 1 | 2 | 3 | 4a | 4b | 5 | 6 | 7 |
| #1 | 1.00 | 0.93 | 0.75 | 0.64 | 0.51 | 0.62 | 0.58 | 0.40 |
| #2 | | 1.00 | 0.50 | 0.30 | 0.37 | 0.22 | 0.29 | 0.43 |
| #3 | | | 1.00 | 0.50 | 0.30 | 0.37 | 0.22 | 0.12 |
| #4a | | | | 1.00 | 0.87 | 0.77 | 0.64 | 0.41 |
| #4b | | | | | 1.00 | 0.88 | 0.78 | 0.47 |
| #5 | | | | | | 1.00 | 0.90 | 0.57 |
| #6 | | | | | | | 1.00 | 0.62 |
| #7 | | | | | | | | 1.00 |

Table 4-C

Correlation Coefficients of Oat Yields in Alberta (1961-86)

| Crop district | Correlation coefficients | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4a | 4b | 5 | 6 | 7 |
| #1 | 1.00 | 0.87 | 0.76 | 0.74 | 0.71 | 0.54 | 0.54 | 0.33 |
| #2 | | 1.00 | 0.90 | 0.59 | 0.35 | 0.61 | 0.42 | 0.21 |
| #3 | | | 1.00 | 0.53 | 0.34 | 0.50 | 0.29 | 0.09 |
| #4a | | | | 1.00 | 0.86 | 0.80 | 0.66 | 0.41 |
| #4b | | | | | 1.00 | 0.87 | 0.73 | 0.45 |
| #5 | | | | | | 1.00 | 0.85 | 0.51 |
| #6 | | | | | | | 1.00 | 0.69 |
| #7 | | | | | | | | 1.00 |

Table 5-A

Correlation Coefficients of Wheat Yields in Saskatchewan (1961-86)

| Crop district | Correlation coefficients | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1a | 1b | 2a | 2b | 3as | 3an | 3bs | 3bn | 4a | 4b | 5a | 5b | 6a | 6b | 7a | 7b | 8a | 8b | 9a | 9b |
| #1a | 1.00 | 0.90 | 0.89 | 0.86 | 0.79 | 0.73 | 0.60 | 0.56 | 0.51 | 0.44 | 0.80 | 0.67 | 0.72 | 0.55 | 0.56 | 0.48 | 0.50 | 0.48 | 0.46 | 0.33 |
| #1b | | 1.00 | 0.84 | 0.87 | 0.69 | 0.67 | 0.53 | 0.55 | 0.40 | 0.35 | 0.91 | 0.77 | 0.79 | 0.58 | 0.54 | 0.48 | 0.65 | 0.56 | 0.53 | 0.31 |
| #2a | | | 1.00 | 0.92 | 0.88 | 0.83 | 0.69 | 0.64 | 0.56 | 0.44 | 0.72 | 0.55 | 0.71 | 0.54 | 0.59 | 0.49 | 0.37 | 0.39 | 0.34 | 0.32 |
| #2b | | | | 1.00 | 0.83 | 0.82 | 0.67 | 0.70 | 0.56 | 0.48 | 0.82 | 0.69 | 0.84 | 0.66 | 0.68 | 0.59 | 0.54 | 0.58 | 0.51 | 0.47 |
| #3as | | | | | 1.00 | 0.94 | 0.87 | 0.78 | 0.73 | 0.64 | 0.61 | 0.47 | 0.71 | 0.59 | 0.69 | 0.55 | 0.33 | 0.46 | 0.41 | 0.40 |
| #3an | | | | | | 1.00 | 0.94 | 0.89 | 0.77 | 0.76 | 0.65 | 0.55 | 0.83 | 0.75 | 0.82 | 0.71 | 0.41 | 0.60 | 0.58 | 0.54 |
| #3bs | | | | | | | 1.00 | 0.93 | 0.89 | 0.88 | 0.51 | 0.44 | 0.71 | 0.73 | 0.86 | 0.75 | 0.31 | 0.50 | 0.54 | 0.45 |
| #3bn | | | | | | | | 1.00 | 0.84 | 0.88 | 0.58 | 0.50 | 0.83 | 0.87 | 0.94 | 0.84 | 0.45 | 0.66 | 0.74 | 0.64 |
| #4a | | | | | | | | | 1.00 | 0.90 | 0.38 | 0.31 | 0.58 | 0.66 | 0.84 | 0.75 | 0.18 | 0.39 | 0.46 | 0.40 |
| #4b | | | | | | | | | | 1.00 | 0.40 | 0.38 | 0.66 | 0.81 | 0.91 | 0.82 | 0.25 | 0.55 | 0.63 | 0.48 |
| #5a | | | | | | | | | | | 1.00 | 0.93 | 0.86 | 0.67 | 0.58 | 0.53 | 0.77 | 0.74 | 0.66 | 0.36 |
| #5b | | | | | | | | | | | | 1.00 | 0.79 | 0.62 | 0.50 | 0.50 | 0.83 | 0.78 | 0.66 | 0.32 |
| #6a | | | | | | | | | | | | | 1.00 | 0.90 | 0.83 | 0.77 | 0.71 | 0.88 | 0.83 | 0.63 |
| #6b | | | | | | | | | | | | | | 1.00 | 0.91 | 0.85 | 0.56 | 0.85 | 0.85 | 0.63 |
| #7a | | | | | | | | | | | | | | | 1.00 | 0.92 | 0.41 | 0.68 | 0.77 | 0.69 |
| #7b | | | | | | | | | | | | | | | | 1.00 | 0.50 | 0.66 | 0.82 | 0.79 |
| #8a | | | | | | | | | | | | | | | | | 1.00 | 0.77 | 0.71 | 0.46 |
| #8b | | | | | | | | | | | | | | | | | | 1.00 | 0.87 | 0.57 |
| #9a | | | | | | | | | | | | | | | | | | | 1.00 | 0.76 |
| #9b | | | | | | | | | | | | | | | | | | | | 1.00 |

Table 5-8

Correlation Coefficients of Barley Yields in Saskatchewan (1961-86)

| Crop district | Correlation coefficients | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1a | 1b | 2a | 2b | 3aa | 3an | 3ba | 3bn | 4a | 4b | 5a | 5b | 6a | 6b | 7a | 7b | 8a | 8b | 9a | 9b |
| #1a | 1.00 | 0.94 | 0.89 | 0.92 | 0.79 | 0.75 | 0.61 | 0.62 | 0.54 | 0.57 | 0.88 | 0.74 | 0.78 | 0.68 | 0.69 | 0.63 | 0.53 | 0.62 | 0.58 | 0.56 |
| #1b | | 1.00 | 0.89 | 0.91 | 0.77 | 0.75 | 0.61 | 0.64 | 0.52 | 0.56 | 0.92 | 0.74 | 0.80 | 0.70 | 0.66 | 0.63 | 0.54 | 0.63 | 0.60 | 0.54 |
| #2a | | | 1.00 | 0.94 | 0.88 | 0.85 | 0.72 | 0.69 | 0.60 | 0.58 | 0.77 | 0.57 | 0.74 | 0.62 | 0.64 | 0.64 | 0.32 | 0.45 | 0.43 | 0.48 |
| #2b | | | | 1.00 | 0.90 | 0.90 | 0.74 | 0.78 | 0.66 | 0.68 | 0.86 | 0.71 | 0.87 | 0.74 | 0.78 | 0.75 | 0.52 | 0.65 | 0.61 | 0.63 |
| #3aa | | | | | 1.00 | 0.93 | 0.88 | 0.82 | 0.81 | 0.74 | 0.68 | 0.50 | 0.75 | 0.66 | 0.76 | 0.67 | 0.30 | 0.50 | 0.48 | 0.55 |
| #3an | | | | | | 1.00 | 0.89 | 0.89 | 0.74 | 0.80 | 0.69 | 0.53 | 0.83 | 0.75 | 0.80 | 0.76 | 0.36 | 0.54 | 0.55 | 0.61 |
| #3ba | | | | | | | 1.00 | 0.93 | 0.86 | 0.88 | 0.58 | 0.42 | 0.71 | 0.72 | 0.81 | 0.72 | 0.29 | 0.47 | 0.51 | 0.50 |
| #3bn | | | | | | | | 1.00 | 0.79 | 0.92 | 0.65 | 0.50 | 0.83 | 0.85 | 0.92 | 0.85 | 0.46 | 0.62 | 0.68 | 0.69 |
| #4a | | | | | | | | | 1.00 | 0.85 | 0.46 | 0.35 | 0.60 | 0.63 | 0.80 | 0.69 | 0.22 | 0.44 | 0.44 | 0.46 |
| #4b | | | | | | | | | | 1.00 | 0.57 | 0.50 | 0.76 | 0.82 | 0.91 | 0.83 | 0.45 | 0.62 | 0.66 | 0.61 |
| #5a | | | | | | | | | | | 1.00 | 0.91 | 0.87 | 0.75 | 0.66 | 0.64 | 0.74 | 0.77 | 0.72 | 0.54 |
| #5b | | | | | | | | | | | | 1.00 | 0.80 | 0.68 | 0.57 | 0.60 | 0.85 | 0.81 | 0.73 | 0.51 |
| #6a | | | | | | | | | | | | | 1.00 | 0.91 | 0.84 | 0.85 | 0.72 | 0.86 | 0.82 | 0.75 |
| #6b | | | | | | | | | | | | | | 1.00 | 0.90 | 0.90 | 0.66 | 0.86 | 0.86 | 0.80 |
| #7a | | | | | | | | | | | | | | | 1.00 | 0.92 | 0.53 | 0.72 | 0.78 | 0.82 |
| #7b | | | | | | | | | | | | | | | | 1.00 | 0.61 | 0.72 | 0.84 | 0.86 |
| #8a | | | | | | | | | | | | | | | | | 1.00 | 0.86 | 0.82 | 0.59 |
| #8b | | | | | | | | | | | | | | | | | | 1.00 | 0.89 | 0.73 |
| #9a | | | | | | | | | | | | | | | | | | | 1.00 | 0.83 |
| #9b | | | | | | | | | | | | | | | | | | | | 1.00 |

Table 5-C

Correlation Coefficients of Oat Yields in Saskatchewan (1961-86)

| Crop district | Correlation coefficients | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1a | 1b | 2a | 2b | 3as | 3an | 3bs | 3bn | 4a | 4b | 5a | 5b | 6a | 6b | 7a | 7b | 8a | 8b | 9a | 9b |
| #1a | 1.00 | 0.91 | 0.90 | 0.87 | 0.81 | 0.75 | 0.65 | 0.59 | 0.64 | 0.53 | 0.78 | 0.68 | 0.69 | 0.57 | 0.59 | 0.50 | 0.46 | 0.55 | 0.46 | 0.54 |
| #1b | | 1.00 | 0.88 | 0.88 | 0.75 | 0.77 | 0.68 | 0.63 | 0.65 | 0.53 | 0.87 | 0.73 | 0.78 | 0.63 | 0.62 | 0.54 | 0.55 | 0.63 | 0.53 | 0.53 |
| #2a | | | 1.00 | 0.91 | 0.89 | 0.84 | 0.76 | 0.71 | 0.70 | 0.56 | 0.74 | 0.55 | 0.73 | 0.58 | 0.63 | 0.53 | 0.40 | 0.48 | 0.41 | 0.47 |
| #2b | | | | 1.00 | 0.84 | 0.86 | 0.79 | 0.77 | 0.66 | 0.67 | 0.83 | 0.70 | 0.85 | 0.69 | 0.77 | 0.67 | 0.58 | 0.65 | 0.57 | 0.65 |
| #3as | | | | | 1.00 | 0.90 | 0.88 | 0.80 | 0.76 | 0.73 | 0.66 | 0.51 | 0.73 | 0.60 | 0.69 | 0.53 | 0.36 | 0.50 | 0.44 | 0.50 |
| #3an | | | | | | 1.00 | 0.93 | 0.90 | 0.79 | 0.83 | 0.72 | 0.59 | 0.84 | 0.77 | 0.87 | 0.74 | 0.46 | 0.61 | 0.61 | 0.61 |
| #3bs | | | | | | | 1.00 | 0.90 | 0.80 | 0.86 | 0.63 | 0.56 | 0.78 | 0.68 | 0.83 | 0.72 | 0.40 | 0.57 | 0.57 | 0.60 |
| #3bn | | | | | | | | 1.00 | 0.77 | 0.92 | 0.66 | 0.57 | 0.82 | 0.85 | 0.91 | 0.83 | 0.50 | 0.66 | 0.71 | 0.65 |
| #4a | | | | | | | | | 1.00 | 0.78 | 0.57 | 0.48 | 0.68 | 0.65 | 0.71 | 0.62 | 0.30 | 0.50 | 0.55 | 0.53 |
| #4b | | | | | | | | | | 1.00 | 0.57 | 0.59 | 0.76 | 0.82 | 0.90 | 0.81 | 0.46 | 0.65 | 0.70 | 0.69 |
| #5a | | | | | | | | | | | 1.00 | 0.91 | 0.89 | 0.72 | 0.63 | 0.61 | 0.82 | 0.81 | 0.72 | 0.56 |
| #5b | | | | | | | | | | | | 1.00 | 0.80 | 0.71 | 0.59 | 0.60 | 0.87 | 0.84 | 0.73 | 0.58 |
| #6a | | | | | | | | | | | | | 1.00 | 0.88 | 0.83 | 0.80 | 0.75 | 0.88 | 0.83 | 0.71 |
| #6b | | | | | | | | | | | | | | 1.00 | 0.88 | 0.89 | 0.67 | 0.85 | 0.85 | 0.71 |
| #7a | | | | | | | | | | | | | | | 1.00 | 0.92 | 0.53 | 0.69 | 0.77 | 0.79 |
| #7b | | | | | | | | | | | | | | | | 1.00 | 0.60 | 0.73 | 0.85 | 0.82 |
| #8a | | | | | | | | | | | | | | | | | 1.00 | 0.86 | 0.79 | 0.56 |
| #8b | | | | | | | | | | | | | | | | | | 1.00 | 0.88 | 0.70 |
| #9a | | | | | | | | | | | | | | | | | | | 1.00 | 0.81 |
| #9b | | | | | | | | | | | | | | | | | | | | 1.00 |

Table 6-A

**Correlation Coefficients of Wheat Yields in Manitoba (1961-76)**

| | Correlation coefficients | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crop district | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| #1 | 1.00 | 0.88 | 0.52 | 0.55 | 0.41 | 0.61 | 0.92 | 0.86 | 0.74 | 0.75 | 0.79 | 0.70 | 0.76 | 0.85 |
| #2 | | 1.00 | 0.75 | 0.81 | 0.66 | 0.84 | 0.83 | 0.96 | 0.90 | 0.71 | 0.76 | 0.88 | 0.77 | 0.88 |
| #3 | | | 1.00 | 0.95 | 0.94 | 0.93 | 0.51 | 0.81 | 0.64 | 0.42 | 0.41 | 0.67 | 0.44 | 0.60 |
| #4 | | | | 1.00 | 0.89 | 0.91 | 0.51 | 0.84 | 0.71 | 0.44 | 0.44 | 0.77 | 0.50 | 0.62 |
| #5 | | | | | 1.00 | 0.90 | 0.35 | 0.69 | 0.57 | 0.23 | 0.27 | 0.69 | 0.28 | 0.53 |
| #6 | | | | | | 1.00 | 0.58 | 0.83 | 0.72 | 0.45 | 0.52 | 0.84 | 0.49 | 0.72 |
| #7 | | | | | | | 1.00 | 0.87 | 0.76 | 0.89 | 0.89 | 0.83 | 0.51 | 0.51 |
| #8 | | | | | | | | 1.00 | 0.88 | 0.80 | 0.78 | 0.81 | 0.83 | 0.85 |
| #9 | | | | | | | | | 1.00 | 0.71 | 0.74 | 0.79 | 0.78 | 0.88 |
| #10 | | | | | | | | | | 1.00 | 0.90 | 0.50 | 0.96 | 0.69 |
| #11 | | | | | | | | | | | 1.00 | 0.68 | 0.93 | 0.78 |
| #12 | | | | | | | | | | | | 1.00 | 0.61 | 0.78 |
| #13 | | | | | | | | | | | | | 1.00 | 0.78 |
| #14 | | | | | | | | | | | | | | 1.00 |

Table 6-8

Correlation Coefficients of Barley Yields in Manitoba (1961-76)

| | Correlation coefficients | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crop district | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| #1 | 1.00 | 0.93 | 0.66 | 0.54 | 0.55 | 0.75 | 0.98 | 0.91 | 0.83 | 0.84 | 0.85 | 0.70 | 0.76 | 0.85 |
| #2 | | 1.00 | 0.81 | 0.75 | 0.73 | 0.86 | 0.93 | 0.97 | 0.91 | 0.81 | 0.87 | 0.84 | 0.80 | 0.87 |
| #3 | | | 1.00 | 0.91 | 0.93 | 0.90 | 0.73 | 0.84 | 0.72 | 0.63 | 0.61 | 0.65 | 0.52 | 0.59 |
| #4 | | | | 1.00 | 0.90 | 0.83 | 0.58 | 0.77 | 0.75 | 0.53 | 0.54 | 0.73 | 0.53 | 0.55 |
| #5 | | | | | 1.00 | 0.89 | 0.62 | 0.75 | 0.66 | 0.52 | 0.52 | 0.69 | 0.52 | 0.46 |
| #6 | | | | | | 1.00 | 0.80 | 0.88 | 0.76 | 0.66 | 0.66 | 0.77 | 0.59 | 0.67 |
| #7 | | | | | | | 1.00 | 0.94 | 0.84 | 0.90 | 0.89 | 0.73 | 0.80 | 0.86 |
| #8 | | | | | | | | 1.00 | 0.92 | 0.87 | 0.84 | 0.80 | 0.78 | 0.87 |
| #9 | | | | | | | | | 1.00 | 0.83 | 0.88 | 0.84 | 0.85 | 0.90 |
| #10 | | | | | | | | | | 1.00 | 0.90 | 0.63 | 0.88 | 0.77 |
| #11 | | | | | | | | | | | 1.00 | 0.78 | 0.93 | 0.84 |
| #12 | | | | | | | | | | | | 1.00 | 0.78 | 0.79 |
| #13 | | | | | | | | | | | | | 1.00 | 0.75 |
| #14 | | | | | | | | | | | | | | 1.00 |

Table 6-C

**Correlation Coefficients of Oat Yields in Manitoba (1961-76)**

| Crop district | Correlation coefficients | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| #1 | 1.00 | 0.93 | 0.66 | 0.56 | 0.64 | 0.61 | 0.93 | 0.91 | 0.91 | 0.82 | 0.77 | 0.74 | 0.72 | 0.80 |
| #2 | | 1.00 | 0.84 | 0.73 | 0.79 | 0.77 | 0.87 | 0.97 | 0.93 | 0.80 | 0.80 | 0.82 | 0.80 | 0.86 |
| #3 | | | 1.00 | 0.92 | 0.93 | 0.86 | 0.69 | 0.83 | 0.71 | 0.58 | 0.63 | 0.70 | 0.63 | 0.63 |
| #4 | | | | 1.00 | 0.88 | 0.82 | 0.57 | 0.73 | 0.64 | 0.47 | 0.50 | 0.70 | 0.49 | 0.55 |
| #5 | | | | | 1.00 | 0.84 | 0.65 | 0.82 | 0.66 | 0.51 | 0.52 | 0.69 | 0.55 | 0.60 |
| #6 | | | | | | 1.00 | 0.67 | 0.73 | 0.63 | 0.54 | 0.59 | 0.68 | 0.50 | 0.53 |
| #7 | | | | | | | 1.00 | 0.89 | 0.83 | 0.89 | 0.79 | 0.64 | 0.72 | 0.67 |
| #8 | | | | | | | | 1.00 | 0.91 | 0.84 | 0.80 | 0.79 | 0.82 | 0.88 |
| #9 | | | | | | | | | 1.00 | 0.79 | 0.78 | 0.74 | 0.73 | 0.89 |
| #10 | | | | | | | | | | 1.00 | 0.80 | 0.53 | 0.83 | 0.68 |
| #11 | | | | | | | | | | | 1.00 | 0.76 | 0.90 | 0.79 |
| #12 | | | | | | | | | | | | 1.00 | 0.70 | 0.79 |
| #13 | | | | | | | | | | | | | 1.00 | 0.77 |
| #14 | | | | | | | | | | | | | | 1.00 |

Table 7-A

**Correlation Coefficients of Wheat Yields in Manitoba (1977-86)**

| | Correlation coefficients | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crop district | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| #1 | 1.00 | 0.97 | 0.93 | 0.76 | 0.93 | 0.89 | 0.95 | 0.90 | 0.83 | 0.85 | 0.83 | 0.63 |
| #2 | | 1.00 | 0.94 | 0.74 | 0.88 | 0.83 | 0.90 | 0.83 | 0.74 | 0.84 | 0.77 | 0.62 |
| #3 | | | 1.00 | 0.83 | 0.86 | 0.84 | 0.77 | 0.72 | 0.72 | 0.85 | 0.62 | 0.54 |
| #4 | | | | 1.00 | 0.74 | 0.90 | 0.61 | 0.61 | 0.66 | 0.85 | 0.55 | 0.61 |
| #5 | | | | | 1.00 | 0.91 | 0.85 | 0.80 | 0.79 | 0.93 | 0.84 | 0.74 |
| #6 | | | | | | 1.00 | 0.84 | 0.83 | 0.89 | 0.90 | 0.84 | 0.73 |
| #7 | | | | | | | 1.00 | 0.97 | 0.85 | 0.72 | 0.90 | 0.61 |
| #8 | | | | | | | | 1.00 | 0.89 | 0.68 | 0.85 | 0.55 |
| #9 | | | | | | | | | 1.00 | 0.67 | 0.80 | 0.49 |
| #10 | | | | | | | | | | 1.00 | 0.77 | 0.83 |
| #11 | | | | | | | | | | | 1.00 | 0.81 |
| #12 | | | | | | | | | | | | 1.00 |

Table 7-8

**Correlation Coefficients of Barley Yields in Manitoba (1977-86)**

| | Correlation coefficients | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crop district | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| #1 | 1.00 | 0.95 | 0.80 | 0.59 | 0.90 | 0.83 | 0.91 | 0.86 | 0.75 | 0.60 | 0.69 | 0.62 |
| #2 | | 1.00 | 0.88 | 0.61 | 0.87 | 0.77 | 0.80 | 0.72 | 0.61 | -0.66 | 0.59 | 0.63 |
| #3 | | | 1.00 | 0.80 | 0.85 | 0.72 | 0.52 | 0.42 | 0.46 | 0.63 | 0.30 | 0.51 |
| #4 | | | | 1.00 | 0.71 | 0.79 | 0.39 | 0.30 | 0.51 | 0.61 | 0.27 | 0.54 |
| #5 | | | | | 1.00 | 0.89 | 0.81 | 0.74 | 0.73 | 0.67 | 0.77 | 0.05 |
| #6 | | | | | | 1.00 | 0.82 | 0.76 | 0.88 | 0.68 | 0.78 | 0.81 |
| #7 | | | | | | | 1.00 | 0.97 | 0.85 | 0.53 | 0.90 | 0.72 |
| #8 | | | | | | | | 1.00 | 0.88 | 0.40 | 0.84 | 0.63 |
| #9 | | | | | | | | | 1.00 | 0.33 | 0.81 | 0.66 |
| #10 | | | | | | | | | | 1.00 | 0.53 | 0.69 |
| #11 | | | | | | | | | | | 1.00 | 0.83 |
| #12 | | | | | | | | | | | | 1.00 |

Table 7-C

**Correlation Coefficients of Oat Yields in Manitoba (1977-86)**

| Crop district | Correlation coefficients | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| #1 | 1.00 | 0.91 | 0.83 | 0.63 | 0.95 | 0.94 | 0.92 | 0.91 | 0.78 | 0.59 | 0.83 | 0.67 |
| #2 | | 1.00 | 0.91 | 0.65 | 0.78 | 0.84 | 0.78 | 0.75 | 0.60 | 0.36 | 0.71 | 0.62 |
| #3 | | | 1.00 | 0.80 | 0.71 | 0.77 | 0.59 | 0.58 | 0.48 | 0.34 | 0.49 | 0.41 |
| #4 | | | | 1.00 | 0.55 | 0.71 | 0.40 | 0.41 | 0.39 | 0.41 | 0.30 | 0.39 |
| #5 | | | | | 1.00 | 0.91 | 0.91 | 0.94 | 0.84 | 0.79 | 0.88 | 0.74 |
| #6 | | | | | | 1.00 | 0.86 | 0.86 | 0.82 | 0.71 | 0.86 | 0.77 |
| #7 | | | | | | | 1.00 | 0.99 | 0.88 | 0.63 | 0.92 | 0.77 |
| #8 | | | | | | | | 1.00 | 0.92 | 0.71 | 0.92 | 0.75 |
| #9 | | | | | | | | | 1.00 | 0.77 | 0.89 | 0.72 |
| #10 | | | | | | | | | | 1.00 | 0.74 | 0.75 |
| #11 | | | | | | | | | | | 1.00 | 0.88 |
| #12 | | | | | | | | | | | | 1.00 |

Table 8

**Weatherstations Corresponding to Consolidated Districts**

| | |
|---|---|
| Alberta | |
| # 1 | Medicine Hat |
| # 2 | (Brooks & Lethbridge)/2 |
| # 3 | Calgary |
| # 4 | Red Deer |
| # 5 | Calgary |
| # 6 | Ellerslie |
| # 7 | Beaverlodge |
| Saskatchewan | |
| # 1 | (Carlyle & Estevan)/2 |
| # 2 | Regina |
| # 3 | (Swift Current A & Swift CurrentB)/2 |
| # 4 | (Medicine Hat & (Swift Current A & Swift current B)/2)/2 |
| # 5 | Yorkton |
| # 6 | Saskatoon |
| # 7 | Kinderley |
| # 8 | (Melfort & Hudson Bay)/2 |
| # 9 | Prince Albert |
| Manitoba | |
| # 1&2&3 | Morden |
| # 4 | (Dauphin & Yorkton)/2 |
| # 5&6 | Morden |
| # 7&8&9&11 | Morden |
| # 10 | Morden |
| # 12 | Morden |

Table 9

**Base Yield Weather Effect, Yield Trend and Coefficient of Determination for All Provinces Consolidated Crop Districts**

| | Wheat | | | | Barley | | | | Oats | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Base yield (1971) | Weather effect (GRODEX) | Yield trend | | Base yield (1971) | Weather effect (GRODEX) | Yield trend | | Base yield (1971) | Weather effect (GRODEX) | Yield trend | |
| | bu/ac | Per cent | Per cent | $R^2$ | bu/ac | Per cent | Per cent | $R^2$ | bu/ac | Per cent | Per cent | $R^2$ |
| Alberta | 25.9** | 5.07 | 1.52** | 0.68 | 38.9** | 0.33 | 1.80** | 0.78 | 50.9** | 0.26 | 1.42** | 0.64 |
| #1 | 18.0 | 1.04** | 3.16** | 0.64 | 30.0** | 1.01** | 2.99** | 0.61 | 35.2** | 0.85** | 1.84* | 0.47 |
| #2 | 28.5 | 0.49** | 1.53** | 0.58 | 45.6** | 0.45** | 1.45** | 0.57 | 55.2** | 0.43** | 0.98* | 0.48 |
| #3 | 27.5 | 0.63** | 0.42 | 0.39 | 43.8** | 0.61** | -0.01 | 0.36 | 54.3** | 0.57 | 0.07 | 0.38 |
| #4 | 26.8 | 0.18+ | 1.37** | 0.45 | 36.9** | 0.18 | 2.04** | 0.51 | 47.9 | 0.21+ | 1.59** | 0.42 |
| #5 | 32.1 | 0.14+ | 1.74** | 0.72 | 40.3 | 0.19* | 2.44** | 0.80 | 57.9 | 0.15+ | 1.61** | 0.66 |
| #6 | 25.2 | -0.06 | 2.14** | 0.70 | 33.7 | -0.11 | 2.74** | 0.80 | 47.9 | 0.09 | 2.34** | 0.79 |
| #7 | 23.8 | 0.23 | 2.01** | 0.36 | 31.8 | 0.20 | 1.94** | 0.40 | 45.1 | 0.23 | 1.90** | 0.40 |
| Saskatchewan | 23.1 | 0.84** | 1.03* | 0.66 | 35.9 | 0.89** | 1.63** | 0.69 | 44.3 | 1.03** | 0.71 | 0.67 |
| #1 | 22.2 | 0.60** | 1.51+ | 0.35 | 32.5 | 0.82** | 2.00+ | 0.37 | 41.7 | 0.93** | 1.09 | 0.42 |
| #2 | 23.3 | 0.47** | 0.62 | 0.38 | 35.2 | 0.59** | 0.93 | 0.40 | 41.3 | 0.69** | 0.56 | 0.43 |
| #3 | 19.9 | 0.70** | 2.40 | 0.50 | 30.6 | 0.75** | 2.30* | 0.45 | 36.9 | 0.81** | 2.22* | 0.43 |
| #4 | 18.5 | 0.67+ | 2.05* | 0.29 | 29.4 | 0.69+ | 1.80+ | 0.25 | 36.9 | 0.77+ | 1.10 | 0.18 |
| #5 | 25.5 | 0.88** | 0.29 | 0.64 | 37.3 | 1.02** | 0.56 | 0.68 | 46.0 | 1.29** | -0.06 | 0.71 |
| #6 | 22.4 | 0.63** | 2.03** | 0.69 | 33.1 | 0.82** | 2.31** | 0.68 | 40.8 | 0.98** | 1.97 | 0.72 |
| #7 | 24.5 | 0.41* | 1.23* | 0.45 | 36.6 | 0.51** | 1.39* | 0.47 | 45.1 | 0.53* | 0.93 | 0.36 |
| #8 | 26.6 | 0.45** | 0.64 | 0.61 | 36.9 | 0.62** | 1.38* | 0.72 | 47.5 | 0.74** | 0.52 | 0.67 |
| #9 | 25.5 | 0.35** | 1.06* | 0.66 | 37.3 | 0.41** | 1.38** | 0.67 | 46.5 | 0.33** | 1.05* | 0.52 |
| Manitoba | 25.1** | 0.51 | 1.66** | 0.61 | 36.1** | 0.58 | 2.57** | 0.72 | 45.2** | 0.67 | 1.32** | 0.62 |
| (recent districts) | | | | | | | | | | | | |
| #1+2+3 | 22.4 | 0.54+ | 2.41 | 0.52 | 40.0 | 0.43 | 1.49 | 0.38 | 46.5 | 0.40 | 0.68 | 0.29 |
| #4 | 20.9 | 0.93+ | 2.44 | 0.53 | 33.4 | 0.93+ | 1.45 | 0.49 | 44.7 | 0.99** | 0.29 | 0.74 |
| #5+6 | 22.6 | 0.46+ | 2.56 | 0.54 | 33.4 | 0.45+ | 2.52 | 0.48 | 41.7 | 0.38+ | 1.88 | 0.50 |
| #7+8+9+11 | 19.5 | 0.58* | 4.46* | 0.78 | 30.6 | 0.58* | 4.81* | 0.80 | 36.6 | 0.53* | 3.88* | 0.75 |
| #10 | 25.3 | 0.34+ | 0.63 | 0.46 | 42.9 | 0.33 | -0.39 | 0.34 | 37.7 | 0.39 | 2.54 | 0.45 |
| #12 | 28.2 | 0.42* | -0.06 | 0.58 | 35.9 | 0.43+ | 0.94 | 0.42 | 45.1 | 0.35+ | 0.85 | 0.45 |
| Manitoba (previous districts) | | | | | | | | | | | | |
| #1+7 | 23.6 | 0.46** | 1.06 | 0.46 | 35.5 | 0.53* | 1.91 | 0.49 | 43.8 | 0.65* | 1.63 | 0.42 |
| #2+8+9+14 | 24.8 | 0.28 | 1.35 | 0.29 | 35.9 | 0.45 | 2.56 | 0.45 | 43.8 | 0.58+ | 0.89 | 0.35 |
| #3+4+5+6 | 24.0 | 0.18 | 2.33+ | 0.34 | 34.1 | 0.18 | 3.70** | 0.49 | 45.1 | 0.20+ | 2.24* | 0.42 |
| #10+11+13 | 27.7 | 0.65* | -0.39 | 0.56 | 38.9 | 0.62** | 0.74 | 0.57 | 48.9 | 0.80** | -0.52 | 0.50 |
| #12 | 23.1 | 0.53* | 1.06 | 0.29 | 30.6 | 0.46 | 1.61 | 0.25 | 40.4 | 0.60* | 0.70 | 0.36 |

**Tests at 1 per cent significance level.
*Tests at 5 per cent level.
+Tests at 10 per cent level.

Table 10

Indices of Weather Effect and of Yield Variability for Alberta, Saskatchewan and Manitoba (1961-84)

| | Provinces | | | | | |
|---|---|---|---|---|---|---|
| | Alberta | | Saskatchewan | | Manitoba | |
| Year | W1 | W2 | W1 | W2 | W1 | W2 |
| 1961 | 0.92 | 0.76 | 0.54 | 0.40 | 0.70 | 0.53 |
| 1962 | 0.96 | 0.91 | 0.99 | 0.40 | 1.17 | 1.22 |
| 1963 | 1.04 | 1.08 | 1.15 | 1.29 | 1.05 | 0.90 |
| 1964 | 0.98 | 0.94 | 0.86 | 0.84 | 0.93 | 1.11 |
| 1965 | 1.08 | 1.03 | 1.10 | 1.01 | 0.94 | 1.10 |
| 1966 | 1.09 | 1.18 | 1.11 | 1.25 | 1.06 | 1.03 |
| 1967 | 0.94 | 0.91 | 0.73 | 0.77 | 0.91 | 1.06 |
| 1968 | 0.95 | 1.03 | 0.94 | 0.88 | 1.09 | 1.13 |
| 1969 | 0.89 | 1.05 | 0.79 | 1.19 | 0.81 | 1.04 |
| 1970 | 1.01 | 1.10 | 1.24 | 1.17 | 0.99 | 0.93 |
| 1971 | 0.98 | 1.02 | 1.04 | 1.19 | 1.08 | 1.21 |
| 1972 | 1.01 | 1.09 | 0.94 | 1.02 | 0.97 | 1.06 |
| 1973 | 0.98 | 1.00 | 1.02 | 1.03 | 1.03 | 1.01 |
| 1974 | 1.00 | 0.90 | 1.17 | 0.87 | 0.96 | 0.78 |
| 1975 | 1.02 | 1.04 | 1.22 | 1.04 | 1.12 | 0.92 |
| 1976 | 1.08 | 1.11 | 1.13 | 1.26 | 0.99 | 1.00 |
| 1977 | 0.97 | 0.98 | 0.96 | 1.17 | 1.06 | 1.15 |
| 1978 | 1.14 | 1.02 | 1.16 | 1.16 | 1.14 | 1.10 |
| 1979 | 0.98 | 1.00 | 0.98 | 0.87 | 1.04 | 0.88 |
| 1980 | 1.01 | 1.11 | 0.90 | 0.91 | 0.88 | 0.75 |
| 1981 | 1.11 | 1.10 | 0.87 | 1.04 | 0.86 | 1.03 |
| 1982 | 1.07 | 1.05 | 1.19 | 1.18 | 1.03 | 1.13 |
| 1983 | 0.97 | 1.01 | 1.06 | 1.02 | 0.99 | 0.88 |
| 1984 | 0.80 | 0.81 | 0.82 | 0.80 | 0.95 | 0.99 |
| 1985 | 0.91 | 0.78 | 1.02 | 0.89 | 1.12 | 1.25 |

W1 Index of weather effect based on GRODEX.

W2 Index of total yield variability.

Figure 1

Outline Map of the Prairie Provinces
Showing Crop District Boundaries

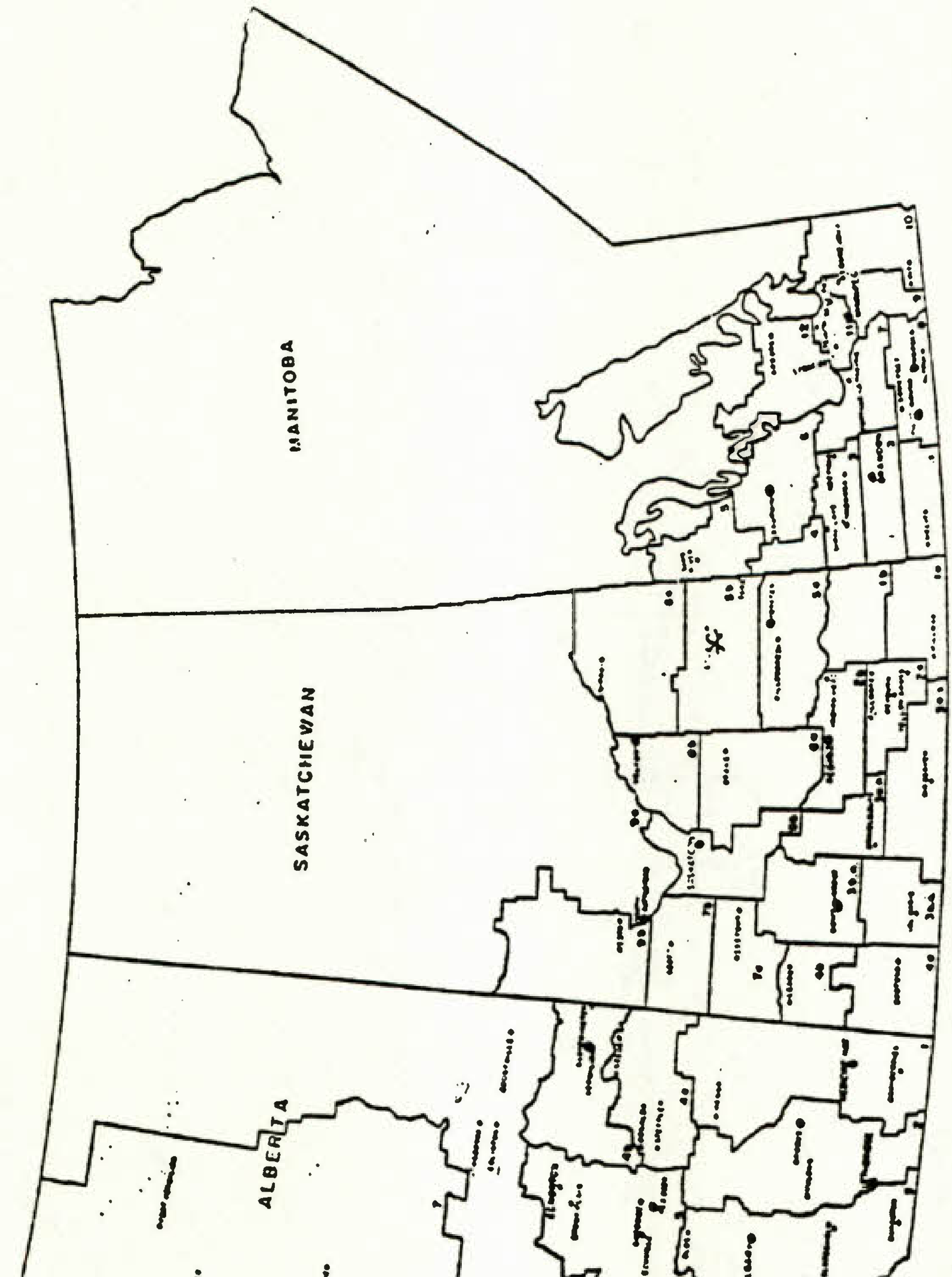


Figure 2

Outline Map of the Prairie Provinces
Showing Crop District Boundaries
Prior to 1977

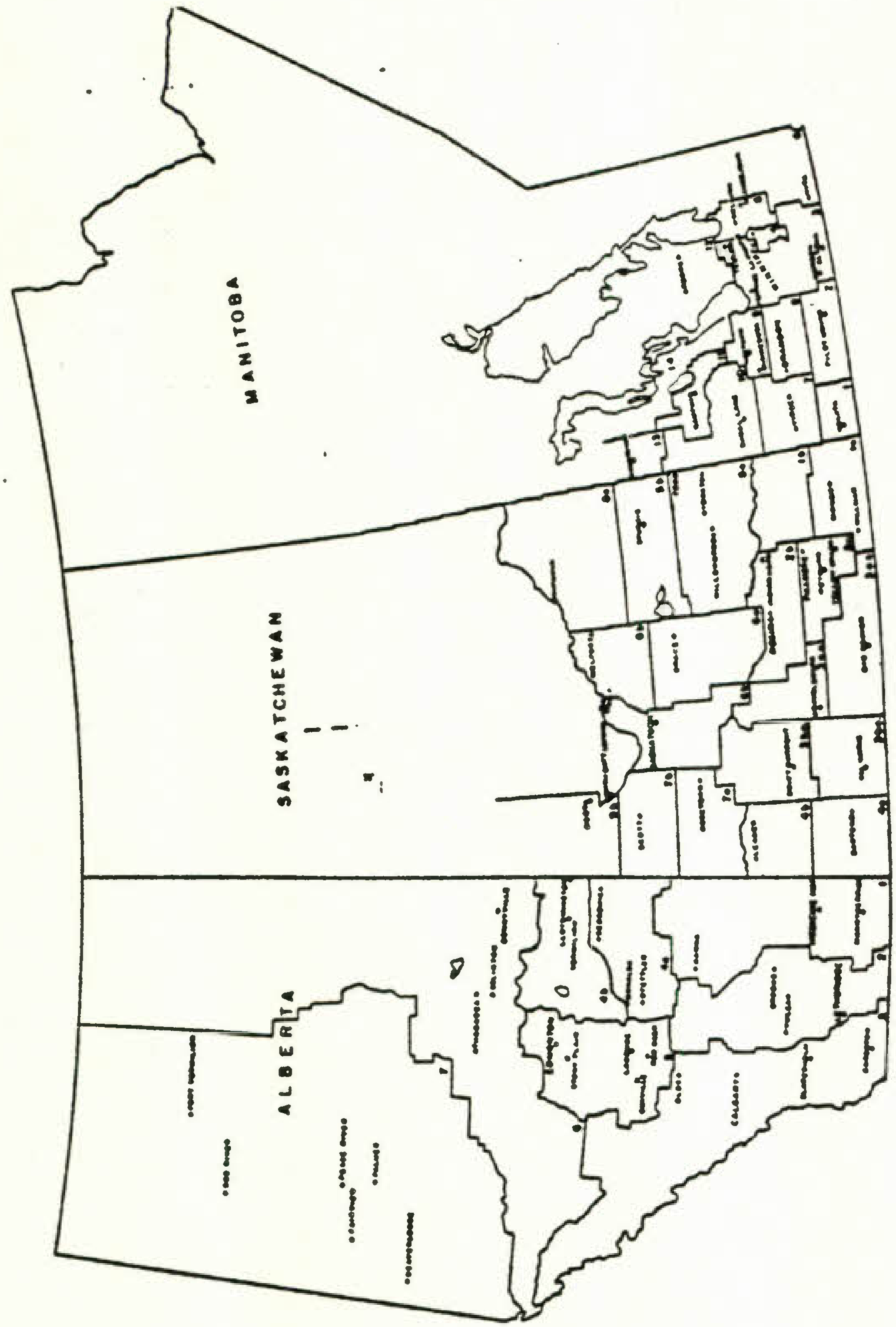


Figure 3

Outline Map of the Prairie Provinces
Showing Soil Zone Boundaries

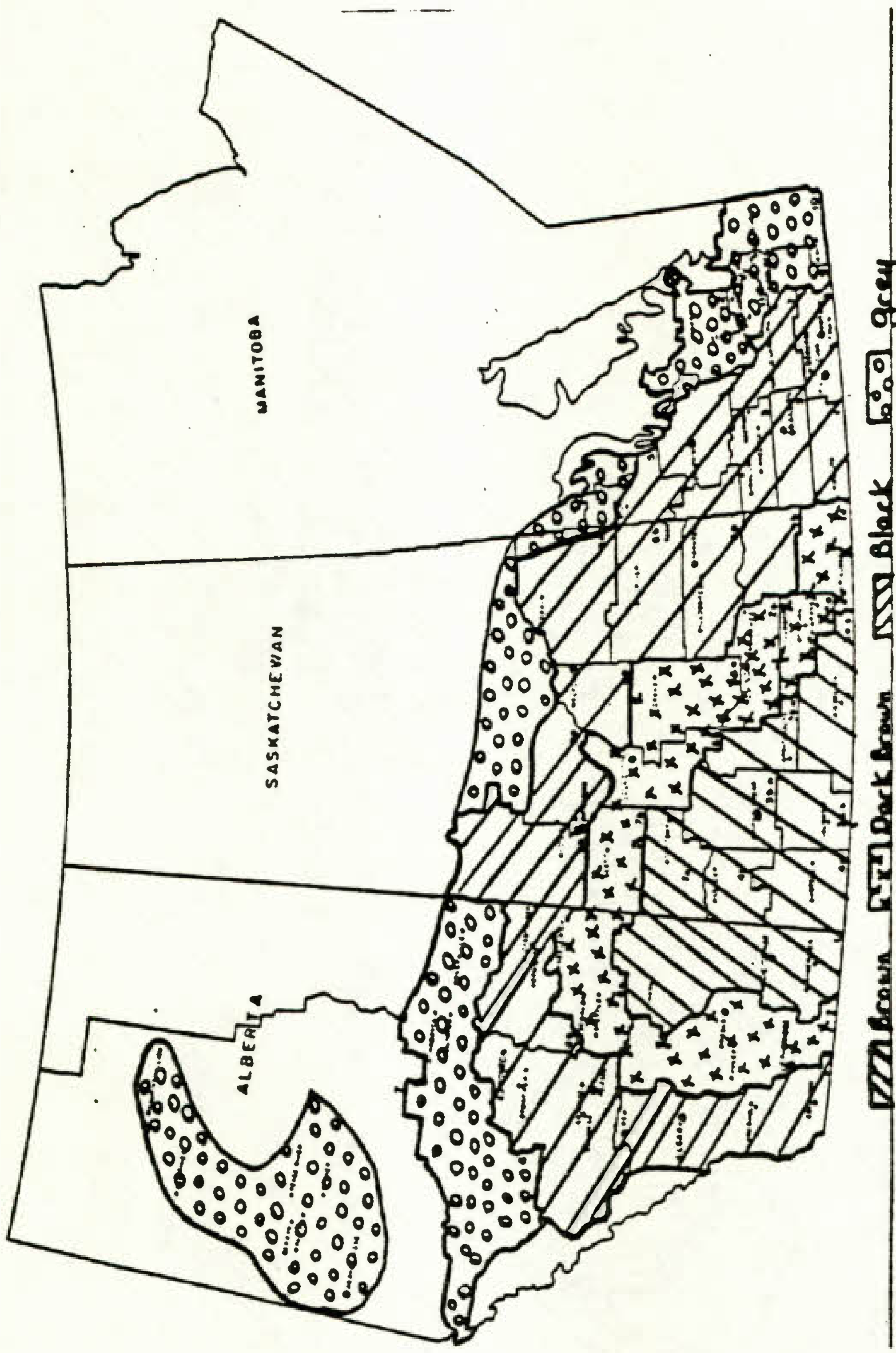


Figure 4-A

Outline Map of the Prairie Provinces
Showing Consolidated Crop District and
Adjusted Soil Zone Boundaries

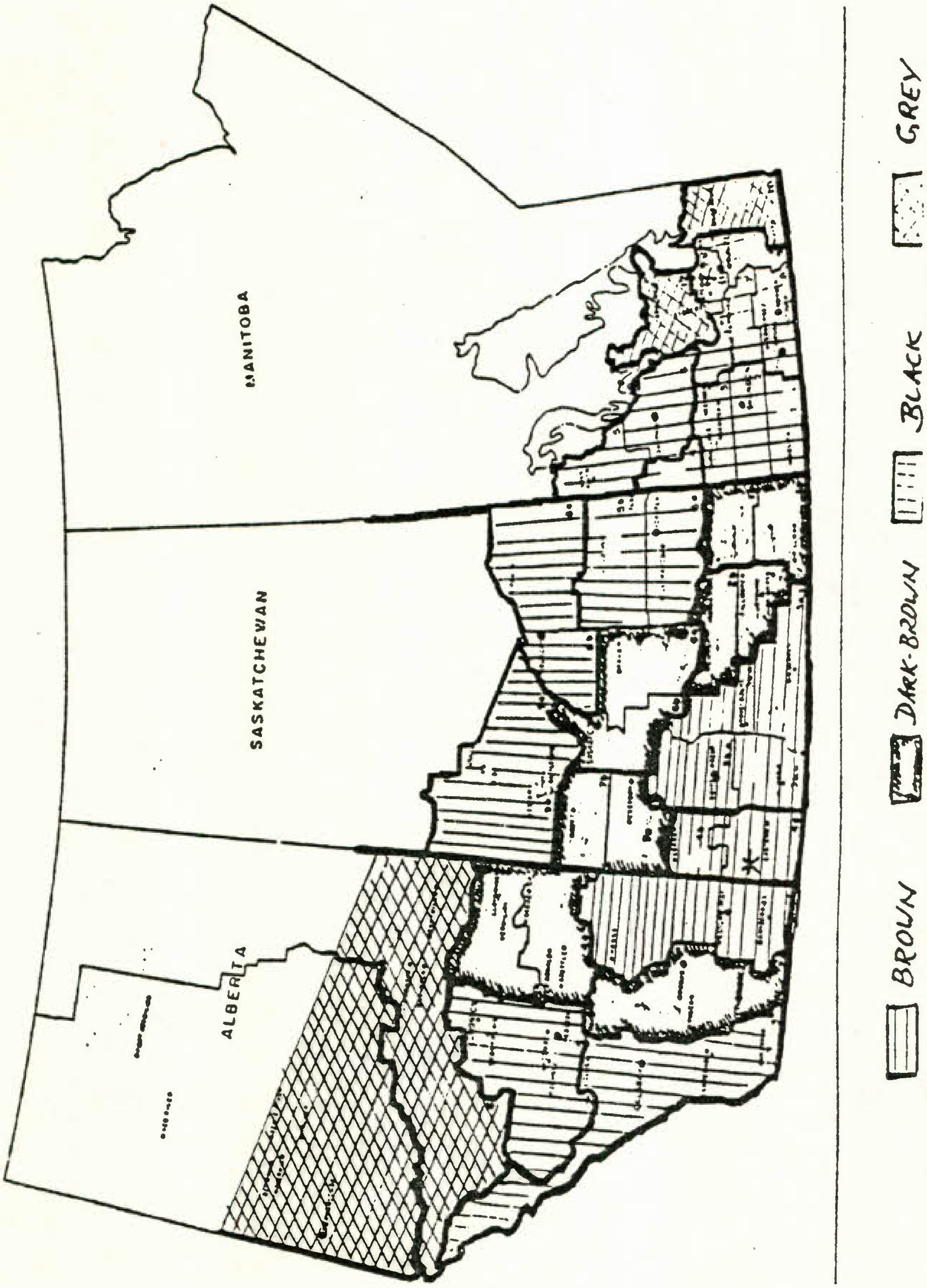


Figure 4-B

Outline Map of the Prairie Provinces Showing Consolidated Crop District Boundaries in Manitoba Prior to 1977

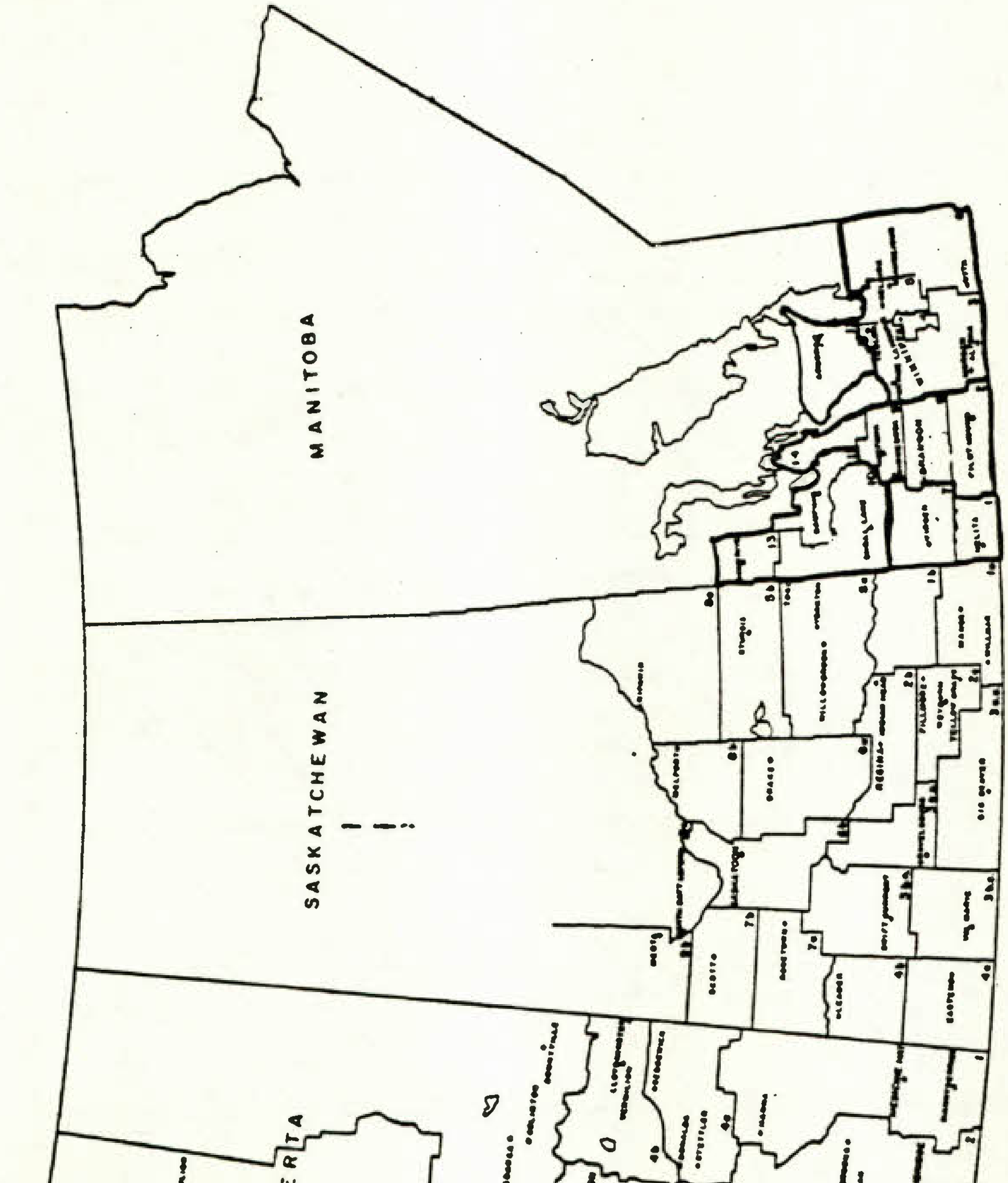
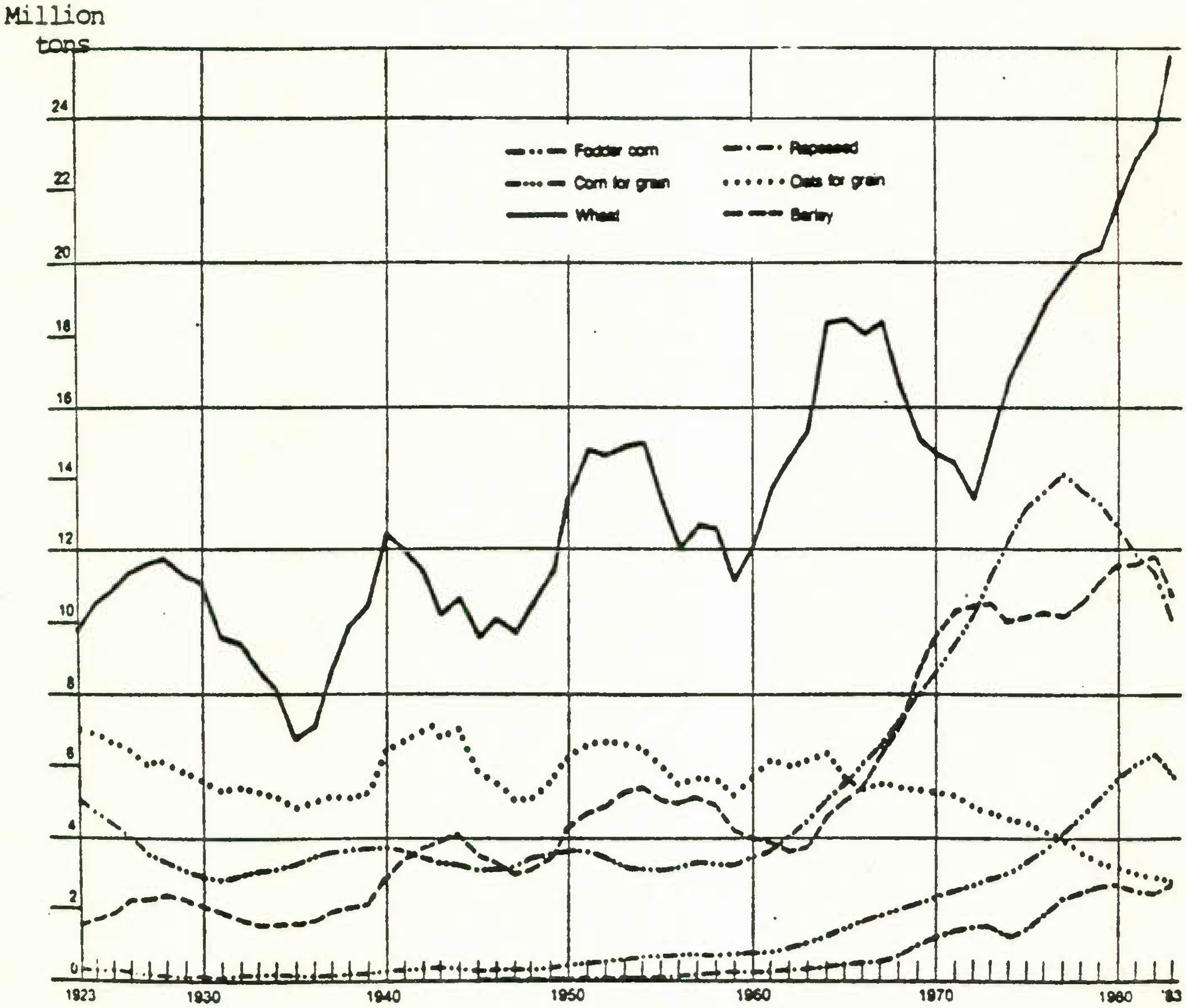


Chart 1

Production of Selected Major Field Crops in Canada, 1923 to 1983




*Source: Based on data from Statistics Canada.*

Chart 2

Production of Wheat in Alberta,
1908 to 1986

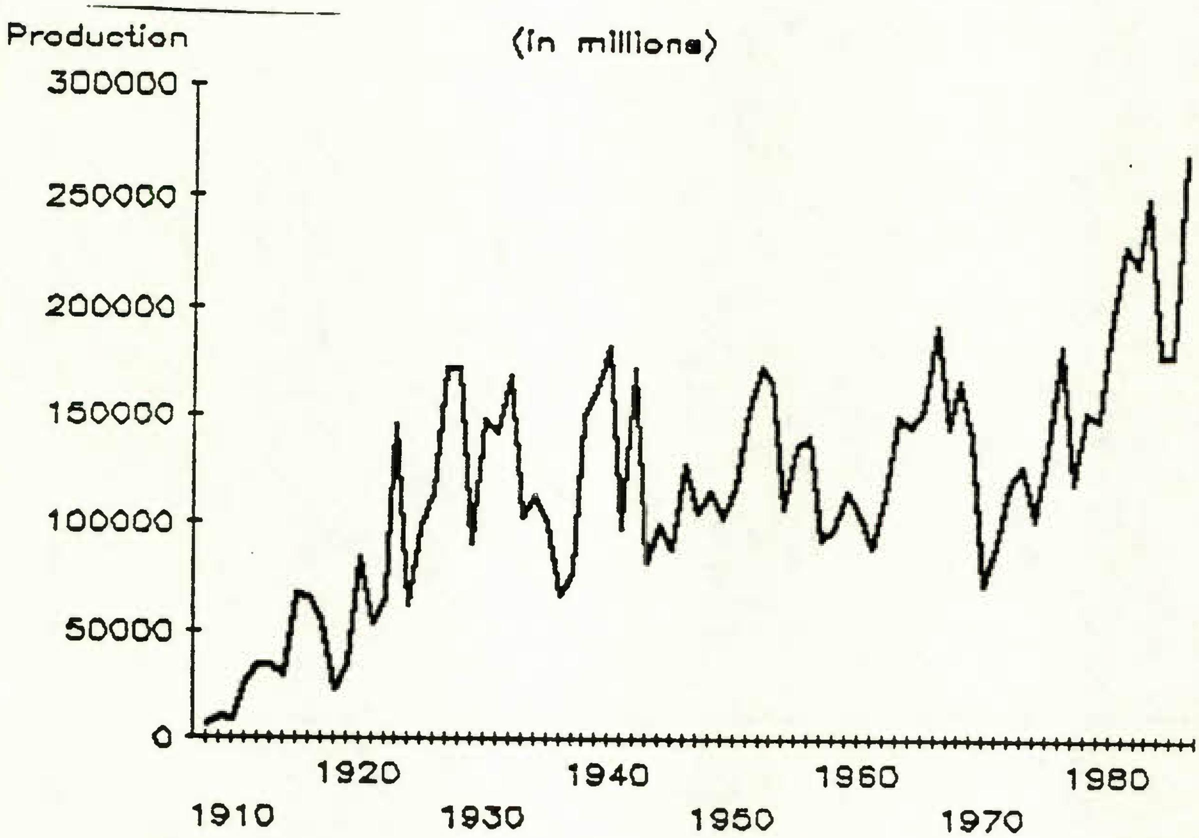


Chart 3

Production of Wheat in Saskatchewan,
1908 to 1986

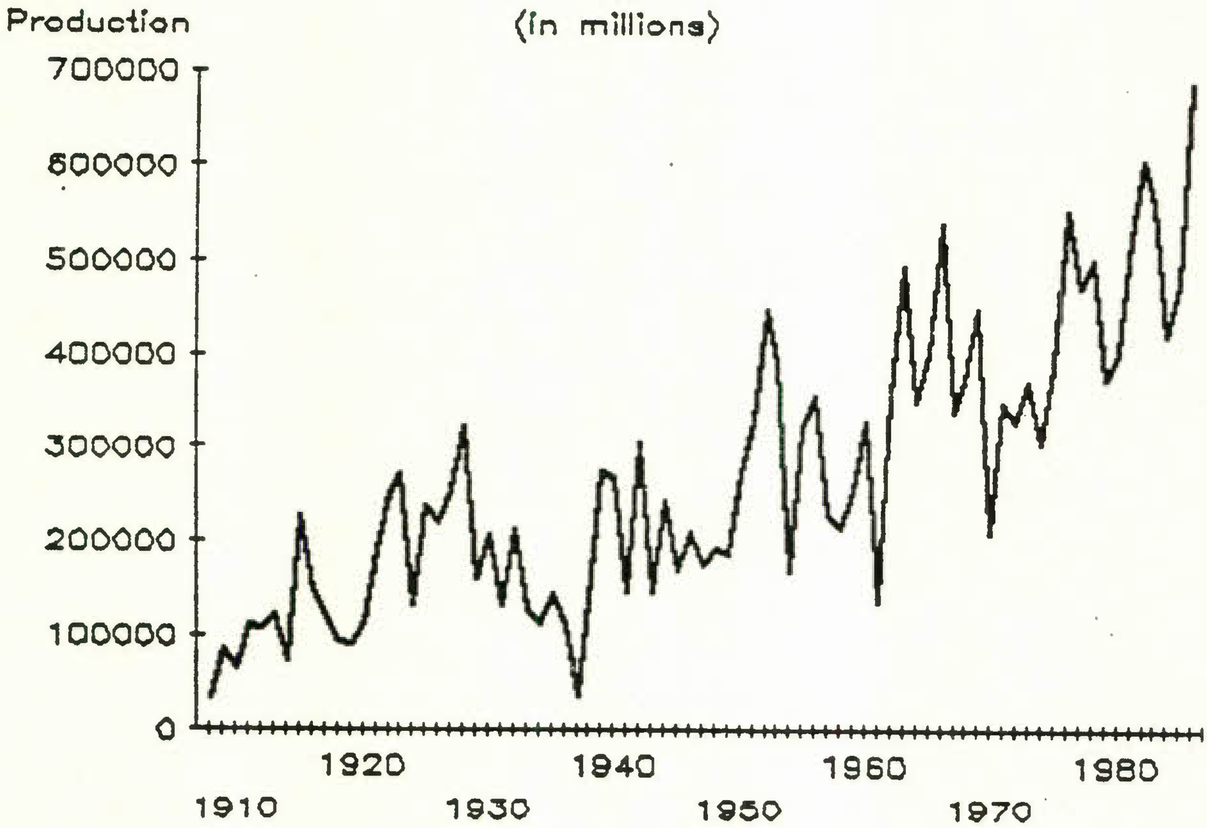


Chart 4

Production of Wheat in Manitoba,
1908 to 1986

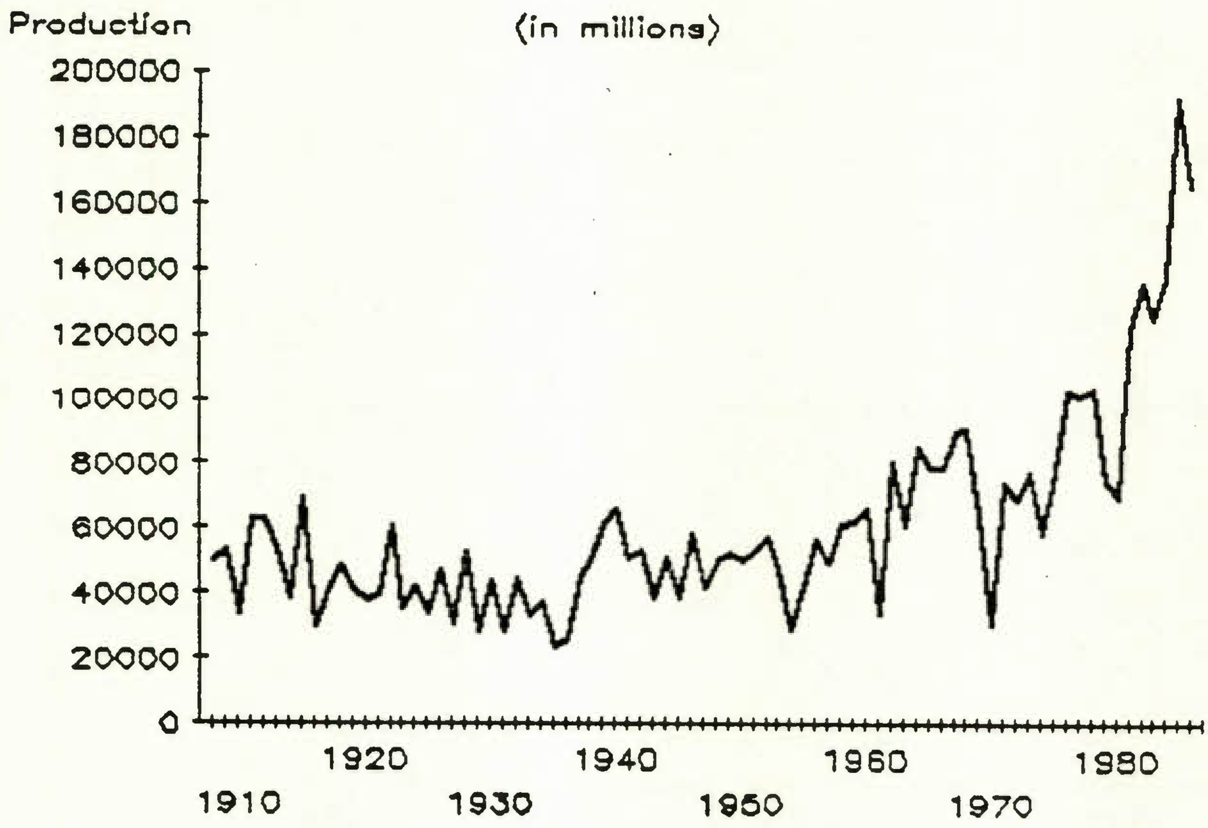


Chart 5

Variability of Wheat Yields in Alberta,
1908-86

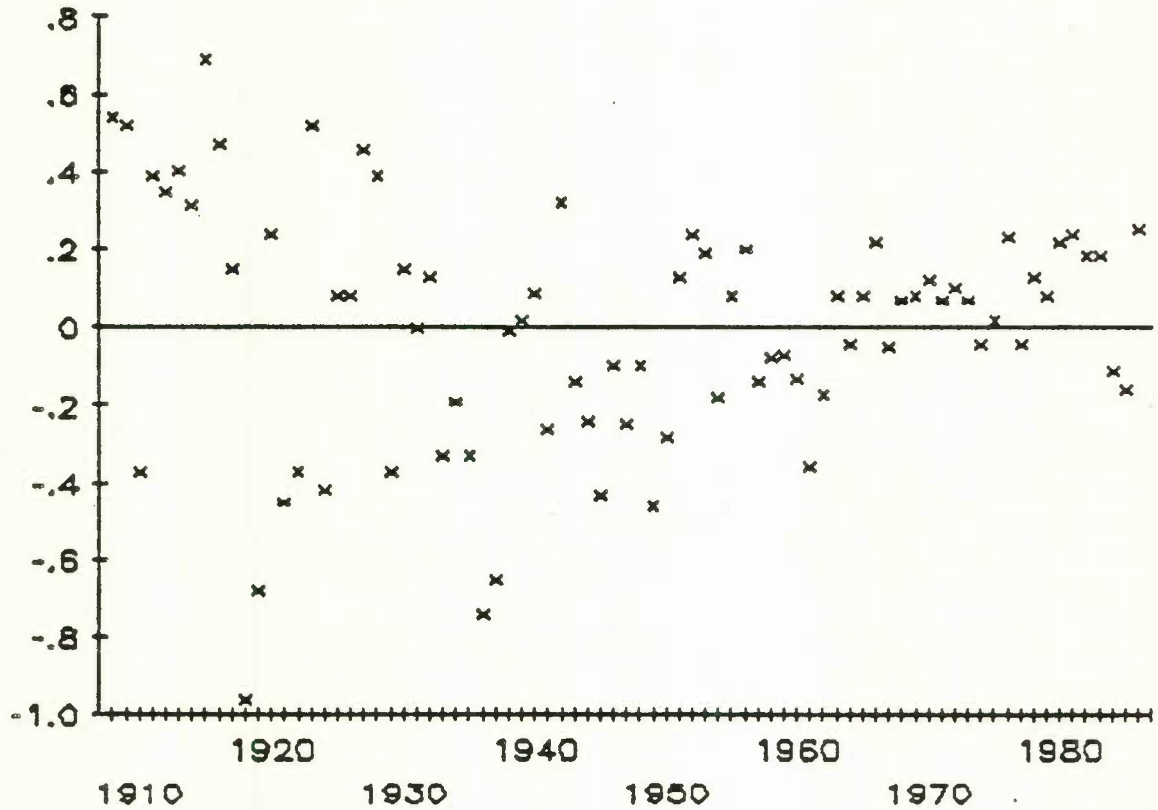


Chart 6

Variability of Wheat Yields in Saskatchewan, 1908-86

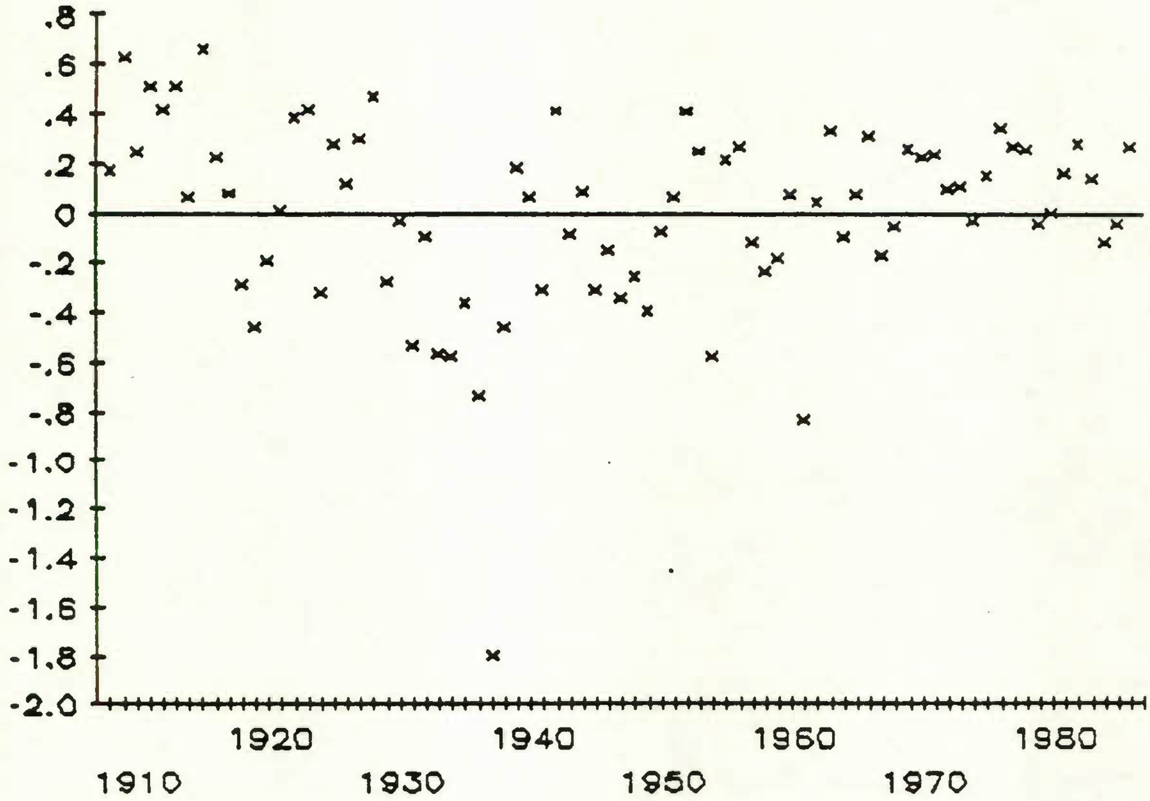
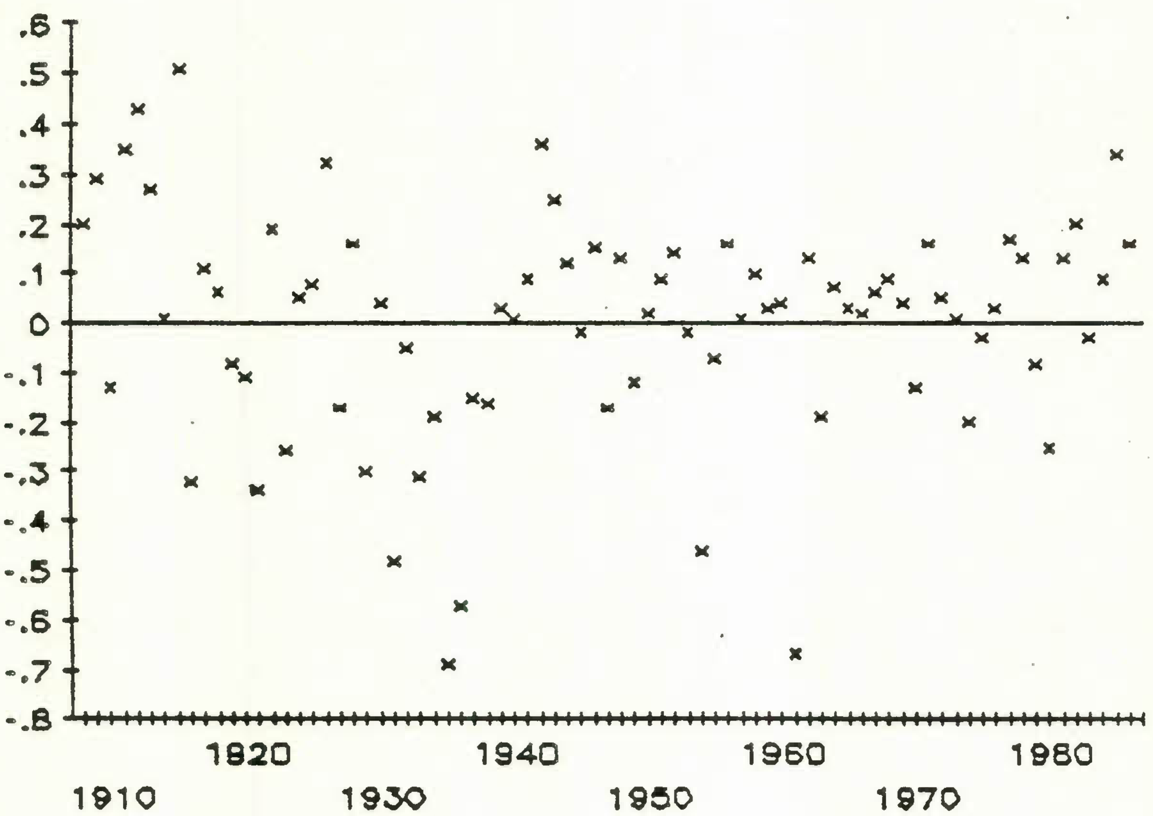


Chart 7

Variability of Wheat Yields in
Manitoba, 1908-86



## APPENDIX A

### Contribution of Components of Value of Wheat Production to Its Variability

The actual value of wheat production differs frequently from what the trend line of value of wheat production would suggest. These deviations from the trend comprise the variability of production value and are represented by the error term or residual u in the equation:

$$V_t = e^{\alpha+\beta\tau} + u_t$$

where $V_t$ represents the value of production in year t.

Yet value of production is simply the factor of price, yield and acreage such that $V_t = P_t Y_t A_t$. Thus, to estimate the share of each of these components in the overall variability, we must fit restricted least-square trends to them so as to obtain three sets of residuals $u_p$, $u_y$ and $u_a$. The contribution of each component to overall instability can then be calculated annually and added over the years. In other words, the percentage contribution $C_i$ of the $i^{th}$ component to the variability of the aggregate over a period of years t, is defined as:

$$C_i = \sum_t c_{it} = \sum_t \left\{ \frac{|u_{it}| \phi_{it}}{\sum_t \left| \sum_i u_{it} \right|} \right\} 100$$

$$\text{where } \phi_{it} = \left( \frac{u_{it}}{|u_{it}|} \right) \left( \frac{\sum_i u_{it}}{\left| \sum_i u_{it} \right|} \right)$$

and where $c_{it}$ is the contribution of the $i^{th}$ component in year t to aggregate variability overall years, $u_{it}$ is the residual of the $i^{th}$ component in year t and $\phi_{it}$ is either 1 or -1 and changes the sign of the residual if it differs from that of the sum of deviations in year t.

As Appendix Table 1 illustrates, the share of each component differs depending upon the length of the time series involved. The contribution of yield variability to total variability is lesser over the 1961 to 1984 time period than over the 1908 to 1984 time period, falling from 16.5, 32.1, and 7.7 in Manitoba, Saskatchewan and Alberta over the long run to 6.7, 12.9, and 2.3 over the short run, respectively.

## APPENDIX A

### Table 1

The Contribution of Price, Acreage and Yield to the Variability of the Value of Wheat Production

| | Long Run (1908-84) | | | Short Run (1961-84) | | |
|---|---|---|---|---|---|---|
| | Price | Acreage | Yield | Price | Acreage | Yield |
| | | | (Per cent) | | | |
| Manitoba | 64.19 | 19.25 | 16.56 | 57.55 | 35.77 | 6.68 |
| Saskatchewan | 60.41 | 7.48 | 32.11 | 42.46 | 44.67 | 12.87 |
| Alberta | 57.20 | 35.04 | 7.76 | 37.98 | 59.66 | 2.36 |

## APPENDIX B

### Aggregation of Crop Districts in Saskatchewan

Although crop districts in Saskatchewan were aggregated by "single-digit" crop districts (i.e., districts sharing the same first digit were lumped together), other arrangements might have been preferable. As shown in Table 5, not all districts sharing the same first digit have yield trends which correlate better than an 'r' value of 0.8. Specifically, the pairs of Districts 3as/3bn, 8a/8b, and 9a/9b fail to meet this first criterion. However, the difference is not a substantial one as all three paris of trends do correlate better than an 'r' value of 0.76 with each other, for each crop studied.

Nor do all single digit crop districts meet the second criterion established in Section 3, namely that there should be no significant difference of yield levels between crop districts. The one exception to this rule is consolidated District 2, in which the difference between Districts 2a and 2b tests significantly at the 1 per cent level.

APPENDIX C

INDICES OF WEATHER EFFECTS (W1) AND OF
YIELD VARIABILITY (W2) FOR ALL PROVINCES AND
CONSOLIDATED CROP DISTRICTS

Table 1

Alberta Provincial Total

| Year | W1 | W2 |
|---|---|---|
| | (Current $) | |
| 1961 | 0.92 | 0.76 |
| 1962 | 0.96 | 0.91 |
| 1963 | 1.04 | 1.08 |
| 1964 | 0.98 | 0.94 |
| 1965 | 1.08 | 1.03 |
| 1966 | 1.09 | 1.18 |
| 1967 | 0.94 | 0.91 |
| 1968 | 0.95 | 1.03 |
| 1969 | 0.89 | 1.05 |
| 1970 | 1.01 | 1.10 |
| 1971 | 0.98 | 1.02 |
| 1972 | 1.01 | 1.09 |
| 1973 | 0.98 | 1.00 |
| 1974 | 1.00 | 0.90 |
| 1975 | 1.02 | 1.04 |
| 1976 | 1.08 | 1.11 |
| 1977 | 0.97 | 0.98 |
| 1978 | 1.14 | 1.02 |
| 1979 | 0.98 | 1.00 |
| 1980 | 1.01 | 1.11 |
| 1981 | 1.11 | 1.10 |
| 1982 | 1.07 | 1.05 |
| 1983 | 0.97 | 1.01 |
| 1984 | 0.80 | 0.81 |
| 1985 | 0.91 | 0.78 |

W1 Index of weather effect based on GRODEX.
W2 Index of yield variability.

**Table 2**

**Alberta Consolidated Crop Districts**

| Year | Crop District 1 | | Crop District 2 | |
|---|---|---|---|---|
| | W1 | W2 | W1 | W2 |
| | (Current $) | | | |
| 1961 | 0.57 | 0.26 | 0.72 | 0.54 |
| 1962 | 0.68 | 0.50 | 0.86 | 0.70 |
| 1963 | 1.21 | 1.09 | 1.10 | 1.04 |
| 1964 | 0.71 | 0.91 | 0.99 | 1.06 |
| 1965 | 1.41 | 1.32 | 1.10 | 1.15 |
| 1966 | 1.20 | 1.59 | 1.22 | 1.37 |
| 1967 | 0.98 | 0.96 | 1.15 | 0.91 |
| 1968 | 0.90 | 1.32 | 0.91 | 1.21 |
| 1969 | 0.83 | 1.24 | 0.96 | 1.16 |
| 1970 | 1.10 | 1.33 | 0.95 | 1.08 |
| 1971 | 0.78 | 1.08 | 0.95 | 1.03 |
| 1972 | 0.84 | 1.00 | 0.87 | 1.10 |
| 1973 | 0.77 | 1.11 | 0.88 | 0.97 |
| 1974 | 1.12 | 0.97 | 0.94 | 0.91 |
| 1975 | 1.51 | 1.25 | 1.28 | 1.10 |
| 1976 | 1.05 | 1.32 | 1.04 | 1.05 |
| 1977 | 0.92 | 0.76 | 0.85 | 0.82 |
| 1978 | 1.46 | 1.07 | 1.37 | 1.08 |
| 1979 | 1.15 | 0.98 | 0.89 | 0.87 |
| 1980 | 1.02 | 1.04 | 0.95 | 1.10 |
| 1981 | 1.09 | 1.16 | 1.16 | 1.25 |
| 1982 | 1.42 | 1.12 | 0.98 | 1.05 |
| 1983 | 0.88 | 1.11 | 0.93 | 1.00 |
| 1984 | 0.67 | 0.63 | 0.78 | 0.66 |
| 1985 | n.a. | 0.58 | n.a. | 0.70 |

W1 Index of weather effect based on GRODEX.
W2 Index of yield variability.

Table 3

Alberta Consolidated Crop

| Year | Crop District 3 W1 | Crop District 3 W2 | Crop District 4 W1 | Crop District 4 W2 |
|---|---|---|---|---|
| | (Current $) | | | |
| 1961 | 0.99 | 0.62 | 0.98 | 0.86 |
| 1962 | 0.85 | 0.76 | 1.01 | 1.13 |
| 1963 | 1.10 | 1.10 | 1.02 | 1.36 |
| 1964 | 0.96 | 0.94 | 0.95 | 0.79 |
| 1965 | 0.97 | 1.05 | 1.05 | 0.99 |
| 1966 | 1.19 | 1.19 | 1.03 | 0.96 |
| 1967 | 0.81 | 0.84 | 0.97 | 0.95 |
| 1968 | 0.87 | 1.14 | 0.96 | 0.80 |
| 1969 | 0.91 | 1.11 | 0.93 | 1.00 |
| 1970 | 0.96 | 1.09 | 1.04 | 1.17 |
| 1971 | 1.00 | 1.00 | 0.99 | 1.08 |
| 1972 | 1.12 | 1.14 | 1.00 | 1.09 |
| 1973 | 0.96 | 0.97 | 1.05 | 1.04 |
| 1974 | 0.94 | 1.00 | 0.99 | 0.82 |
| 1975 | 0.97 | 1.02 | 0.99 | 0.98 |
| 1976 | 1.16 | 1.06 | 1.01 | 1.14 |
| 1977 | 0.96 | 0.99 | 0.93 | 1.08 |
| 1978 | 1.33 | 1.27 | 1.05 | 0.87 |
| 1979 | 0.85 | 0.96 | 0.97 | 1.08 |
| 1980 | 1.12 | 1.19 | 1.04 | 1.17 |
| 1981 | 1.24 | 1.36 | 1.07 | 0.92 |
| 1982 | 1.11 | 1.18 | 1.05 | 1.13 |
| 1983 | 0.81 | 1.08 | 0.97 | 0.93 |
| 1984 | 0.76 | 0.55 | 0.85 | 0.89 |
| 1985 | n.a. | 0.59 | n.a. | 0.87 |

W1 Index of weather effect based on GRODEX.
W2 Index of yield variability.

Table 4

Alberta Consolidated Crop Districts

| Year | Crop District 5 | | Crop District 6 | | Crop District 7 | |
|---|---|---|---|---|---|---|
| | W1 | W2 | W1 | W2 | W1 | W2 |
| | (Current $) | | | | | |
| 1961 | 1.00 | 0.80 | 1.00 | 1.17 | 0.97 | 1.31 |
| 1962 | 0.96 | 1.05 | 0.99 | 1.02 | 1.01 | 1.25 |
| 1963 | 1.03 | 1.15 | 1.00 | 0.98 | 0.96 | 0.56 |
| 1964 | 0.99 | 0.95 | 1.01 | 0.95 | 1.10 | 1.11 |
| 1965 | 0.99 | 0.93 | 0.99 | 0.90 | 1.06 | 0.83 |
| 1966 | 1.05 | 1.13 | 1.00 | 1.09 | 1.02 | 1.05 |
| 1967 | 0.94 | 0.97 | 1.01 | 0.91 | 0.94 | 0.76 |
| 1968 | 0.96 | 0.87 | 1.01 | 0.94 | 1.04 | 1.18 |
| 1969 | 0.97 | 0.99 | 1.02 | 1.09 | 0.91 | 0.82 |
| 1970 | 0.99 | 1.09 | 0.99 | 1.06 | 0.95 | 1.00 |
| 1971 | 1.00 | 0.97 | 1.01 | 0.87 | 1.04 | 1.13 |
| 1972 | 1.03 | 1.12 | 0.99 | 1.05 | 0.98 | 1.11 |
| 1973 | 0.99 | 0.89 | 0.99 | 0.97 | 0.94 | 1.02 |
| 1974 | 0.98 | 0.89 | 0.97 | 0.80 | 0.95 | 0.98 |
| 1975 | 0.99 | 0.98 | 1.08 | 1.03 | 0.95 | 1.11 |
| 1976 | 1.04 | 1.05 | 0.99 | 1.18 | 1.06 | 1.16 |
| 1977 | 0.99 | 1.18 | 1.01 | 1.02 | 1.08 | 1.05 |
| 1978 | 1.08 | 1.00 | 1.00 | 0.98 | 0.96 | 0.96 |
| 1979 | 0.95 | 1.04 | 0.99 | 1.00 | 1.03 | 1.16 |
| 1980 | 1.03 | 1.05 | 0.99 | 1.06 | 0.86 | 1.10 |
| 1981 | 1.06 | 1.06 | 0.99 | 1.10 | 1.01 | 0.93 |
| 1982 | 1.03 | 0.99 | 1.00 | 1.02 | 1.01 | 0.82 |
| 1983 | 0.94 | 0.91 | 1.00 | 0.94 | 1.10 | 1.13 |
| 1984 | 0.93 | 0.93 | 1.03 | 0.96 | 0.95 | 0.98 |
| 1985 | n.a. | 0.92 | n.a. | 1.00 | n.a. | 0.73 |

W1 Index of weather effect based on GRODEX.
W2 Index of yield variability.

Table 5

Saskatchewan Provincial Total

| Year | W1 | W2 |
|---|---|---|
| | (Current $) | |
| 1961 | 0.54 | 0.40 |
| 1962 | 0.99 | 0.97 |
| 1963 | 1.15 | 1.29 |
| 1964 | 0.86 | 0.84 |
| 1965 | 1.10 | 1.01 |
| 1966 | 1.11 | 1.25 |
| 1967 | 0.73 | 0.77 |
| 1968 | 0.94 | 0.88 |
| 1969 | 0.79 | 1.19 |
| 1970 | 1.24 | 1.17 |
| 1971 | 1.04 | 1.19 |
| 1972 | 0.94 | 1.02 |
| 1973 | 1.02 | 1.03 |
| 1974 | 1.17 | 0.87 |
| 1975 | 1.22 | 1.04 |
| 1976 | 1.13 | 1.26 |
| 1977 | 0.96 | 1.17 |
| 1978 | 1.16 | 1.16 |
| 1979 | 0.98 | 0.87 |
| 1980 | 0.90 | 0.91 |
| 1981 | 0.87 | 1.04 |
| 1982 | 1.19 | 1.18 |
| 1983 | 1.06 | 1.02 |
| 1984 | 0.82 | 0.80 |
| 1985 | 1.02 | 0.89 |

W1 Index of weather effect based on GRODEX.
W2 Index of yield variability.

Table 6

Saskatchewan Consolidated Crop Districts

| | Crop District 1 | | Crop District 2 | | Crop District 3 | |
|---|---|---|---|---|---|---|
| Year | W1 | W2 | W1 | W2 | W1 | W2 |
| | | | (Current $) | | | |
| 1961 | 0.65 | 0.21 | 0.67 | 0.44 | 0.74 | 0.31 |
| 1962 | 0.96 | 1.42 | 1.12 | 1.25 | 1.11 | 1.13 |
| 1963 | 1.28 | 1.40 | 1.31 | 1.28 | 1.02 | 1.49 |
| 1964 | 1.10 | 1.20 | 1.08 | 1.07 | 0.92 | 0.89 |
| 1965 | 1.03 | 1.20 | 1.22 | 1.08 | 1.27 | 1.22 |
| 1966 | 0.89 | 1.17 | 0.93 | 1.06 | 1.23 | 1.36 |
| 1967 | 0.69 | 0.84 | 0.67 | 0.69 | 0.98 | 0.70 |
| 1968 | 0.79 | 0.77 | 0.94 | 0.68 | 0.82 | 0.83 |
| 1969 | 0.95 | 1.38 | 0.84 | 1.29 | 0.73 | 1.40 |
| 1970 | 1.25 | 1.10 | 1.16 | 1.11 | 1.40 | 1.33 |
| 1971 | 1.06 | 1.32 | 0.88 | 1.19 | 0.87 | 1.11 |
| 1972 | 1.29 | 1.05 | 1.02 | 1.08 | 0.74 | 1.10 |
| 1973 | 0.88 | 1.15 | 1.01 | 1.13 | 0.81 | 0.97 |
| 1974 | 1.12 | 0.92 | 1.03 | 0.75 | 1.23 | 0.87 |
| 1975 | 1.34 | 1.00 | 0.95 | 0.94 | 1.14 | 1.12 |
| 1976 | 1.22 | 1.05 | 1.18 | 1.28 | 1.22 | 1.40 |
| 1977 | 0.77 | 1.25 | 0.96 | 1.33 | 1.03 | 1.23 |
| 1978 | 1.33 | 1.30 | 0.87 | 1.29 | 0.97 | 1.17 |
| 1979 | 0.90 | 0.73 | 0.89 | 0.85 | 1.06 | 0.92 |
| 1980 | 0.93 | 0.82 | 0.93 | 0.74 | 0.96 | 0.90 |
| 1981 | 0.86 | 0.99 | 0.91 | 1.01 | 1.05 | 0.95 |
| 1982 | 1.02 | 0.99 | 1.17 | 1.19 | 1.32 | 1.23 |
| 1983 | 0.83 | 0.85 | 1.14 | 0.98 | 1.03 | 0.95 |
| 1984 | 0.64 | 0.67 | 0.83 | 0.71 | 0.63 | 0.59 |
| 1985 | n.a. | 0.88 | n.a. | 0.78 | n.a. | 0.35 |

W1 Index of weather effect based on GRODEX.
W2 Index of yield variability.

Table 7

Saskatchewan Consolidated Crop Districts

| | Crop District 4 | | Crop District 5 | | Crop District 6 | |
|---|---|---|---|---|---|---|
| Year | W1 | W2 | W1 | W2 | W1 | W2 |
| | | | (Current $) | | | |
| 1961 | 0.71 | 0.36 | 0.41 | 0.27 | 0.53 | 0.39 |
| 1962 | 1.13 | 0.87 | 0.98 | 0.96 | 0.90 | 0.86 |
| 1963 | 1.11 | 1.20 | 1.07 | 1.21 | 1.19 | 1.42 |
| 1964 | 0.85 | 0.93 | 1.12 | 1.03 | 0.80 | 0.71 |
| 1965 | 1.07 | 1.20 | 1.05 | 0.98 | 0.96 | 1.07 |
| 1966 | 1.09 | 1.61 | 0.97 | 1.16 | 1.15 | 1.38 |
| 1967 | 0.96 | 0.73 | 0.60 | 0.71 | 0.79 | 0.78 |
| 1968 | 1.09 | 1.07 | 0.98 | 0.89 | 1.15 | 1.05 |
| 1969 | 0.95 | 1.04 | 0.80 | 1.17 | 0.92 | 1.23 |
| 1970 | 0.95 | 1.33 | 1.21 | 1.10 | 1.35 | 1.26 |
| 1971 | 1.01 | 1.08 | 1.08 | 1.22 | 1.18 | 1.35 |
| 1972 | 0.91 | 1.09 | 0.75 | 1.01 | 1.04 | 1.00 |
| 1973 | 0.98 | 0.90 | 1.09 | 1.09 | 1.03 | 1.02 |
| 1974 | 1.00 | 1.06 | 1.01 | 0.79 | 1.35 | 0.87 |
| 1975 | 1.19 | 1.26 | 1.23 | 0.98 | 0.99 | 1.00 |
| 1976 | 0.98 | 1.27 | 1.01 | 1.22 | 0.95 | 1.26 |
| 1977 | 1.03 | 0.95 | 0.94 | 1.17 | 0.93 | 1.16 |
| 1978 | 1.20 | 1.09 | 1.19 | 1.22 | 1.06 | 1.08 |
| 1979 | 1.09 | 1.16 | 0.70 | 0.60 | 1.04 | 0.81 |
| 1980 | 0.87 | 1.07 | 1.08 | 0.88 | 0.79 | 0.76 |
| 1981 | 0.68 | 1.11 | 1.20 | 1.28 | 0.77 | 0.92 |
| 1982 | 1.16 | 1.27 | 1.15 | 1.08 | 1.18 | 1.16 |
| 1983 | 0.94 | 1.19 | 1.23 | 0.97 | 1.20 | 1.01 |
| 1984 | 0.91 | 0.66 | 0.83 | 1.00 | 0.71 | 0.66 |
| 1985 | n.a. | 0.39 | n.a. | 1.28 | n.a. | 0.89 |

W1 Index of weather effect based on GRODEX.
W2 Index of yield variability.

Table 8

Saskatchewan Consolidated Crop Districts

| | Crop District 7 | | Crop District 8 | | Crop District 9 | |
|---|---|---|---|---|---|---|
| Year | W1 | W2 | W1 | W2 | W1 | W2 |
| | | | (Current $) | | | |
| 1961 | 0.73 | 0.54 | 0.60 | 0.48 | 0.83 | 0.61 |
| 1962 | 1.06 | 0.79 | 0.87 | 0.87 | 0.88 | 0.88 |
| 1963 | 0.94 | 1.32 | 0.95 | 1.22 | 1.06 | 1.28 |
| 1964 | 0.93 | 0.70 | 0.79 | 0.79 | 0.59 | 0.50 |
| 1965 | 1.03 | 0.87 | 1.06 | 0.91 | 0.97 | 0.92 |
| 1966 | 1.01 | 1.41 | 1.23 | 1.22 | 1.07 | 1.20 |
| 1967 | 0.89 | 0.89 | 0.83 | 0.79 | 0.84 | 1.03 |
| 1968 | 0.79 | 0.88 | 0.94 | 1.06 | 1.03 | 0.91 |
| 1969 | 0.81 | 1.06 | 0.81 | 1.02 | 0.84 | 1.03 |
| 1970 | 1.10 | 1.33 | 1.13 | 1.07 | 1.08 | 1.20 |
| 1971 | 1.07 | 1.17 | 1.01 | 1.20 | 1.07 | 1.21 |
| 1972 | 0.92 | 0.99 | 1.02 | 1.06 | 0.87 | 0.91 |
| 1973 | 1.07 | 0.99 | 1.11 | 0.98 | 1.04 | 1.04 |
| 1974 | 1.20 | 0.97 | 0.89 | 0.83 | 1.16 | 0.94 |
| 1975 | 1.13 | 1.09 | 1.18 | 0.99 | 1.12 | 1.04 |
| 1976 | 1.13 | 1.25 | 1.13 | 1.24 | 0.98 | 1.18 |
| 1977 | 0.99 | 1.03 | 1.02 | 1.16 | 1.01 | 1.07 |
| 1978 | 1.00 | 1.02 | 1.17 | 1.14 | 1.09 | 0.99 |
| 1979 | 1.01 | 1.05 | 1.04 | 0.80 | 1.04 | 0.93 |
| 1980 | 0.95 | 0.96 | 0.93 | 1.01 | 0.93 | 1.04 |
| 1981 | 1.03 | 1.02 | 0.88 | 0.97 | 0.85 | 0.95 |
| 1982 | 1.04 | 1.24 | 1.11 | 1.10 | 1.05 | 1.08 |
| 1983 | 1.07 | 1.11 | 1.09 | 0.92 | 0.92 | 0.99 |
| 1984 | 0.93 | 0.77 | 1.02 | 0.98 | 1.07 | 0.92 |
| 1985 | n.a. | 0.77 | n.a. | 1.32 | n.a. | 1.05 |

W1 Index of weather effect based on GRODEX.
W2 Index of yield variability.

Table 9

Manitoba Provincial Total

| Year | W1 | W2 |
|---|---|---|
| | (Current $) | |
| 1961 | 0.70 | 0.53 |
| 1962 | 1.17 | 1.22 |
| 1963 | 1.05 | 0.90 |
| 1964 | 0.93 | 1.11 |
| 1965 | 0.94 | 1.10 |
| 1966 | 1.06 | 1.03 |
| 1967 | 0.91 | 1.06 |
| 1968 | 1.09 | 1.13 |
| 1969 | 0.81 | 1.04 |
| 1970 | 0.99 | 0.93 |
| 1971 | 1.08 | 1.21 |
| 1972 | 0.97 | 1.06 |
| 1973 | 1.03 | 1.01 |
| 1974 | 0.96 | 0.78 |
| 1975 | 1.12 | 0.92 |
| 1976 | 0.99 | 1.00 |
| 1977 | 1.06 | 1.15 |
| 1978 | 1.14 | 1.10 |
| 1979 | 1.04 | 0.88 |
| 1980 | 0.88 | 0.75 |
| 1981 | 0.86 | 1.03 |
| 1982 | 1.03 | 1.13 |
| 1983 | 0.99 | 0.88 |
| 1984 | 0.95 | 0.99 |
| 1985 | 1.12 | 1.25 |

W1 Index of weather effect based on GRODEX.
W2 Index of yield variability.

Table 10

Manitoba Consolidated Crop Districts, 1977-84

| | Crop Districts 1, 2, and 3 | | Crop District 4 | | Crop Districts 5 and 6 | |
|---|---|---|---|---|---|---|
| Year | W1 | W2 | W1 | W2 | W1 | W2 |
| | | | (Current $) | | | |
| 1977 | 1.01 | 1.23 | 1.14 | 1.39 | 1.01 | 1.20 |
| 1978 | 1.17 | 1.16 | 1.28 | 1.27 | 1.15 | 1.12 |
| 1979 | 1.06 | 0.83 | 0.87 | 0.75 | 1.05 | 0.83 |
| 1980 | 0.82 | 0.75 | 1.14 | 1.05 | 0.84 | 0.86 |
| 1981 | 1.05 | 1.03 | 1.14 | 1.21 | 1.05 | 1.05 |
| 1982 | 1.01 | 1.15 | 1.07 | 0.98 | 1.01 | 1.10 |
| 1983 | 0.83 | 0.91 | 1.18 | 1.01 | 0.85 | 0.80 |
| 1984 | 0.97 | 0.87 | 0.88 | 1.05 | 0.97 | 0.97 |

W1 Index of weather effect based on GRODEX.
W2 Index of yield variability.

Table 11

Manitoba Consolidated Crop Districts, 1977-84

| | Crop Districts 7, 8, 9, and 11 | | Crop District 10 | | Crop District 12 | |
|---|---|---|---|---|---|---|
| Year | W1 | W2 | W1 | W2 | W1 | W2 |
| | | | (Current $) | | | |
| 1977 | 1.01 | 1.18 | 1.00 | 1.15 | 1.01 | 1.13 |
| 1978 | 1.20 | 1.12 | 1.11 | 1.13 | 1.14 | 1.11 |
| 1979 | 1.07 | 0.99 | 1.04 | 0.85 | 1.05 | 0.96 |
| 1980 | 0.80 | 0.71 | 0.88 | 0.90 | 0.85 | 0.89 |
| 1981 | 1.06 | 1.01 | 1.04 | 0.99 | 1.05 | 0.95 |
| 1982 | 1.01 | 1.14 | 1.01 | 1.06 | 1.01 | 1.02 |
| 1983 | 0.81 | 0.83 | 0.88 | 0.84 | 0.86 | 0.75 |
| 1984 | 0.96 | 0.99 | 0.98 | 1.01 | 0.97 | 1.13 |

W1 Index of weather effect based on GRODEX.
W2 Index of yield variability.

Table 12

Manitoba Consolidated Crop Districts, 1961-76

| | Crop Districts 1 and 7 | | Crop Districts 2, 8, 9, 11, and 14 | | Crop Districts 3, 4, 5, and 6 | |
|---|---|---|---|---|---|---|
| Year | W1 | W2 | W1 | W2 | W1 | W2 |
| | | | (Current $) | | | |
| 1961 | 0.74 | 0.45 | 0.81 | 0.46 | 0.87 | 0.75 |
| 1962 | 1.18 | 1.22 | 0.13 | 1.24 | 1.05 | 1.23 |
| 1963 | 0.99 | 0.96 | 0.99 | 0.88 | 1.01 | 0.70 |
| 1964 | 0.84 | 1.12 | 0.88 | 1.13 | 1.00 | 1.12 |
| 1965 | 1.07 | 1.07 | 1.05 | 1.05 | 1.00 | 1.21 |
| 1966 | 0.96 | 1.05 | 0.97 | 1.05 | 1.02 | 0.94 |
| 1967 | 0.85 | 0.84 | 0.88 | 1.04 | 0.96 | 1.19 |
| 1968 | 0.82 | 1.03 | 0.86 | 1.23 | 1.07 | 1.20 |
| 1969 | 0.96 | 1.22 | 0.97 | 1.08 | 0.77 | 0.81 |
| 1970 | 0.97 | 0.97 | 0.98 | 1.00 | 1.03 | 0.82 |
| 1971 | 1.24 | 1.21 | 1.18 | 1.21 | 1.04 | 1.23 |
| 1972 | 1.01 | 1.10 | 1.01 | 1.13 | 1.01 | 1.07 |
| 1973 | 1.00 | 1.13 | 1.00 | 1.06 | 1.00 | 1.02 |
| 1974 | 1.03 | 0.86 | 1.02 | 0.80 | 1.00 | 0.73 |
| 1975 | 1.23 | 0.98 | 1.17 | 0.94 | 1.00 | 0.94 |
| 1976 | 1.06 | 0.99 | 1.05 | 0.96 | 0.93 | 1.07 |

W1 Index of weather effect based on GRODEX.
W2 Index of yield variability.

Table 13

Manitoba Consolidated Crop Districts, 1961-76

| Year | Crop Districts 10, 11, and 13 | | Crop District 12 | |
|---|---|---|---|---|
| | W1 | W2 | W1 | W2 |
| | (Current $) | | | |
| 1961 | 0.48 | 0.30 | 0.68 | 0.49 |
| 1962 | 1.06 | 1.00 | 1.30 | 1.18 |
| 1963 | 1.12 | 0.99 | 0.94 | 0.60 |
| 1964 | 0.76 | 0.95 | 0.78 | 0.96 |
| 1965 | 0.81 | 0.97 | 0.96 | 1.17 |
| 1966 | 0.95 | 1.01 | 1.04 | 1.17 |
| 1967 | 0.95 | 0.98 | 0.97 | 1.18 |
| 1968 | 0.66 | 0.94 | 1.13 | 1.27 |
| 1969 | 0.83 | 1.12 | 1.09 | 1.19 |
| 1970 | 0.99 | 0.97 | 0.80 | 1.05 |
| 1971 | 1.13 | 1.17 | 1.07 | 1.45 |
| 1972 | 0.99 | 0.97 | 0.95 | 1.21 |
| 1973 | 0.97 | 0.92 | 1.06 | 1.16 |
| 1974 | 0.98 | 0.84 | 1.02 | 0.67 |
| 1975 | 1.15 | 0.90 | 1.11 | 0.78 |
| 1976 | 1.08 | 1.08 | 0.98 | 0.85 |

W1 Index of weather effect based on GRODEX.
W2 Index of yield variability.

LIST OF TABLES AND FIGURES

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