A REGIONAL CROP FORECASTING MODEL FOR THE CANADIAN PRAIRIES

by

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ABSTRACT

The practice of summerfallowing has substantially influenced crop allocation in the Canadian Prairies because fallow land generally contain higher levels of soil moisture and fertility than stubble land, and is more favourable for the production of certain crops. The purpose of this study was to examine this influence by differentiating acreage allocation between fallow and stubble land. An acreage allocation model was specified in this study, and the allocation of fallow and stubble acreages to the major crops was estimated separately to reflect different responses from producers with respect to the choice of crops to grow on fallow and on stubble land.

It has been well recognized that the average yield of each crop, a major factor in the determination of crop allocation, is significantly higher on fallow cropping than on stubble cropping. Therefore, differentiating producer's response between fallow and stubble cropping would depict the crop allocation decisions more accurately and hence reduce aggregation bias. This should reduce aggregation error and improve forecasting ability of the acreage allocation model.

The model was further disaggregated provincially to allow for regional variations in cropping pattern. This analysis covered the seeded acreages of wheat, oats, barley, rapeseed, flaxseed, and sunflower using time series data from 1961 to 1981.

The basic model used in the analysis was a multinomial logit acreage allocation model. The allocation of the total acreage of cropland to the production of alternative crops was explained in terms of a set of percentage shares which lie between zero and one with their sum equal to one, thus constraining the sum of forecasted acreages to the total acreage. A set of six exponential acreage functions, one for each crop covered in this study, was specified as proxies for producers' acreage response relationship. Exogenous variables included in the set of acreage functions were expected relative returns from alternative crops, inventories of grains, total acreage of cropland, the LIFT program, and a rapeseed adoption variable. The multinomial logit model was then incorporated with the set of acreage functions.

Based on this model, the percentage share of the acreage of each crop i was derived by estimating a set of acreage ratios of each of the alternative crop to a common crop, flaxseed. Since the disturbance term was correlated across the equations in the model due to the restriction that all acreage shares summed up to one, Zellner's Seemingly Unrelated Regression method was employed for efficient estimation of the system of equations.

The results of the estimation showed that the estimated parameters on most of the explanatory variables were substantially different between crops seeded on fallow and stubble, and among the three Prairie provinces. These differences were evidence of different response in acreage allocation between fallow and stubble cropping.

Based on the results of the estimation, historical levels of acreage of each crop grown on fallow and stubble in the three Prairie provinces were simulated. Comparing with the results generated from a Naive model, the results of the simulation indicated that the acreage allocation model generally performed well in within-estimation period forecasting. However, for acreages of crops grown on stubble seedbed, the performance of the model in acreage simulation was generally impaired by errors transmitted from inaccurate estimation of total area seeded to stubble to some extent, with wheat acreage affected most.

Reasonably accurate forecasts were obtained for acreages seeded to the five major crops in the Prairies in 1982 and 1983. It was very encouraging that this model seemed to have better overall performance than Agriculture Canada and the Canada Grains Council in forecasting seeded acreages in 1982 and 1983. All three studies performed very well in predicting wheat acreage with very low forecasting errors. This study proved to be more satisfactory than the other two studies in the prediction of barley and rapeseed acreages. Both the present study and the Canada Grains Council performed better than Agriculture Canada in predicting oats and flaxseed acreages.

The forecasting performance of this model has demonstrated empirically the advantage of differentiating crop allocation between fallow and stubble acreages, and the usefulness of the multinomial logit model in analyzing crop allocation.

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Chapter I

INTRODUCTION

Crop production is a major part of the agricultural industry and a major source of farm income in Western Canada. In 1980, income from crop operations in Manitoba, Saskatchewan, and Alberta was 6,375 million dollars, which accounted for about 67 percent of total farm income on the Prairies. The export of Prairie grains and oilseeds is of special importance for the Canadian economy in terms of income generation, balance of payments, as well as employment. Due to this economic significance, overall planning and forecasting of Prairie crop production is useful to the grain industry in determining supplies for the export and domestic markets and government programs designed to stabilize farm income and employment.

Aggregate supply response studies on various crops throughout Canada have been undertaken over the last three decades. They provided effective information for the development of agricultural policies in determining the factors which influence crop production.[1] However, little research has been conducted on the influence of crop rotation. In this regard, the practice of summerfallow on the Prairies is of particular

[1] Conventionally producers supply responses were measured in terms of acreage rather than production because seeding acreage is considered to be the best proxy for producers' intention on crop production which reflects the willingness of farmers to respond to changes in prices and other relevant factors and abstracts the stochastic factors on crop yields.

interest. The purpose of this study is to examine this factor quantitatively to improve the forecasting ability of conventional supply response models.

1.1 THE PRACTICE OF SUMMERFALLOWING IN THE CANADIAN PRAIRIES

Fallowing land has been a unique characteristic of crop production in Western Canada which dates back to pioneer days. Many Prairie farmers traditionally leave a certain portion of the cultivated land fallow each year. The primary purpose for summerfallowing is to restore the level of soil moisture to ensure favourable conditions for crops in the year after fallow. Other advantages of summerfallowing include increasing soil fertility throuth decomposition of organic matter, controling weeds and diseases, and enabling a more even distribution and more effective use of labour and machinery. Fallowing cultivated land has been regarded as an effective and low cost method for minimizing production risks and improving crop yields. The percentage of cultivated land under fallow was fairly stable in the past.

However, during the past two decades the disadvantages of summerfallow, such as erosion from wind and water and soil salinity have become apparent. The development of moisture conserving tillage practises, and the successful application of chemical fertilizers and herbicides have effectively reduced farmers' reliance on summerfallow for sustaining crop yields. The adoption of modern power equipment also enabled efficient accomplishment of the peak seasonal work loads during seeding and harvesting operations. Higher farm land prices in recent years have quickly increased the opportunity cost of leaving valuable land idle. Increasing production costs, in contrast to depressed product markets in recent years, have reduced average return per seeded acres. The squeeze on farm incomes, coupled with the awareness of economy of scale, have tended to encourage farmers to increase seeded areas to compensate for lower average returns and to reduce average costs. These factors have made the fallow option less attractive and resulted in farmers opting for more stubble cropping in spite of the comparatively favourable yields from fallowed land. As a result, the trend has been to decrease fallow-seeded cropping with a corresponding increase in stubble-seeded cropping across the Prairies although the rates of change have varied by province. The percentage of the total acreage seeded on stubble has increased steadily over the last two decades in all Prairie provinces except in 1970 when the trend was interupted by the LIFT program.[2] In 1981 the percentage of acreage seeded on stubble land in Manitoba was about 80 percent, in Saskatchewan 30 percent, and in Alberta 60 percent.[3]

Although the practice of summerfallow can be reduced, it is not likely to be eliminated completely. A minimum level of summerfallow is likely to be maintained in each Prairie province and it will depend on soil types and moisture conditions of the province. At present the level of summerfallow in each province is still higher than the lower limit

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[2] The Lower Inventories For Tomorrow (LIFT) program was implemented in 1970. This program provided Prairie farmers compensation payments for reducing wheat acreage below 1969 levels and increasing summerfallow or perennial forage by the same amount.

[3] Kraft D. and Fields V., Fertilizer Demand in the Prairie Provinces, Unpublished paper, Department of Agriccultural Economics, University of Manitoba, 1982. Figure 1.

thought to be technically feasible.[4] However, summerfallow is expected to approach the technically feasible level unless there are substantial changes in the structure of crop yields, production costs between crops seeded on stubble and fallow seedbeds, or unusual weather conditions.

1.2 OBJECTIVE AND SCOPE

The practice of summerfallowing has substantial influence on crop allocation in the Canadian Prairies. The primary objective of this study is to differentiate crop allocation between fallow and stubble land by analyzing the allocation of fallow acreage separately from the allocation of stubble acreage to improve the forecasting ability of acreage response model.

It has been well recognized that the conditions of fallow and stubble land are different in terms of the levels of soil moisture, fertility, and weed populations. It is believed that these differences would result in different cropping patterns between fallow and stubble land because fallow land is more favourable for the production of some crops.[5] Therefore, the allocation of fallow and stubble acreage should be analyzed separately to reflect the different response from producers with respect to the choice of crops to grow on fallow and stubble land. The necessity of disaggregating fallow and stubble acreage in crop alloca-

[4] Kraft and Fields, ibid., pp.3-5.

[5] A preliminary examination of published data suggests the distribution of the principal crops grown on a stubble seed-bed is significantly different from that grown on fallow seed-bed in the Prairies. Wheat has been the dominant crop grown on fallow while oats, barley and sunflowers have been grown primarily on stubble. More rapeseed has been grown on fallow and more flaxseed has beed grown on stubble.

tion analysis is reinforced by the fact that the average yield of each crop, a major factor in the determination of acreage allocation, is substantially higher on fallow cropping than on stubble cropping. Previous research on acreage allocation in the Prairies ignored this factor. Empirical estimations were performed on aggregated fallow and stubble land. This aggregation assumed implicitly that the productivity of fallow and stubble land were homogeneous which is clearly indefensible. Average yields of crops used in those aggregated studies were actually weighted average productivity of fallow and stubble cropping. Gupta has shown that an aggregated model using some weighted averages of micro variables as explanatory variables would lead to aggregation bias and may impair forecasting ability of the model.[6] Therefore, differentiating producers' response between fallow and stubble cropping would depict the crop allocation decisions more accurately and hence reduce aggregation bias. This might improve the predictive performance of the aggregated model.

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[6] Gupta examined the aggregation bias using a simple model which defined a micro model $y_{it} = b_i x_{it} + c_i z_{it}$ $(i=1,..n,\ t=1,..T)$ and a corresponding macro model: $Y_t = bX_t + cZ_t$. Where $Y_t = \sum_{i=1}^{n} y_{it}$, $X_t = \sum_{i}^{n} r_i x_{it}$, $Z_t = \sum_{i}^{n} e_i z_{it}$. Auxiliary equations, $x_{it} = B_i X_t + C_i Z_t$ and $z_{it} = D_i X_t + E_i Z_t$, were also defined to facilitate the expression of the macro parameters in terms of the micro parameters. It was shown that the aggregation bias was $\mathrm{Cov}(b_i/r_i, r_i B_i) + \mathrm{Cov}(c_i/e_i, e_i D_i)$ for the parameter b and $\mathrm{Cov}(b_i/r_i, r_i c_i) + \mathrm{Cov}(c_i/e_i, e_i E_i)$ for the parameter c. The resulting aggregation error in prediction was also shown. See Gupta, K.L. <u>Aggregation in Economics</u>, Rotterdam University Press, 1969, pp.1-9. The situation Gupta defined was not identical to the present study because in this study the weights r and e change over the years 1,..T. However, the implications of aggregation bias in parameters and aggregation error in prediction in his study should hold in this study.

In recognition of regional differences of cropping patterns among the Prairie provinces, an attempt will be made to disaggregate crop acreages seeded in Manitoba, Saskatchewan, and Alberta to provide a more accurate representation of regional factors and conditions.

In the Prairies, the annual growth of cultivated land has been rather limited over the last two decades. The increment of acreage seeded has been largely attributed to reduction in summerfallow acreage. Therefore, given the level of summerfallow acrage in a particular year, a substantial increase in the acreage of any one crop means the necessity of a reduction in the acreage of other crops in that year. All crops grown in a particular area are practically competing against one another for available cropland. The interrelationship among acreage allocation of various crops is apparent. This study also intends to account for this interdependence of acreage allocation by two means : 1) Employ a simultaneous estimation method for the acreage allocation model based on the approach developed by Colman.[7] 2) Incorporate a complete and consistent set of direct and indirect expected return variables into the system of equations.

Acreage of six principal crops grown in the Prairies, wheat, oats, barley, rapeseed, flaxseed, and sunflowers, which constitute well over 90 perecnt of total acreage of all crops grown in the Prairies, are included in the model.[8] Time series data for the period 1961 to 1981 will

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[7] Colman, D., Prairie Grain and Oilseed Acreage Response, Working Paper, No. 7, Agriculture Canada, Policy, Planning and Economics Branch, 1979, pp. 9-10.

[8] Sunflower acreage is included only in Manitoba. Sunflowers have been mainly grown on stubble land within some regions in Manitoba for crop

be used for the analysis.

The application of a multinomial logit acreage allocation model to crops seeded on stubble and on fallow in Manitoba, Saskatchewan, and Alberta is presented in the following chapters. Chapter Two presents a review of some recent studies on acreage response which are related to this study. Chapter Three elaborates on the specification and derivation of the model. Chapter Four analyses the results of empirical estimation. Chapter Five examines the results of historical simulation and evaluates the forecasting ability of this model. Chapter Six summarizes and assesses the overall performance of this model and suggests the directions for future research.

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diversification and rotation because comparatively, sunflowers are more drought resistant. Acreage of rye is not included in the model although rye is one of the major crops grown in the Prairies because the acreage planning of rye is considered to be independent of acreage allocation of other major crops. Rye is generally seeded in fall while all other major crops are seeded in the spring. When producers plan the allocation of cropland to various crops in the spring, rye is not considered as one of the alternatives, therefore, the interdependence of crops grown in the Prairies does not apply to rye and it is improper to include acreage of rye in the model using simultaneous methods.

Chapter II

REVIEW OF RELATED STUDIES

Much of the theoretical framework for the analysis of Prairie crop production has been discussed by Pietryk[9] in a comprehensive review of the theoretical framework of producer response and marketing mechanisms for Prairie grains and oilseeds. No attempt is made in this study to reproduce Pietryk's work. Instead, some recent developments in empirical analysis of acreage supply response will be examined.[10]

2.1 LITERATURE REVIEW

This section summarizes some of the recent attempts to comprehend and evaluate alternative approaches of estimating acreage response relationships for the major Prairie crops. Meilke (1976) analysed the long-run acreage response of board-grains, namely, wheat, oats, and barley. The paper focused on differentiating the impacts of initial and final payments set by the Canadian Wheat Board (CWB). Paddock (1971) analysed

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[9] Pietryk, J.W., An Econometric Analysis of Sunflower Production in Manitoba, M.Sc. thesis, University of Manitoba, 1976, pp. 17-33, 52-58. Analysis of the supply function, static and dynamic price expectation models, the role and function of the Canadian Wheat Board in the determination of grain prices in Western Canada, and other marketing alternatives were covered.

[10] Only acreage analysis related to Western Canada will be examined because the climate, soil type, marketing machenism, and other backgrounds are significantly different between Eastern and Western Canada. As such, this study would profit little from acreage analysis for Eastern Canada.

the short-run supply response of rapeseed acreage aggregated at the Prairie level, while Uhm (1975) investigated the long-run response of rapeseed at both the provincial and Prairie levels. Pietryk (1976) conducted both short-run and long-run analysis of sunflower acreage in Manitoba. Lowe and Petrie (1978) covered acreage response analysis of wheat, oats, barley, rapeseed, and flaxseed in a large scale crop supply model for the Prairies. Colman (1979) further developed the Lowe-Petrie model by introducing simultaneous and constrained estimation methods for the acreage response model.

2.1.1 Meilke

Meilke hypothesized that in the case of planting decisions, Prairie farmers respond differently toward changes in initial and final payments set by the CWB. Two sets of three linear equations were specified for the acreage of wheat, oats, and barley which differed only in terms of how the initial and final payments were specified. In one set of equations initial and final payments were included as separate price variables, while in the other a combined single measure of price was used. Each equation was estimated for aggregate seeded area in the Prairie provinces for the period 1949 to 1974.

Seeded area of wheat was specified to be a function of wheat price, barley price, delivery quota restrictions on wheat, and a dummy variable for the policy Lower Inventory For Tomorrow (LIFT) in 1970. Acreage of oats was hypothesized to be dependent on oats price, wheat price, and the relative yield of wheat to oats. Acreage of barley was explained by barley price, wheat price, quota restrictions on wheat, and the price of livestock. All exogenous variables (except LIFT) were lagged one year. A lagged dependent variable was included in each acreage equation.

Three estimation procedures including OLS method, OLS with the Hilderth-Lu correction for serial correlation, and a seemingly unrelated regression procedure were used for the estimation. The parameter estimates obtained from these three estimation procedures were reported to be nearly the same. Thus, only the OLS results were presented. The results were generally satisfactory in terms of expected signs and statistical properties. Based on statistically significant coefficients and different magnitudes of elasticities on initial and final payment variables, Meilke concluded that the hypothesis was confirmed. Small elasticities estimates for the final payments (ranging between 0.05 and 0.15 in the short-run and between 0.09 and 0.28 in the long-run in absolute values) in contrast to large elasticity estimates for the initial payments (ranging between 0.53 and 1.65 in the short-run and between 1.01 to 2.95 in the long-run), however, suggested that grain producers were not responsive to changes in final payments. However, initial payments could be set to influence producers' planning in order to achieve acreage targets.

2.1.2 Paddock

Paddock analyzed rapeseed acreage response for the Prairies using rapeseed price and the price of flaxseed in the previous year, wheat exports, and a trend variable. Both linear and logarithmic forms of the relationship were estimated for the period 1951 to 1967. The results obtained from the logarithmic function were chosen because they seemed to provide a better fit. Good statistical performance and explanatory power were cited. Short-run elasticities of rapeseed acreage ranged from 1.35 with respect to wheat exports to 2.35 with respect to lagged rapeseed price in absolute values. Paddock attributed the highly elastic rapeseed acreage response to relative ease of entry into and exit from rapeseed production, which also explained the wide fluctuation of rapeseed acreage over the estimation period.

2.1.3 Uhm

Uhm estimated rapeseed acreage as a linear function of its own price and the price of wheat in the previous year, rapeseed yields lagged one year, rapeseed export sales, wheat stocks, LIFT program, lagged effect of LIFT program, and lagged rapeseed acreage for the period 1958 to 1972. OLS was used for the estimation of Manitoba and Prairie acreage. Three-stage Least Squares was used for estimating Saskatchewan and Alberta acreage because autocorrelation was considered a possibility. Generally good statistical performance was observed. All coefficient estimates were consistent with a priori expectations. Regional difference existed in terms of estimated price elasticities among provinces. Short-run elasticities of rapeseed acreage with respect to rapeseed price ranged between 1.27 (Manitoba) and 0.90 (Saskatchewan). The direct price elasticity for the Prairies was estimated to be 1.176 in the short-run and 2.52 in the long-run compared to the short-run elasticity of 2.35 obtained by Paddock.

2.1.4 Pietryk

Pietryk explained the seeded area of sunflowers in Manitoba for the period 1955 to 1973 based on the relative expected gross receipts of sunflowers compared to selected competing crops, and rainfall prior to and during seeding. The former is hypothesized to embody producers' economic considerations regarding land allocation, including all institutional and technical factors. The latter is postulated to delay seeding and cause alteration in producers' planning based on the economic factors.

Two linear equations incorporating alternative specifications of direct and cross-return variables were specified. One equation adopted the relative expected gross receipts from sunflowers compared to rapeseed because rapeseed represents the major non-Board alternative to sunflowers, while the other incorporated the relative expected gross receipts from sunflowers to wheat because wheat is considered the most important Board alternative to sunflowers. Rainfall during May was included in both equations. Static and distributed lag forms of both equations were estimated using OLS.

The statistical results of the estimations were not satisfactory. In both specifications the only variable significant at the 5% level was the lagged dependent variable although expected signs were obtained for all estimates. The estimation of the static form of both equations generated surprisingly low R squares (about .13). The incorporation of a distributed lag improved the R square dramatically to about .75. These results implied a rigidity in the cropping pattern due to non-economic factors. The forecasting of turning points within and beyond the estimation period was reported to be fairly good. However, forecasting errors outside the estimation period were quite large. Pietryk attributed the poor statistical and forecasting performance to the institutional enviroments producers faced.

2.1.5 Lowe and Petrie

Lowe and Petrie constructed a crop supply model with a wider scope than the other studies examined. The most relevant aspect to this study was the Western Canadian acreage sub-model which analyzed area seeded to wheat, oats, barley, rapeseed, and flaxseed.

Wheat acreage was explained by CWB final payments for wheat and barley, risk, lagged marketings, wheat stocks, and rainfall. Barley acreage was dependent on the final payment for barley, average yield of barley, land payment arrears, and hog inventories. Oats acreage was determined by a first difference of the final payment for oats, production of oats in the previous year, stocks of oats, summerfallow acreage in the previous year, and a time trend. Rapeseed acreage was explained by rapeseed price in the previous year, wheat stocks, non-forage cultivated acreage, and summerfallow acreage in the previous year. Flaxseed acreage was analyzed using flaxseed price lagged for one year, wheat stocks, and lagged rapeseed acreage. These specifications were derived from extensive experiments on re-estimating and complimenting existing specifications using most recent data and modified variable specifications. Also included in this sub-model were equations of total non-forage cultivated acreage, and summerfallow acreage to add completeness to the system of acreage response equations. A dummy variable reflecting the effect of the LIFT program was included in all equations.

Each equation in the system was estimated independently using OLS for the period 1959 to 1977 and the results were reported to be satisfactory. Most of the coefficient estimates in acreage equations of major crops were highly significant with expected signs. Between 61 (oats and flaxseed acreage) and 94 (barley acreage) percent of the variation in acreage of the five crops was explained. The elasticity of wheat acreage with respect to final payments for wheat and barley were estimated to be 2.08 and -1.19 respectively compared to 0.08 and -0.05 obtained by Meilke.[11]

Alternative specifications attempting disaggregation of wheat acreage grown on fallow and on stubble as well as a regional disaggregation were fruitless in improving the results from the aggregated model and were abandoned.

2.1.6 Colman

Colman further developed the Lowe-Petrie Western Canada acreage response model through extensive research and experiments on alternative specifications of the model and exogenous variables. Along with an unconstrained independent equation model, a naive acreage response model and a multinomial logit acreage allocation model were constructed. Both

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[11] It should be noted that Meilke's specification of final payments was lagged one year while Lowe-Petrie used a two-year lag.

models constrained the sum of the acreage of the five major crops to a predetermined aggregate acreage.

The independent equation model included an acreage response equation for each of the major crops, and equations for summerfallow acreage as well as the aggregate acreage of the five crops. All equations were linear. After lenthy experiments, the following specifications were adopted because of better statistical fitting. Wheat acreage was explained by two separate expected prices on wheat,[12] the LIFT program, April-May rainfall, and excess supply of wheat. Oats acreage was explained by the difference between the expected return from oats and barley, a time trend, and rainfall. Barley acreage was explained by the difference between the expected return from barley and average expected return from all five crops,[13] land payment arrears, number of sows, three-year average yield of barley, and a dummy variable for a distributed lag response to the LIFT program. Rapeseed acreage was found to be a function of the lagged ratio of rapeseed price to average barley selling prices, wheat stocks, a LIFT dummy, and a structural shift after 1969. Flaxseed acreage was explained by the lagged relative price of flaxseed to rapeseed, wheat stocks, and the LIFT program.

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[12] One incorporated the 'Gallagher Expectations Variable' which assumed expected price to be a varyingly weighted function of CWB initial payment and selling prices for wheat for the pre-1970 period, the other is CWB initial payment for the post 1970 period. Colman, D., op.cit., pp. 17-19.

[13] Expected returns are derived by multiplying CWB final realized price by average yield in the previous year.

The naive constrained model was a modification of the independent equation model. An identity equation was specified which defined aggregate acreage as the sum of the acreage of wheat, oats, barley, rapeseed, and flaxseed. Upon satisfactory determination of the aggregate acreage based on the aggregate acreage equation in the independent equation model, the acreage of any one of the five crops can be treated as a residual equal to the aggregate acreage minus the sum of projected acreages of the other four crops, thus constraining the sum of acreage projections of the five crops to the predetermined aggregate acreage. Oats acreage was chosen to be determined residually because it is minor relative to the acreages of the other four crops.

The multinomial logit acreage allocation model consisted of a system of four equations intercorrelated through the residuals. An exponential function $A_i = e^{f_i}$ was postulated to be a proxy for the acreage response relationship for crop i, where A_i is the acreage of crop i and f_i is a linear function with the same specification as the acreage equation of crop i in the independent equation model. Based on this assumption, the acreage share of crop i (S_i) was expressed as : $S_i = A_i / (\sum_{j=1}^{5} A_j) = e^{f_i} / (\sum_{j=1}^{5} e^{f_j})$, and the ratio of the acreage share of each of the i crop to that of one common crop k is expressed as : $A_i / A_k = e^{f_i} / e^{f_k}$. To facilitate empirical estimation this relationship was transformed into a linear function $\ln(A_i / A_k) = f_i - f_k$. Based on the estimation of $\ln(A_i / A_k)$ for all i ($i \neq k$), the acreage share of each of the five crops can be derived and their sum was constrained to be one. Barley acreage was chosen to be the common denominator (k) in the model.

The independent equations model was estimated using OLS for the period 1958 to 1977 and also for 1966 to 1977. Better results were obtained employing the longer estimation period for wheat and flaxseed acreage equations, and employing the shorter estimation period for all other equations. Generally good statistical properties were reported. Most exogenous variables in the equations had statistically significant coefficients with the expected signs. Between 72 percent (flaxseed acreage) and 94 percent (barley acreage) of variations in the individual acreages were explained by the equations. Evidence of a structural change after 1969 in wheat acreage response was cited regarding price expectation although no explanation was given for this shift. All equations in the model were tested and corrected for autocorrelation in the residuals. With the exception of the barley acreage equation, negative autocorrelation was found in all other equations. The independent equations model was also estimated in distributed lag form. The results showed that incorporating the distributed lag model added very little explanatory power to the basic equations. The coefficients on lagged dependent variables, which ranged between .31 (wheat acreage equation) and .00119 (rapeseed acreage equation), were rather small, and none of them were statistically significant at the 5% level.

The Zellner Seemingly Unrelated Regression method was employed for the estimation of the multinomial logit model to account for the interrelationship of acreage allocation among various crops. Two sets of results based on marginally different specifications were presented to exhibit the stability of the results. Although the explanatory power of the system of equations based on this approach were generally not as good as that achieved from the alternative independent equations model, the results generally had good statistical properties and encouraging predictive ability outside the estimation period.

2.2 CRITIQUE

Previous studies related to crop supply response in Western Canada have produced estimated results which had generally good statistical performance and were in agreement with economic theory. However, differences existed among the research efforts in terms of the scope and specification of the models, variable definition, estimation methods, and the period of analysis. Thus results and their implications were not comparable, and therefore will not be discussed here. This section will focus on the advantages and disadvantages of these studies regarding the methodology employed, the structure of the models, and the specification of the main economic factors.

The influence of summerfallow on Prairie farmers' production planning was totally ignored in most previous studies. Lowe and Petrie showed they were aware of the summerfallow question by specifying wheat acreage grown on stubble and on fallow separately. However, this attempt was given up prematurely due to the less favourable results obtained from their preliminary experiment. Alternatively, summerfallow acreage was incorporated into acreage equations of oats and rapeseed as an exogenous variable. An independent summerfallow acreage equation was also specified. Colman followed the Lowe-Petrie approach in specifying an equation for summerfallow acreage.

These measures, however, are inappropriate to reflect the actual relationship between fallowing and cropping patterns on the Prairies. Incorporating summerfallow acreage as an independent variable in the acreage equation of selected crops presumed that : i) the allocation of acreage to all other crops is unaffected by the practice of fallowing, ii) summerfallow acreage is independent of other factors influencing acreage response such as price expectations, and government programs such as LIFT. These assumptions are clearly indefensible. Also, it has been well recognized that the conditions of stubble and fallow land are different in terms of the levels of soil moisture, fertility, and weed populations. Due to these differences fallowed land is more favourable for the production of some crops. Therefore, the allocation of stubble acreage should be analyzed separately from the allocation of fallow acreage to reflect this difference in cropping patterns between stubble and fallow land. The necessity of disaggregating stubble from fallow land in acreage allocation analysis is reinforced by the fact that the average yield of crops, a major factor in the determination of acreage supply, is substantially higher on fallow seedbed than on stubble land. In addition, the relative yields for a crop such as wheat seeded on stubble in comparison to fallow are different than barley, oats, rapeseed, and flax. The aggregation of stubble and fallow acreage sacrifices this information and reduces the variability in available data. This misspecification would lead to aggregation bias and impair parameter estimates as well as forecasting abilities.

Lowe and Petrie's experience of less favourable statistical results obtained from disaggregating wheat acreage seeded on stubble and on fallow is likely because, in aggregate analysis, the variations in wheat acreage seeded on stubble and on fallow would cancel out to a certain extent. Less variations in the dependent variable would generally favour the explanatory power and parameter significance in statistical estimation. However, poor forecasting performance may accompany an aggregate study showing good statistical fit when aggregation bias exists. The theoretical advantage in the disaggregation of stubble and fallow acreage is that by eliminating aggregation bias the forecasting performance of conventional acreage supply analysis could be improved.

With the exception of the analysis by Uhm and Pietryk, the studies reviewed aggregated area seeded to the Prairie level. A certain level of aggregation over time periods and individual producers is inevitable to facilitate empirical analysis. However, spatial aggregation at the Prairie level tends to impart an unnecessary aggregation bias since data exist at the provincial level. Uhm empirically confirmed the variations in acreage responses among the Prairie provinces. Aggregation neglects these variations and assumes a homogenous pattern of crop production across the Prairies. Direct application of the results to assist regional policy formulation could thus be restricted by the aggregation.

The single equation approach was adopted by all studies except Colman. In the production process all crops grown in a particular region compete with one another for limited cropland. Given the level of cropland available in a certain time period, an increase in the acreage of any one crop can be accomplished only by corresponding reductions in acreage of other crops. Therefore, the allocation of acreage to alternative crops is essentially an integrated planning process. The adoption of the single equation method to analyze the acreage of each crop in isolation without considering the competitive nature of acreage allocation would result in inefficient estimation of the parameters. Colman's experiment on the multinomial logit model which employed a simultaneous estimation procedure to a system of seemingly unrelated acreage response equations is a more realistic approach to account for the interdependent relationship.

Lowe and Patrie's analysis of the five major crops grown on the Prairies suffered the shortcoming of lacking a constraint on the forecasted acreages. Thus it was possible that the sum of forecasted acreages could exceed the total seeded acreage. Colman remedied this through the construction of a naive model, and a multinomial logit acreage allocation model which constrained the sum of individual acreages to a predetermined total acreage in alternative approaches. However, the naive model provided no guarantee of a positive 'residual' acreage. The multinomial logit model has the advantage of constraining the sum of acreage shares of all major crops to be one, thus ensuring all individual acreages to be positive and to add up to the total acreage.

Distributed lag models have been tested by most previous researchers involved in acreage allocation analysis. A lagged dependent variable played a dominant role in Pietryk's analysis of sunflower acreage in that it accounted for a substantial portion of the explanatory power of the model he employed. Uhm obtained highly significant results incorporating a distributed lag in the ayalysis of rapeseed acreage. Meilke successfully estimated long-run responses of the acreage of wheat, oats, barley with a highly significant coefficient on the lagged dependent variable in all equations. Colman's experiment did not support the distributed lag hypothesis in spite of its theoretical advantage of incorporating dynamic analysis in the measurement of producer response. However, it is reasonable to assume that habitual behaviour and other non-economic factors may impose rigidity in cropping pattern and prevent producers from making instaneous adjustments. Thus, the distributed lag model is more realistic and, therefore, deserves further empirical research.

According to economic theory, producers' expectation of profit on various crops is the most important factor in determining the allocation of land and other resources. It has been the subject of extensive investigation by researchers studying crop supply response. There were disagreements among previous researchers regarding the proxy for profit. These disagreements centered on the specification of which variable best represents 'profit'. Some of the variables suggested were : (i) expected price alone, (ii) expected price and expected yield, and (iii) expected return measured by the product of expected price and yield. There was also controversy regarding the selection of competing crops and the form of how cross-prices were incorporated.

Since the CWB, the authorized international marketing agent for wheat, oats, and barley, has a dominant role in price setting of Board-grains, expected prices for the Board-grains have been formulated mainly based on CWB payments. Meilke tested two alternative specifications;

one included CWB initial and final payments as separate variables, the other combined them as one variable. A one year lag was applied to all initial payments, final payments, and the combined variables to reflect producers' 'expectation' of these payments. Lowe and Petrie used final payments lagged two years from the year when the crop is being seeded as proxies for expected prices on wheat and barley, and the first difference of final payment lagged two years as the proxy for expected oats price. Since final payments are not known to producers until 18 months after seeding, the last observed final payments are for crops seeded almost two years ago. Colman followed Lowe and Petrie in using the last observed final payments as a proxy for expected prices of barley and oats. However, expected price of wheat was formulated based on a function of initial payment and wheat selling quotas for the pre-1970 period and initial payment alone was used as a proxy for expected wheat price for the post-1970 period.

Although Meilke empirically confirmed different influences of initial and final payments on acreage supply response, the specification of both initial and final payments as seperate variables may not be desirable in time series analysis because often the number of historical observations is very limited and the degree of freedom are of concern, especially when there are many other important factors to be incorporated. By specifying final payment lagged for one year as a proxy for expected final payment, Meilke assumed that, when planning acreage allocation in crop year t, producers expect the final payment they will receive for crops being seeded in year t to be the same as the final payment they received for crops seeded in year t - 1. However, since final payment is not received until approximately 18 months after the crop is being seeded, the final payments for crops seeded in year t - 1 would not be known to the producer at seeding time in year t. Thus, implicit in this assumption is that producers forecast final payments for crops seeded in year t - 1 accurately at seeding time in year t. Lowe and Petrie adopted a more plausible assumption that expected final payments were based on the last observed final payments. However, the influence of initial payments on acreage response, which has been confirmed by Meilke, was totally ignored. Since initial payments counted for the major portion of producers' gross receipts from board grains, it is unlikely that producers would overlook initial payments and respond solely to expected final payments. Colman was not consistent in his hypotheses regarding producers' price expectation on Board-grains. Neither did he theoretically justify the assumptions that producers rely on the initial payment in formulating expected price for wheat, and final payments in formulating expected prices for oats and barley.

Lowe-Petrie included separate expected price and expected yield variables in oats and barley acreage equations, while expected price alone was specified in all other equations as a proxy for profit. Colman specified a combination of expected price and yield as an expected total return variable in oats and barley acreage equations, thus impling that producers react to changes in price and yield of oats and barley indifferently in contrast to Lowe-Petrie's hypothesis of different responses. Colman's specification of expected price alone in other acreage equations shares Lowe-Petrie's assumption that the level of production is not a significant determinant influencing the allocation of wheat, rapeseed, and flaxseed acreage. This assumption also applied to Paddock's analysis of rapeseed acreage, as well as Meilke's specification of wheat, oats, and barley acreage.

Meilke included expected barley price in the equation for wheat acreage, and an expected wheat price variable in equations for oats acreage and barley acreage as a proxy for competitive crops. Lowe-Petrie also specified an expected barley price variable in the wheat acreage equation to reflect cross-price effects. However, the influence of competing crops was not accounted for in all other acreage equations. In contrst to Lowe-Petrie, Colman included proxies for direct and cross-price factors in all but the wheat acreage equations. The difference between the expected return for barley and average return of the five major crops was specified in the barley acreage equation. Likewise, the difference between the expected returns from oats and barley was specified in the oats acreage equation. However, price ratios of rapeseed to barley and flaxseed to rapeseed were employed in the rapeseed and flaxseed acreage equations respectively. Flaxseed and wheat were postulated to be the competing crops for rapeseed by Paddock, and Uhm respectively. Pietryk specified two equations of sunflower acreage which employed alternative assumptions regarding the choice of competing crop.

Lowe-Petrie implied that in the allocation of cropland to wheat production, producers considered barley to be competitive, while in the allocation of cropland to the remaining crops producers did not consider any other crop to be significantly competitive. Inconsistency in Colman's specification of proxies for cross-prices among various acreage equations leads to rather confusing implicatins. Based on Pietryk's hypothesis that wheat and rapeseed represent the Board and non-Board alternatives to sunflowers respectively, incorporating both cross-return factors into a single sunflower acreage equation may explain this competing relationship better than incorporating them separately into alternative sunflower acreage equations.

The contradictions among these researchers and the inconsistency in the Lowe-Petrie and Colman specifications are mainly attributed to the adoption of an experimental approach. In the process of acreage allocation to various crops, however, all crops grown in any given area are practically competing against one another for the cropland resource, thus only a complete system of direct and indirect price variables can adequately reflect this competitive relationship.

2.3 SUMMARY

Some promising ideas have emerged from recent studies on acreage response, particularly from Colman. Colman's application of a multinomial logit approach in specifying a system of acreage response equations, which are correlated through the residuals, explicitly accounted for the interrelationship of acreage allocation among alternative crops. The application of simultaneous estimation procedures also enabled efficient statistical estimation for the system of equations. Another desirable property of this approach is that it imposes a constraint on the sum of acreage projections, which is important for forecasting purposes because it limits acreage predictions within a realistic boundry. These desirable properties coupled with the encouraging forecasting performance of the model indicates the advantages of the simulataneous approach over alternative independent equation approach.

However, there is still much to be improved in Colman's specification. Just like other related studies, the failure to disaggregate stubble acreage and fallow acreage, and to disaggregate among the Prairie provinces in his study would lead to aggregation bias and impair parameter estimates and forecasting ability. In addition, Colman selected barley acreage as the common acreage denominator for the other four crops. However, over the period of analysis barley acreage has increased steadily and may result in bias in forecasting if barley acreage ceases to move along the same path. His variable specification based entirely on empirical testing resulted in discrete assumptions among various acreage equations regarding the proxies for profit, price expectation, and the specification of indirect price variables.

This study will basically follow the multinomial logit acreage allocation model developed by Colman, and further develop this model to improve forecasting performance by applying disaggregation of stubble and fallow acreage, and disaggregation among the Prairie provinces. Theoretical considerations will dominate the selection of the common denominator and the specification of a proxy for profit and related variables. The hypothesis of the distributed lag model, which has been supported by most empirical studies of acreage response, will be tested.

Chapter III

MODEL SPECIFICATION

This chapter presents the analytical model that will be used for the analysis of acreage allocation in Western Canada. The basic analytical model incorporated in this study is a multinomial logit model which was introduced by Theil (1969), developed by McFadden (1974), and subsequently exploited by Tyrrell and Mount (1978) as a budget allocation model. Colman (1979) first incorporated the multinomial logit model in empirical analysis of acreage allocation among major crops in Western Canada.

A system of acreage functions representing farmers acreage allocation behaviour for the six crops included in this study will first be specified. The multinomial logit specification of acreage allocation will then be presented and incorporated with the system of acreage functions. An appropriate estimation method for estimating this system of structural relationships will also be examined. Finally, the definition and formulation of exogenous variables will be discussed.

3.1 THE SPECIFICATION OF INDIVIDUAL ACREAGE FUNCTIONS

3.1.1 Acreage Functions

The acreage of crop i, for i = 1, 2, ..., n, is assumed to be determined by a simple exponential function as shown below in equation (1).[14]

$$A_i = e^{f_i(\vec{I}_{ij},\ Z,\ e_i)} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where A_i is acreage of crop i.

f_i is a linear function of $\vec{I}_{ij}$ and Z in unknown parameters.

$\vec{I}_{ij}$ is a vector of expected return of crop i relative to each competing crop j.

$j = 1, 2, \ldots n$ and $j \neq i$.

Z refers to all other factors which may affect farmers decision in land allocation.

e_i is a random disturbance term.

Since this study covers acreage of wheat, oats, barley, rapeseed, flaxseed, and sunflowers, which are represented by w, o, b, r, fl, and sn respectively, detailed specifications of f_i for i = w, o, b, r, fl, sn are presented in equations (1.1) to (1.6).

$$f_w = w0 + w1*Iwfl + w2*Iwb + w3*Iwo + w4*Iwr + w5*Iwsn + w6*TA + w7*GIw + w8*LIFT + e_w \quad \ldots\ldots\ldots\ldots(1.1)$$

$$f_o = o0 + o1*Iflo + o2*Iwo + o2*Ibo + o4*Iro + o5*Isno + o6*TA + o0*GIw + o8*GIfl + e_o \quad \ldots\ldots\ldots\ldots(1.2)$$

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[14] Since farmers in a region tend to maintain a minimum acreage for each crop grown in the area for rotation purposes and for growing livestock feed, the exponential form of the acreage function is specified because it imposes a positive minimum acreage for each crop.

$$f_b = b0 + b1*Ibfl + b2*Iwb + b3*Ibo + b4*Ibr + b5*Ibsn + b6*TA + b7*GIw + b8*GIb + e_b \quad \ldots\ldots (1.3)$$

$$f_r = r0 + r1*Irfl + r2*Iwr + r3*Ibr + r4*Iro + r5*Irsn + r6*TA + r7*GIw + r8*GIr + r9*RAPEADP + e_r \quad \ldots\ldots (1.4)$$

$$f_{sn} = s0 + s1*Iflsn + s2*Iwsn + s3*Ibsn + s4*Irsn + s5*Isno + s6*TA + s7*GIw + s8*GIsn + e_{sn} \quad \ldots\ldots (1.5)$$

$$f_{fl} = f0 + f1*Iwfl + f2*Ibfl + f3*Irfl + f4*Iflo + f5*Iflsn + f6*TA + f7*GIw + f8*GIfl + e_{fl} \quad \ldots\ldots (1.6)$$

where ix is the coefficient on each corresponding variable for i = w, o, b, r, fl, sn; x = 0, 1, 2, ..., 9.

I_{ij} refers to (ecpected return from crop i) / (expected return from crop j), eg., Iwfl = relative expected return of wheat to flaxseed.

GIi refers to grain inventory of crop i.

TA is total acreage of w, o, b, r, fl, and sn.

LIFT is a zero-one dummy variable which reflects the effect of LIFT program in 1970.

RAPEADP refers to rapeseed adoption which reflects the rate farmers adopt management skills.

e_i refers to the error term.

3.1.2 The Selection of Exogenous Variables

Based on the economic theory of profit maximization, producers' major economic considerations in formulating production plans and allocating resources to alternative uses are the expected returns from various products and associated production costs. In agricultural crop production, however, since there is little difference in the average cost for growing alternative crops, and any difference in production cost in growing alternative crops would be known by producers, the comparison of profit among crops can be made on the basis of revenue.[15] Thus, expected returns on alternative crops are the most important factors affecting producer decision on acreage allocaton. Since every crop grown in a particular area competes with all alternative crops for the same input, i.e., cropland, a set of variables representing relative expected return of crop i to each alternative crop j[16] are therefore specified for each acreage function f_i to form a complete system of direct and cross-return relationships reflecting the competitive nature among cropping alternatives in the same area. The system of relative expected return variables also embodies changes in technology over time which influence the long-term direction of crop production - such as the varying rate of development of higher yielding varieties among alternative crops, the advances in disease and pest controls which reduce risks - by accounting for differences in yield changes.[17]

It is hypothesized in this study that production planning for various crops is influenced by a resource constraint such as the quantity of available cropland. The total acreage of cropland (TA) is therefore in-

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[15] Craddock, W.J., "Economics of Oilseed Production", Oilseed and Pulse Crop in Western Canada Symposium, 1975, p. 684.

[16] Refers to I in equations (1.1) - (1.6), where i = w, o, b, r, fl, sn; and j = w, o, b, r, fl, sn, and i = j.

[17] Meilke, K.D. and Kramar, R.E., "Acreage Response in Ontario", Canadian Journal of Agricultural Economics, vol. 24, no.1, 1976, p. 53.

cluded in the determination of acreage of each crop to reflect the supply of cropland. A dummy variable, LIFT, is specified in the wheat acreage function to reflect the influence of the LIFT program in 1970. Since the purpose of LIFT was to encourage farmers to reduce wheat acreage and hold cropland out of grain production without a wholesale switch to other crops,[18] the operation of this program was expected to cause a drastic reduction in wheat acreage and an increase in summerfallow acreage. Therefore, the effect of LIFT on other crops is presumed to be minor.[19] Wheat stocks are included in all acreage functions because wheat is the most important crop grown on the Prairies and is considered as the major alternative to other crops. Therefore, a build-up of on-farm wheat stocks is expected to cause farmers to reallocate land away from wheat production to alternate uses. Stocks of oats, barley, rapeseed, and flaxseed are specified in each respective acreage function since large carryovers of a crop would generally discourage producers from the production of that particular crop.[20] Rapeseed is a relatively new crop in the Prairies which requires a higher level of management than other alternative crops in terms of fertilizer technology, disease, pests and weeds controls. A rapeseed adoption (Rapeadp) variable is specified in

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[18] Sahi, R.K. and Craddock, W.J., "Effect of LIFT on Land Use", Canadian Farm Economics, no.5, 1971, p.2.

[19] Ibid., pp. 1-7. Sahi and Craddock conducted an investigation into the impact of LIFT on Prairie land utilization and concluded that it resulted in a large increase in summerfallow acreage in 1970. However, no significant influence on acreage of other crops was found.

[20] There is a contractual arrangement between sunflower producer and CSP Foods Ltd., a dominant buyer of sunflower seeds, which stipulates that total production of sunflower seeds from the area specified in the contract be purchased. Producers historically have sold their entire crop within the marketing year and no inventory on sunflower seeds have been recorded. Pietryk, op. cit., pp. 52-53.

the rapeseed acreage function as a proxy for farmers' learning process in the adoption of advanced management skills.[21]

Other non-controllable factors such as weather and risk are omitted from the analysis and treated as part of the random disturbance in spite of their possible influence on the determination of acreage allocation in order to concentrate on the economic factors.

3.2 THE MULTINOMIAL LOGIT SPECIFICATION OF ACREAGE ALLOCATIONS

The multinomial logit model explains the allocation of total acreage of cropland to the production of alternative crops in terms of a set of percentage shares which lie between zero and one and add to one, thus constraining the sum of projected acreage of individual crops to the total acreage of cropland.

3.2.1 The Model

In the allocation of total acreage of cropland (TA) to the production of n crops, The percentage share of acreage of crop i (S_i) is given by :

$$S_i = A_i \;/\; TA = A_i \;/\; (\sum_{k=1}^{n} A_k) \;\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

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[21] Some researchers, such as Lowe-Petrie, and Colman, included a TREND variable in their acreage function of oats to account for the steady shift from oats acreage to barley acreage over the last two decades. Since this trend was mainly attributed to less success in the development of high yield varieties of oats in contrast to that of barley which made oats less competitive than barley, the set of relative return variables in the system of equations was presumed to pick up this influence and a trend variable is considered unnecessary.

where the subscript i refers to individual crops.

$i = 1, 2, 3, \ldots, n$

A_i is the acreage of crop i.

$TA = \sum_{k=1}^{n} A_k$

It follows from equation (2) that the sum of acreage shares of all individual crops will always equal one.

$$\sum_{i=1}^{n} S_i = \left(\sum_{i=1}^{n} A_i \right) / \left(\sum_{k=1}^{n} A_k \right) = 1 \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Incorporating the exponential acreage function in equation (1) into equation (2), we obtain:

$$S_i = \frac{A_i}{\sum_{k=1}^{n} A_k} = \frac{e^{f_i(\vec{I}_{ij},\ Z,\ e_i)}}{\sum_{k=1}^{n} f_k(I_{kj},\ Z,\ e_k)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where $i = 1, 2, \ldots, n$, and $j \neq i$, $j \neq k$

It follows that the ratio of the acreage share of crop i (S_i) to a common acreage share of crop m (S_m) can be expressed as :

$$\frac{S_i}{S_m} = \frac{A_i / (\sum_{k=1}^{n} A_k)}{A_m / (\sum_{k=1}^{n} A_k)} = \frac{A_i}{A_m} = \frac{e^{f_i(\vec{I}_{ij},\ Z,\ e_i)}}{e^{f_m(\vec{I}_{mg},\ Z,\ e_m)}} \ldots\ldots\ldots\ldots (5)$$

where $j = 1, 2, \ldots, n$ and $j \neq i$

$g = 1, 2, \ldots, n$ and $g \neq m$

It also follows that the percentage share of acreage of crop i (S_i) can be expressed as :

$$S_i = \frac{A_i}{A_m} \cdot S_m = \frac{e^{f_i(\vec{I}_{ij},\ Z,\ e_i)}}{e^{f_m(\vec{I}_{mg},\ Z,\ e_m)}} \cdot S_m \quad \ldots\ldots\ldots\ldots\ldots (6)$$

$$\text{where}\quad S_m = \frac{A_m}{\sum_{k=1}^{n} A_k} = \frac{A_m / A_m}{\sum_{k=1}^{n} (A_k/A_m)} = \frac{1}{\sum_{K=1}^{m-1}(A_k/A_m)+1+\sum_{k=m+1}^{n}(A_k/A_m)}$$

Equation (6) shows that the acreage share of any crop j (S_j) can be derived from the set of n - 1 acreage ratios of A_i to one common acreage A_m for i = 1, 2, ..., n and i ≠ m. The acreage of each crop j (A_j) can be obtained by multiplying S_j to the predetermined total acreage (TA). The acreage of the crop employed as the common base (A_m) can be treated as a residual and set equal to the total acreage minus the sum of acreages of all other crops.

In order to obtain the acreage share (S_j) for crop j, the set of n-1 acreage ratios A_i / A_m as given by the exponential form in equation (5) must be estimated.

Major advantages of this approach include : i) The sum of projected acreages of all crops is constrained to the predetermined total acreage since the sum of the percentage shares always equals one, ii) farmers' simultaneous allocation of cropland among alternative crops has been embodied in the specification, and iii) projected acreage of any crop will always be positive.

3.2.2 Choice of the Crop to be the Common Denominator for Other Acreages

To facilitate empirical estimation, the acreage of one of the crops covered in this study had to be chosen as the common denominator for the others. Since there is no theoretical basis on which to make this selection, the choice was made through the elimination of crops exhibiting a trend in seeded area. A close examination of the movement of the acreages of the crops under study revealed that with the exception of wheat and flaxseed, the acreages of all other crops exhibited a consistent trend over the period of analysis for all three provinces. The acreages of barley, rapeseed, and sunflowers showed an increasing trend, while oats had a decreasing trend between 1961 and 1981. The presense of a trend is not desirable for the acreage serving as the common denominator because it may build in bias on post-estimation forecasting if the trend does not continue. Wheat acreage may not be appropriate because the annual area seeded is almost as large as the sum of the acreages of all other crops. If chosen to be the common denominator, the size of the wheat acreage would restrict the variations in acreage ratios. Therefore, flaxseed acreage was chosen as the common denominator because it showed no trend over the period of analysis and was relatively small.

3.2.3 The Form of the Model

To facilitate empirical estimation, the exponential form of acreage ratios in equation (5) was transformed into linear function by taking the natural logarithm :

$$\ln(A_i/A_m) = \ln(e^{f_i}/e^{f_m}) = f_i(\overset{>}{I}_{ij}, Z, e_i) - f_m(\overset{>}{I}_{mg}, Z, e_m) \; ......(7)$$

Incorporating equations (1.1) - (1.6) into equation (7), the form of the model to be used in estimating crop acreages was obtained in equations (8.1) - (8.5).

$$\begin{aligned}\ln(A_w/A_{fl}) = {} & wf0 + wf1*lwfl + wf2*lwb + wf3*lwo + wf4*lwr + wf5*lwsn \\ & + wf6*lbfl + wf7*lrfl + wf8*lflo + wf9*lflsn + wf10*TA \\ & + wf11*Glw + wf12*LIFT + wf13*Glfl + e_{wf} \quad\ldots\ldots\ldots (8.1)\end{aligned}$$

$$\begin{aligned}\ln(A_o/A_{fl}) = {} & of0 + of1*lflo + of2*lwo + of3*lbo + of4*lro + of5*lsno \\ & + of6*lwfl + of7*lbfl + of8*lrfl + of9*lflsn + of10*TA \\ & + of11*Glw + of12*Glo + of13*Glfl + e_{of} \quad\ldots\ldots\ldots (8.2)\end{aligned}$$

$$\begin{aligned}\ln(A_b/A_{fl}) = {} & bf0 + bf1*lbfl + bf2*lwb + bf3*lbo + bf4*lbr + bf5*lbsn \\ & + bf6*lwfl + bf7*lrfl + bf8*lflo + bf9*lflsn + bf10*TA \\ & + bf11*Glw + bg12*Glb + bf13*Glfl + e_{bf} \quad\ldots\ldots\ldots (8.3)\end{aligned}$$

$$\begin{aligned}\ln(A_r/A_{fl}) = {} & rf0 + rf1*lrfl + rf2*lwr + rf3*lbr + rf4*lro + rf5*lrsn \\ & + rf6*lwfl + rf7*lbfl + rf8*lflo + rf9*lflsn + rf10*TA \\ & + rf11*Glw + rf12*RAPEADP + rf13*Glr + rf14*Glfl + e_{rf} (8.4)\end{aligned}$$

$$\begin{aligned}\ln(A_{sn}/A_{fl}) = {} & sf0 + sf1*lflsn + sf2*lwsn + sf3*lbsn + sf4*lrsn + sf5*lsno \\ & + sf6*lwfl + sf7*lbfl + sf8*lrfl + sf9*lflo + sf10*TA \\ & + sf11*Glw + sf12*Glfl + e_{sf} \quad\ldots\ldots\ldots\ldots\ldots (8.5)\end{aligned}$$

The final specification of the model, as shown in equations (8.1) to (8.5), consists of a system of five equations in which the dependent variables are the logarithms of the ratios of the acreages of wheat, oats, barley, rapeseed, and sunflowers to flaxseed acreage. The explanatory variables in each equation are postulated to influence the logarithm of the ratio of acreage of crop i to acreage of flaxseed. Therefore, the coefficient B_j for any variable X_j in any one of the equations

(8.1) to (8.5) should be interpreted as consisting of two parts : $B_{ji} - B_{jfl}$. Where B_{ji} reflects the effect of X_j on the acreage of crop i, and B_{jfl} reflects the effect of X_j on the acreage of flaxseed. Therefore, 'a priori' expectation on the signs of these structural coefficients, which depend on the relative impact of X_j on acreage of crop i to flaxseed, can not be established in a straightforward manner.[22]

3.3 APPROPRIATE ESTIMATION TECHNIQUE

The multinomial logit acreage allocation model presented in the previous section consists of a system of five equations which are correlated through the disturbance terms because of the restriction that the sum of the individual acreage shares equal one. For example, if a higher-than average prediction is made for acreages of wheat, oats, barley, rapeseed, and sunflowers in a given year, the arithmetic of the model would result in a lower-than-average prediction of acreage for the residual crop, namely, flaxseed for that year.

The presence of cross equation correlation of the disturbance terms in this model suggests that for efficient estimation, the correlation among disturbance terms across equations must be taken into account explicitly. Zellner's Seemingly Unrelated Estimation Method, which applies generalized least-squares estimation to a system of seemingly unrelated equations, is considered most appropriate for estimating this relationship and was therefore adopted for the regression. The nonzero covariances explicitly account for the cross-equation disturbance corre-

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[22] Colman, D., op.cit., p. 41.

lations at a given point in time, and thus efficient estimation can be achieved.[23]

3.4 VARIABLE DEFINITION AND FORMULATION

The model developed earlier in this chapter postulated that factors influencing the allocation of cropland to alternative crops include : expected relative returns from alternative crops, inventories of grains, total acreage of cropland, the LIFT program, and rapeseed adoption. This section reports the formulation of these variables and the rationale behind them.

3.4.1 Relative Expected Returns Variables

The specification of expected returns is basically in line with Colman's assumptions[24] that : 1) It is the expected return per acre, defined as the expected price multiplied by the expected yield per acre, which is most relevant to producers' response. These expected return variables are essentially incorporated as proxies for farmers expectations of profit. There is no theoretical ground for producers to differentiate the components of profit, i.e., whether the potential profit be generated from favourable price or yield. Therefore, Meilke and Kramer's suggestion of imcorporating separate price and yield variables[25] is not considered in this analysis. The specification of ex-

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[23] Zellner, A., "An Efficient Method of Estimating Seemingly Unrelated Regressions and Test for Aggregation Bias", Journal of the American Statistical Association, 57(298), 1962, pp. 348-68.

[24] Colman, D., op. cit., pp. 12-13.

pected return instead of separate price and yield variables also preserves substantial degrees of freedom. 2) Rather than incorporate separately the expected return of every crop, the concept of relative return is adopted by incorporating ratios of the expected returns of alternative crops because the specification of profit in real terms instead of nominial terms can better reflect inter-crop competition.

Although most studies related to supply response analysis assumed that producers base their expected yield for a crop on average yield in the previous year, it is hypothesized in this analysis that producers formulate yield expectations based on the experience of the past three consecutive years because crop yields tend to be affected by weather which can not be adequately reflected by looking at only the past year. The expected $\text{yield}_t = (\text{yield}_{t-1} + \text{yield}_{t-2} + \text{yield}_{t-3}) / 3$

In order to formulate producers' expectation of prices for various crops, the marketing mechanism for Prairie crops is briefly examined. The CWB has become the dominant institution which has direct or indirect influence over the marketing of crops grown in the Prairie provinces. Since the establishment of the CWB in 1935 as a Crown Agency by the passage of the CWB Act, the CWB has had direct influence over the marketing of wheat grown in the Prairie provinces. Subsequent revisions and policy changes have made the CWB a government-controlled compulsory marketing agency for wheat in the export and domestic consumption markets, as well as for oats and barley in export markets.[26] For administrating

[25] Meilke, K. and Kramar, R., "Acreage Response in Ontario", C.J.A.E., Vol 24, no.1, 1976, pp. 55.

[26] The CWB also had monopoly control over the marketing of interprovin-

these responsibilities, the CWB implemented some policies and programs to control prices, delivery, as well as transportation of Prairie grains.

The most influential instrument administered by the CWB is the price pooling system which averages out price variations within a crop year and provides producers the same price throughout the crop year for grains marketed through the Board. Under the price pooling system, Prairie grain producers receive an initial payment upon delivery of their wheat, oats, and barley and a final payment some time after the Board has completed marketing the grains. Interim payments have also been paid in certain years prior to making the final payments to adjust the initial payments to a level justified by price movements and furture commitments. The delivery quota system is implemented to provide farmers equal opportunity to sell their grains to the CWB. The delivery quotas are based upon the land area a farmer has improved for crop production. When export sales are depressed and/or stocks of grain are high, the quota restrictions may not permit producers to sell all their grains.

Besides the Board market, there are alternative non-Board open markets including grains sold between farms, to feed mills, country elevators, and other uses, which are not subject to the intervention of the CWB. Prices in the non-Board markets are determined by market forces. In spite of the existence of various selling prices in off-Board mar-

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cial feed grains in Western Canada from 1948 until a new national feed grain policy was established in 1974 which allows private trading of feed grains for domestic consumption.

kets, CWB payments have been found to be most significant as a basis for price expectations by Meilke, Lowe-Petrie, and Colman although the forms under which these payments are incorporated are different. Since most of the wheat and about three-quarter of oats and barley grown in the Prairies are sold via the CWB,[27] the CWB payments can best reflect the prices upon which grain producers formulate their expectations. Therefore, expected prices of wheat, oats, and barley are formulated entirely on the basis of the CWB payments in this analysis.

Although Meilke empirically confirmed that prairie farmers react differently to changes in initial and final payments, the cost in terms of the degrees of freedom sacrificed by incorporating initial and final payments separately were found to be unacceptable for this analysis. Interim payments have not been made frequently over the period of analysis, and it is not likely that producers would count on them. Therefore, a more proper assumption would be that producers form their price expectations on wheat, oats, and barley based on a combination of initial and final payments.

Before 1971, initial payments were not known to producers prior to seeding each year. However, they have been announced prior to seeding in each crop year since 1971. Final payments are generally announced about six months after the close of each marketing year. For crops seeded in the spring of year t the final payments would not be known to producers until January in year $t + 2$. It is assumed producers formulate their price expectations on the latest information available for initial and

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[27] Lowe, J.C. and Petric, T.M., op. cit., p.22.

final payments at the time planting decisions are made. Therefore, expected prices of wheat, oats, and barley are specified as initial payments lagged for one year plus final payments lagged for two years for the period prior to 1971, and current initial payments plus final payments lagged for two years for the period since 1971.

The marketing procedure for sunflower seeds is similar to that for wheat, oats, and barley through the CWB price pooling system except that the dominant buyer of sunflower seeds is CSP Foods LTD., which is a joint venture owned by Manitoba Pool Elevators and Saskatchewan Wheat Pool. CSP Foods LTD. has had contractual arrangement with sunflower producers since 1950 to purchase producers' total production from contracted areas. Under these contracts, the producers are paid an initial price plus a pooled final payment which depends on the realized revenue of the processing firm.

The initial price for sunflowers was announced prior to seeding in each crop year from 1959 to 1974 as a guaranteed floor price. Since 1975 the floor price has not been guaranted. Instead, a flexible initial price equivale to 80 percent of rapeseed price at time of delivery has been adopted. Final payment is generally received by producers within six months of the close of the marketing year.[28] Therefore, producers' expectation of the price of sunflower seeds is formulated by combining the guaranteed floor price in the current year and the final payment lagged for two years for the period 1961 to 1974, and formulated by combining the initial price lagged for one year and final payment lagged

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[28] Pietryk, J.W., op. cit., pp.52-54.

for two years since 1975.

Prices of rapeseed and flaxseed are established in the non-Board open market.[29] Producers usually receive the full payment for their crops upon delivery to the country elevator. It is, therefore, postulated that producers' expectations of rapeseed and flaxseed prices are based upon the average prices of rapeseed and flaxseed received during the six months prior to seeding.

3.4.2 Other Variables

The rapeseed adoption variable is specified to reflect the systematic upward shift in rapeseed acreage due to farmers' gradual learning and adoption of advanced management skills for growing rapeseed. It is postulated that this adoption process lasted for about a decade from 1960 to 1970. During this period there was a rapid expansion in rapeseed production in the Prairies. The rapeseed adoption variable is therefore assigned the value of one in 1960, increased by one for each additional year until 1970, and then assigned the same value of 11 since 1970.

The LIFT variable which measures the impact of the LIFT Program in 1970 is a zero-one dummy variable asigned the value of one in 1970 and zero otherwise.

Alternative formulations of grain inventory variables have been tested in this analysis. These included absolute levels of grain stocks, stocks of each grain as a percentage of total stocks of all grains, and

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[29] Pietryk, op. cit., p.55.

expected stocks.[30] No significant difference was found among the results generated from these alternative formulations. Therefore, absolute levels of grain inventories were adopted for simplicity.

The total acreage variable (TA) is represented by TAs and TAf for stubble acreage and fallow acreage respectively. TAs is defined as the sum of acreage of wheat, oats, barley, rapeseed, flaxseed, and sunflowers seeded on stubble. TAf is defined as the sum of acreage of wheat, oats, barley, rapeseed, and flaxseed seeded on fallow.

3.5 SIMULATION PROCEDURES

The acreages of wheat, oats, barley, rapeseed, flaxseed, and sunflowers can be simulated according to the following procedures :

1). Simulate the endogenous variables in the model, i.e., logarithm of acreage ratios of wheat, oats, barley, rapeseed, and sunflowers to flaxseed ($\ln(\widehat{A_w/A_{fl}})$, $\ln(\widehat{A_o/A_{fl}})$, $\ln(\widehat{A_b/A_{fl}})$, $\ln(\widehat{A_r/A_{fl}})$, $\ln(\widehat{A_{sn}/A_{fl}})$) by inserting relevant values of exogenous variables into the system of estimated equations and computing the predicted values of the endogenous variables.[31]

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[30] Expected stocks for each crop were formulated in terms of the difference between expected supply and expected disappearence from which a minimum level of stocks was deducted to account for stocks farmers usually keep.

[31] '^' mark on top of a variable indicates that the variable is projected. Sunflower acreage A_{sn} applies to the simulation of Stubble/Manitoba only.

2). Take anti-log of the simulated endogenous variables, the estimated acreage ratios ($(\widehat{A_w/A_{fl}})$, $(\widehat{A_o/A_{fl}})$, $(\widehat{A_b/A_{fl}})$, $(\widehat{A_r/A_{fl}})$, and $(\widehat{A_{sn}/A_{fl}})$) are obtained.

3). The percentage share of acreage of crop i (S_i) for i = w, o, b, r, sn is simulated using the formula :

$$\hat{S}_i = (\widehat{A_i/A_{fl}}) * \hat{S}_{fl}$$

$\hat{S}_{fl}$ is acreage share of flaxseed and is equal to :

$$1 / ((\widehat{A_w/A_{fl}}) + (\widehat{A_o/A_{fl}}) + (\widehat{A_b/A_{fl}}) + (\widehat{A_r/A_{fl}}) + (\widehat{A_{sn}/A_{fl}}) + 1)$$

4). The acreage of crop i (A_i) is then simulated as below :

i. For crops seeded on stubble :

$$\hat{A}_i = \hat{S}_i * \hat{TAs}, \quad \text{for } i = w, o, b, r, sn.$$

$$\hat{A}_{fl} = \hat{TAs} - \hat{A}_w - \hat{A}_o - \hat{A}_b - \hat{A}_r - \hat{A}_{sn}$$

ii. For crops seeded on fallow :

$$\hat{A}_i = \hat{S}_i * \widehat{TAf}, \quad \text{for } i = w, o, b, r.$$

$$\hat{A}_{fl} = \widehat{TAf} - \hat{A}_w - \hat{A}_o - \hat{A}_b - \hat{A}_r$$

Chapter IV

RESULTS OF THE ESTIMATION

The application of Zellner's Seemingly Unrelated regression procedure on the multinomial logit model for the allocation of stubble and fallow acreage in Manitoba, Saskatchewan, and Alberta generated six different sets of estimates. These estimates are Stubble/Manitoba, Stubble/Saskatchewan, Stubble/Alberta, Fallow/Manitoba, Fallow/Saskatchewan, and Fallow/Alberta. Each of these six models was made up of a system of four equations - wheat/flaxseed, oats/flaxseed, barley/flaxseed, and rapeseed/flaxseed equations. A sunflowers/flaxseed equation was included in the Stubble/Manitoba model to add completeness to the system of acreage equations because sunflowers are primarily grown in Manitoba on stubble seedbed. Basically the corresponding equations in these models incorporated the same set of explanatory variables except that equations in the Stubble/Manitoba model included a few more relative return variables to account for cross-return effect from sunflowers. Some variables which were statistically insignificant in the preliminary analysis were dropped from the final estimation. Most of the grain inventory variables were dropped with the exception of wheat and flaxseed stocks. A lagged dependent variable was initially included among the list of exogenous variables in all equations based on the hypothesis of the distributed lag model. However, it was dropped from some of the equations because of statistical insignificance. This left some equations in distributed lag form and others in static form.

The results of the estimation are summarized in Tables 4.1 to 4.6. The statistics in parentheses beneath each regression coefficient are the t-values. The level of significance for each coefficient is indicated by the number of asterisks besides the coefficient. Three, two, and one asterisk indicate that the coefficient is statistically significant at the one, five, and ten percent level of confidence respectively. The Coefficient of Multiple Determination adjusted for degree of freedom ($\bar{R}^2$) is presented.[32] Durbin-Watson statistic and Durbin's h-statistic are also reported for testing autocorrelation of the residuals over time.

4.1 CROPS SEEDED ON STUBBLE

4.1.1 Manitoba

The results of estimating the acreage allocation model for crops seeded on stubble in Manitoba are presented in Table 4.1. In the specification of the multinomial logit acreage allocation model, the explanatory variables in the equation, i/flaxseed, are postulated to influence the logarithm of the acreage ratio of crop i to flaxseed. Straight interpretation of the estimated coefficients is difficult. For example, the coefficient of the stock of wheat is (-.013745) in the wheat/flaxseed equation. Stated in the simplest manner, it indicated that an increase in the wheat inventory by ten thousand bushels would reduce the logarithm of wheat to flaxseed acreage ratio by .13745. More meaningful

[32] Since the number of regressors is large in relation to the sample observation in this model, the values of R square would be misleadingly high, therefore, only the adjusted R square is reported, which is a modified coefficient of determination taking into account the number of exogenous variables in relation to the number of observations.

TABLE 4.1 Results Of Estimating The Stubble/Manitoba Model

Exogenous Variable	Dependent Variables (natural logs) Acreage of Wheat to Flax	Acreage of Barley to Flax	Acreage of Rapeseed to Flax	Acreage of Oats to Flax	Acreage of Sunflower to Flax
Adjustment Coefficient	.65736	.02377	.6553	.41864	.65275
Income of Wheat to Flax	-3.6136*** (-3.22)	-3.5729* (-1.63)	-5.0539*** (-2.70)	-.56502 (-0.38)	3.3619 (1.39)
Income of Barley to Flax	7.4032*** (5.50)	6.0547** (2.08)	1.9064 (0.78)	-.42242 (-0.23)	-14.809*** (-2.89)
Income of Rapeseed to Flax	.32400 (0.68)	.88358 (1.25)	6.4801*** (4.81)	.67192 (1.06)	5.5762*** (5.88)
Income of Flax to Oats	.61723 (0.84)	-1.2033 (-0.88)	5.0070*** (3.31)	-1.6927 (-1.25)	.50453 (1.33)
Income of Flax to Sunflower	2.1222*** (4.27)	2.8431 (1.43)	-1.3117 (-1.24)	.40158* (1.68)	-6.4732** (-2.44)
Income of Wheat to Barley	6.2725*** (5.93)	4.0157** (1.96)			
Income of Wheat to Oats	-1.0110* (-1.52)			1.2547 (1.04)	
Income of Wheat to Rapeseed	.43777 (0.93)		3.3626* (1.67)		
Income of Wheat to Sunflower	-2.1002*** (-4.07)				-1.4348 (-0.62)
Income of Barley to Oats		1.0332 (0.75)		.48195 (0.32)	
Income of Barley to Rapeseed		.42577 (0.47)	-1.7220 (-0.71)		
Income of Barley to Sunflower		-2.6115 (-1.21)			2.884 ** (2.54)
Income of Rapeseed to Oats			-4.7316*** (-3.51)	-.59241 (-0.99)	
Income of Rapeseed to Sunflower			1.2298 (1.25)		-6.6274*** (-5.77)
Income of Sunflower to Oats				.058632 (0.37)	-1.5551*** (-3.23)
Rapeseed Adoption			.092818* (1.81)		
LIFT	-.38223*** (-2.97)				
Total Stubble Acreage (million acres)	.35230*** (4.11)	.04419 (0.39)	.40836*** (3.35)	-.13187** (-1.96)	.73489*** (3.86)
Inventory of Flaxseed ('000 bushels)	.07142*** (3.15)	.14695*** (3.55)	.03784 (1.32)	.09455** (2.27)	.06288* (1.69)
Inventory of Wheat ('000 bushels)	-.01374*** (-4.59)	-.00914** (-2.16)	.00297 (0.76)	-.01526*** (-5.58)	.00549 (1.22)
Inventory of Barley ('000 bushels)		-.14139** (-2.01)			
Intercept	-11.284*** (-6.45)	-7.7886** (-2.48)	-8.9805*** (-6.11)	1.6069 (1.08)	3.3805 (1.40)
$\bar{R}^2$	.96	.87	.98	.89	.93
D-W	2.26	1.70	2.52	1.66	2.13
D-h	-1.13	.70	-2.10	.96	-.69

***, **, and * indicate that the coefficient is statistically significant at the one, five, and ten percent level of confidence respectively.
D-W : Durbin-Watson statistics
D-h : Durbin's h-statistics

interpretation of the results would be best accomplished by computing the elasticities of acreage share of each crop with respect to the explanatory variables through simulation procedures. However, this was not done due to resource constraints.

Many estimated coefficients of the relative return variables in the model were found to be statistically insignificant. These results were not particularly surprising because a complete set of relative return variables incorporated in the equations were likely to be correlated. Insignificant coefficients on these variables were probably a result of the interaction among the set of relative return variables. Attempts were made to improve the statistical fit by dropping the insignificant relative return variables. However, the results showed a dramatic decline in the adjusted R square and an increase in the standard error of the estimation. This could be because the inclusion of a complete system of relative return variables, which reflected the influence of all competing crops correctly specified the acreage allocation relationships. Dropping the insignificant relative return variables from the analysis impaired the completeness of the specification. Therefore, the system of relative return variables were retained despite the problem of multicollinearity.

Rapeseed and oats stocks were dropped since they failed to produce statistically significant coefficients. Coefficients on the remaining variables in the model were all highly significant with the exceptions of the area of the six crops seeded on stubble (TAs) in the barley/flaxseed equation and inventory of wheat in the rapeseed/flaxseed equation.

The value of the coefficient on the lagged dependent variable in wheat/flaxseed, rapeseed/flaxseed, and sunflowers/flaxseed equations was about .34, which means that the coefficient of adjustment for these equations was around .66, and implied long-run responses about fifty percent larger than the short-run responses.[33] Interpreting in terms of a partial-adjustment distributed lag model, about 64 percent of the desired adjustment was realized during any one year and about three years would be required to complete 95 percent of the full adjustment. The barley/flaxseed equation had a very large lagged dependent variable coefficient (.98), and hence the estimated adjustment coefficient was close to zero, which appeared rather unrealistic. The coefficient of the lagged dependent variable in oats/flaxseed equation was .58, hence the adjustment coefficient was .42, which implied that the long-run response of the dependent variable to changes in exogenous variables was two and half times as large as that of the short-run. It would take about six years to complete 95 percent of the full adjustment.

The over all goodness of fit of the system of equations in explaining changes in the dependent variables was considered quite satisfactory as indicated by the values of the adjusted R square, which ranged from .87 for the barley/flaxseed equation to .98 for the rapeseed/flaxseed equation. Approximately 87 to 98 percent of the variations in the dependent variables were explained by the system of equations.

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[33] The coefficient of adjustment is defined as the difference between one and the coefficient of the lagged dependent variable. Long-run regression coefficients can be derived by dividing the short-run coefficients by the coefficient of adjustment.

Judging from the values of the Durbin-Watson statistic, which fell in the inconclusive range at the five percent level of significance for all equations in the model, serial correlation in the residuals did not appear to be a problem. Durbin's h-statistic was also examined for detecting autocorrelation because it had been suggested that the Durbin-Watson statistic was not appropriate for testing the existence of autocorrelation when the lagged dependent variable was used as a regressor.[34] All equations but the rapeseed/flaxseed equation satisfied the null hypothesis of no autocorrelation at the five percent level of significance.

4.1.2 Saskatchewan

The results of estimating the Stubble/Saskatchewan model were presented in Table 4.2. The variable LIFT was removed from the model because statistical results did not justify its retention.

Although only a few relative return variables in the model had coefficients which were significant at the five percent level of confidence, the whole system of variables had to be accepted in order to save the completeness of the structural model. Stocks of barley, rapeseed, and oats were dropped from the estimation because of insignificant coeffi-

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[34] The Durbin-Watson Statistic is biased toward two when a lagged dependent variable is included as a regressor. Nerlove, M. and Wallis, K., "Use of the Durbin-Watson Statistic in Inappropriate Situations", Econometrica, vol. 34, 1966, pp. 235-8. It should also be noted that Durbin-h Statistic is appropriate only for testing autocorrelation for models involving lagged dependent variables with sample size larger than 30. See J. Durbin, "Testing for Serial Correlation in Least-Squares Regression When Some of the Regressors are Lagged Dependent Variables", Econometrica, vol. 38, 1970, pp. 410-21.

cients. The lagged dependent variable was dropped from all, except the barley/flaxseed equation, because either the estimated coefficient was not significantly different from zero, or a negative coefficient was obtained which resulted in unacceptable economic implications. The removal of these variables from the model did not cause much loss in explanatory power of the equations although the estimated coefficients on some of the variables remaining in the system changed substantially.

The estimated coefficient of the lagged dependent variable in the barley/flaxseed equation was .49. Thus, the coefficient of adjustment was about .51, which indicated the long-run response was twice as large as the short-run response. Since around 51 percent of the desired adjustment was realized during any single year, the effect of a particular change in the explanatory variable could be expected to be significant for a period of four years.

The wheat/flaxseed and rapeseed/flaxseed equations, despite many variables in these equations had low t-ratios, explained about 84 and 86 percent of the variations in the dependent variable respectively. However, the corrected R square in the barley/flaxseed and oats/flaxseed equations disclosed that only about 58 and 67 percent of the respective fluctuations in the dependent variables were explained.

The Durbin-Watson Statistic for each equation in the model and Durbin's h-statistic for the barley/flaxseed equation indicated that there was no evidence of the presence of serial correlation with the exception of the wheat/flaxseed equation.

TABLE 4.2 Results of Estimating The Stubble/Saskatchewan Model

Dependent Variables (natural logs)

Exogenous Variable	Acreage of Wheat to Flax	Acreage of Barley to Flax	Acreage of Rapeseed to Flax	Acreage of Oats to Flax
Adjustment Coefficient		.51088		
Lagged Dependent Variable		.48912*** (4.04)		
Income of Wheat to Flax	6.0957* (1.53)	.84523 (0.19)	-3.1952 (-1.29)	2.3682 (1.44)
Income of Barley to Flax	-6.9814 (-1.48)	-.57093 (-1.11)	-.84248 (-0.33)	-.15234 (-0.06)
Income of Rapeseed to Flax	1.3196 (1.30)	.47224 (0.40)	4.1010*** (3.52)	-.47964 (-0.52)
Income of Flax to Oats	.68075 (0.57)	.33686 (0.21)	-.01787 (-0.02)	.78050 (0.65)
Income of Wheat to Barley	-3.6977 (-0.96)	.12829 (0.03)		
Income of Wheat to Oats	-1.4139 (-1.19)			-1.7534* (-1.56)
Income of Wheat to Rapeseed	2.1613** (2.13)		2.2254 (0.92)	
Income of Barley to Oats		-.36133 (-0.20)		.66711 (0.39)
Income of Barley to Rapeseed		1.3283 (1.21)	1.4366 (0.62)	
Income of Rapeseed to Oats			.29200 (-0.43)	-.31457 (-0.44)
Rapeseed Adoption			.13206*** (6.65)	
Total Stubble Acreage (million acres)	.44264*** (6.72)	.02073 (0.25)	.24909*** (5.78)	-.97911* (-1.90)
Inventory of Flaxseed ('000 bushels)	-.02664 (-1.12)	.09870*** (3.41)	.01546 (0.85)	.04145* (1.91)
Inventory of Wheat ('000 bushels)	-.00108 (-1.17)	-.00086 (-0.66)	.00080 (1.02)	-.00172** (-2.02)
Intercept	2.3871 (0.46)	-1.3238 (-0.27)	-6.5731*** (-4.53)	1.9143 (1.14)
Adjusted R^2	.84	.58	.86	.67
Durbin-Watson Statistics	2.62	2.27	2.30	2.36
Durbin's h-statistic		-.93		

***, **, and * indicate that the coefficient is statistically significant at the one, five, and ten percent level of confidence respectively.

Adjusted R^2: Coefficient of Multiply Determination adjusted for degree of freedom.

4.1.3 Alberta

Table 4.3 shows the estimation results of the Stubble/Alberta model. The specification of a variable for LIFT in the wheat/flaxseed equation did not produce a coefficient significantly different from zero. Therefore it was eliminated from the model.

The system of relative return variables, despite the fact that none of their estimated coefficients had high t-ratios, had a significant contribution to the explained variance of the dependent variables. They were retained in the model for the same reason as discussed before. The stocks of barley, rapeseed, and oats were removed from the estimation since they entered the model at statistically insignificant levels.

The hypothesis of the distributed lag model was statistically supported in the barley/flaxseed and oats/flaxseed equations. The magnitude of the adjustment coefficients, about .36 and .49 for the barley/flaxseed and oats/flaxseed equations respectively, indicated that long-run response was about two times larger than short-run response in the barley/flaxseed equation and about twice as large as the short-run response in the oats/flaxseed equation. 95 percent of the full adjustment in the oats/flaxseed equation would take place in less than five years, while it would take almost 7 years to complete this adjustment in the barley/flaxseed equation. The result that the lagged dependent variable was the most significant variable in the oats/flaxseed and barley/flaxseed equations implied the existence of rigidity in cropping patterns. These two equations also had low explanatory power, with adjusted R square about .53 and .66 respectively. The rapeseed/flaxseed equation was the

TABLE 4.3 Results of Estimating The Stubble/Alberta Model

	Dependent Variables (natural logs)			
Exogenous Variables	Acreage of Wheat to Flax	Acreage of Barley to Flax	Acreage of Rapeseed to Flax	Acreage of Oats to Flax
Adjustment Coefficient		.36047		.49196
Lagged Dependent Variable		.63953*** (5.99)		.50804*** (3.63)
Income of Wheat to Flax	3.5127 (1.07)	-2.2662 (-0.46)	-.38415 (-0.11)	.69338 (0.36)
Income of Barley to Flax	-6.4068 (-1.60)	4.8714 (0.72)	.64661 (0.15)	2.1743 (0.49)
Income of Rapeseed to Flax	.43795 (0.48)	-.28113 (-0.21)	-.22914 (-0.11)	1.2427 (1.21)
Income of Flax to Oats	-1.4531 (-1.22)	.84333 (0.29)	-.73724 (-0.74)	2.1527 (0.83)
Income of Wheat to Barley	-3.2849 (-1.01)	4.3130 (0.95)		
Income of Wheat to Oats	.03705 (0.30)			1.7936 (1.12)
Income of Wheat to Rapeseed	.20778 (0.29)		-.37425 (-0.14)	
Income of Barley to Oats		-.62499 (-0.19)	-3.3713 (-0.94)	
Income of Barley to Rapeseed		-.21890 (-0.22)	-.65887 (-0.21)	
Income of Rapeseed to Oats			.65517 (0.60)	-.89433 (-1.11)
Rapeseed Adoption			.26375*** (11.48)	
Total Stubble Acreage (million acres)	.50710*** (5.82)	-.05263 (-0.35)	.10400 (1.05)	-.17641 (-1.31)
Inventory of Flaxseed ('000 bushels)	.25626*** (3.19)	.23161** (2.03)	.15646* (1.74)	.15090 (1.45)
Inventory of Wheat ('000 bushels)	-.01372*** (-5.27)	-.00398 (-1.10)	-.01047*** (-3.89)	-.42397 (-1.24)
Intercept	7.8664* (1.79)	-.49478 (-0.89)	.90851 (0.51)	-1.0581 (-0.29)
Adjusted R^2	.75	.66	.90	.53
Durbin-Watson Statistics	1.76	1.73	2.01	1.78
Durbin's h-statistics		.63		.51

***, **, and * indicate that the coefficient is statistically significant at the One, five, and ten percent level of confidence respectively.

Adjusted R^2: Coefficient of Multiply Determination adjusted for degree of freedom.

most satisfactory equation in this model, explaning over 90 percent of the variatons in the dependent variable. The wheat/flaxseed equation explained about 75 percent of the variations in the dependent variable although most variables in this equation had higher t-ratios than those in the rapeseed/flaxseed equation. High explanatory power in the rapeseed/flaxseed equation was probably attributed to the rapeseed adoption variable which picked up much of the strong upward movement of the dependent variable between 1961 and 1971.

The Durbin-Watson Statistic for each equation and Durbin's h-statistic for the barley/flaxseed and oats/flaxseed equations allowed us to accept the null hypothesis of no autocorrelation at the five percent level of confidence.

4.2 CROPS SEEDED ON FALLOW

4.2.1 Manitoba

The results of estimating the Fallow/Manitoba model are presented in Table 4.4. Insignificant coefficients on many of the relative return variables in the system appeared to be a result of intercorrelation among these variables. The wheat/flaxseed equation performed relatively well. Over 82 percent of the variation in the dependent variable was explained. Most variables other than the set of relative return variables were highly significant at the one percent level, with autocorrelation absent. The value of the coefficient on the lagged dependent variable was .52. Hence the adjustment coefficient was about .48, which implied that the long-run response of the dependent variable to changes

TABLE 4.4 Results Of Estimating The Fallow/Manitoba Model

Dependent Variables (natural logs)

Exogenous Variables	Acreage of Wheat to Flax	Acreage of Barley to Flax	Acreage of Rapeseed to Flax	Acreage of Oats to Flax
Adjustment Coefficient	.48511			
Lagged Dependent Variable	.51489*** (3.81)	1.1870*** (5.97)		
Income of Wheat to Flax	.72133 (0.39)	1.6733 (0.43)	-4.0528 (-1.64)	1.2415 (0.84)
Income of Barley to Flax	-.64358 (-0.30)	-3.9769 (-0.84)	4.6535 (1.44)	-2.7394 (-1.29)
Income of Rapeseed to Flax	-.60831 (-0.99)	-1.7707 (-1.48)	3.9737** (2.56)	.33093 (0.45)
Income of Flax to Oats	-1.6129** (-2.15)	-3.9850** (-2.08)	3.8604*** (3.37)	-1.4123 (-0.96)
Income of Wheat to Barley	-1.6778 (-0.96)	-2.2923 (-0.62)		
Income of Wheat to Oats	1.3350** (2.02)			-.34198 (-0.31)
Income of Wheat to Rapeseed	-.44139 (-0.66)		4.1495 (1.48)	
Income of Barley to Oats		4.5205** (2.27)		2.4836 (1.42)
Income of Barley to Rapeseed		-2.3269 (-1.54)	-4.9019 (-1.44)	
Income of Rapeseed to Oats			-2.9748*** (-3.01)	-.68099 (-1.11)
Rapeseed Adoption			.24779*** (7.73)	
LIFT	-.50725*** (-3.44)			
Total Fallow Acreage (million acres)	.21163 (1.47)	.40943* (1.77)	-.13179 (-0.51)	.20610 (1.38)
Inventory of Flaxseed ('000 bushels)	.17072*** (4.93)	.24598*** (4.25)	.09325** (2.25)	.07404* (1.78)
Inventory of Wheat ('000 bushels)	-.01711*** (-6.93)	.00241 (0.44)	-.00340 (-0.77)	-.01023*** (-2.90)
Inventory of Barley ('000 bushels)		-.02426*** (-2.47)		
Intercept	4.0319 (1.44)	6.9355 (1.27)	-7.2744*** (-3.84)	1.0656 (0.55)
Adjusted R^2	.82	.67	.94	.62
Durbin-Watson Statistics	1.91	1.69	2.43	1.87
Durbin's h-statistics	.03	1.14		

***, **, and * indicate that the coefficient is statistically significant at the one, five, and ten percent level of confidence respectively.

Adjusted R^2: Coefficient of Multiple Determination adjusted for degree of freedom.

in the explanatory variables was about twice that in the short-run, and 95 percent of the adjustment would take place in five years.

The barley/flaxseed equation had highly significant lagged dependent variable whose coefficient, with size exceeded one (1.19), which implied an unstable situation in that in the long-run, the size of the dependent variable would explode. The lagged dependent variable was retained in this equation despite its rather absurd long-run implication because it had a substantial contribution on the overall explanatory power of this equation. Barley stocks were found to have a negative effect on the barley/flaxseed acreage ratio. This equation explained about 67 percent of the variation in the dependent variable.

The lagged dependent variable and rapeseed stocks in the rapeseed/flaxseed equation, as well as the lagged dependent variable and oats stocks in the oats/flaxseed equation were eliminated from the analysis since none of them appeared to be a significant determinant in the model. The rapeseed/flaxseed equation had very high R square of .94, the oats/flaxseed equation had relatively low R square of .62. Wheat stocks were the most significant determinant in the oats/flaxseed equation. The negative sign on the coefficient of wheat stock implied that increases of wheat stocks caused flaxseed acreage to increase more than that of oats acreage. Serial correlation was not a problem in any of the equations in the model as indicated by the Durbin-Watson statistic and Durbin's h-statistic.

TABLE 4.5 Results of Estimating the Fallow/Saskatchewan Model

Exogenous Variables	Dependent Variables (natural logs) Acreage of Wheat to Flax	Acreage of Barley to Flax	Acreage of Rapeseed to Flax	Acreage of Oats to Flax
(adjustment coefficient)	(.49818)	(.48659)	(.25356)	
Lagged Dependent Variable	.50182 (4.04)***	.51341 (4.49)***	.74644 (6.33)***	
Income of Wheat to Flax	-5.2992 (-1.56)*	-.61086 (-.17)	-8.7913 (-4.21)***	.51808 (.28)
Income of Barley to Flax	9.0782 (2.43)***	5.1417 (1.45)	5.8810 (3.09)***	2.6240 (1.15)
Income of Rapeseed to Flax	2.1463 (2.27)**	1.0460 (1.15)	8.7380 (6.66)***	-.38105 (-.39)
Income of Flax to Oats	2.8010 (2.17)**	3.1927 (1.95)*	4.5894 (5.76)***	.78370 (.56)
Income of Wheat to Barley	7.2872 (2.32)**	1.0848 (.33)		
Income of Wheat to Oats	-2.5465 (-1.92)**			-.22064 (-.17)
Income of Wheat to Rapeseed	1.9958 (1.94)**		10.954 (4.73)***	
Income of Barley to Oats		-3.4379 (-1.83)*		-1.3405 (-.77)
Income of Barley to Rapeseed		-1.4787 (-1.56)*	7.5815 (3.71)***	
Income of Rapeseed to Oats			-3.6301 (-5.02)***	.35792 (.48)
Rapeseed Adoption			.12147 (4.27)***	
LIFT	-.93504 (-3.87)***			
Total Fallow Acreage (million acres)	-.00672 (-.09)	.05943 (.79)	-.05380 (-1.23)	-.03333 (-.52)
Inventory of Flaxseed (thousand bushels)	.06144 (1.42)	.07962 (2.15)**	.08386 (3.00)***	.01736 (.54)
Inventory of Wheat (thousand bushels)	-.00443 (-3.19)***	-.00233 (-1.71)*	-.00330 (-3.43)***	-.00406 (-3.53)***
Inventory of Rapeseed (thousand bushels)			-.03708 (-3.42)***	
Intercept	-12.567 (-2.40)***	-7.8527 (-1.80)*	-9.6837 (-4.69)***	.22476 (.08)
$\bar{R}^2$	.7666	.4631	.9534	.5877
D-W	2.68	2.29	2.55	2.31
D-h	-2.59	-1.49	-1.65	

***, **, and * indicate that the coefficient is statistically significant at the one, five, and ten percent level of confidence respectively.

$\bar{R}^2$: Coefficient of Multiple Determination adjusted for degree of freedom.

D-W : Durbin-Watson statistics

D-h : Durbin's h-statistic

4.2.2 Saskatchewan

The results for the estimation of the Fallow/Saskatchewan model are presented in Table 4.5. The results showed that the rapeseed/flaxseed equation had excellent statistical properties. All variables in this equation were significant at the one percent level except the area of the five crops seeded on fallow (TAf). Over 95 percent of the variations in the dependent variable was explained. The wheat/flaxseed equation likewise performed well, all variables other than total acreage of the five crops seeded on fallow and inventory of flaxseed were significant at the five percent level. The overall goodness of fit of this equation in explaining the movement of dependent variable was reasonable as indicated by the R value (.77). The adjusted coefficients of determination were quite low in both the barley/flaxseed and oats/flaxseed equations, being .46 and .59 respectively.

The coefficient of inventory of wheat had a high t-ratio and was negative in all equations, which implied that an increase in carry over of wheat could cause an increase in flaxseed acreage more than in barley, rapeseed, or oats acreage. Similar to the estimates in Maitoba, wheat stocks were the most significant determinant in the oats/flaxseed equation.

Neither the lagged dependent variable nor oats stocks appeared to play a role in the oats/flaxseed equation. Therefore, these variables were eliminated from the final specification. The coefficient of the lagged dependent variable in both the wheat/flaxseed and barley/flaxseed equations were of moderate size, around .50, and implied long-run response about twice as large as that of the short-run. The time period required to approach 95 percent of total adjustment would be about four years. The rapeseed/flaxseed equation had a larger coefficient on the lagged dependent variable (.75), which implied a long-run response about four time as large as the short-run response, and the adjustment would remain significant for a period of ten years.

Although generally high values of Durbin-Watson and Durbin h-statistics for the equations in this model caused concern, there was no evidence of autocorrelation among the error terms since these values were still within the inconclusive values at the five percent level of confidence except for the wheat/flaxseed equation.

4.2.3 Alberta

Table 4.6 presents the results of estimating the Fallow/Alberta model. Barley, rapeseed, and oats stocks were dropped from the final specification because of very poor statistical results. The lagged dependent variable was also removed from the rapeseed/flaxseed and oats/flaxseed equations due to poor statistical performance. Many relative return variables in this system of equations had poor performance, which was not surprising because the problem of multicollinearity was anticipated and tolerated. All remaining variables in the model were highly significant at the one percent level of confidence.

Among the system of equations, the rapeseed/flaxseed equation had the best statistical fit with high explanatory power which accounted for more than 84 percent of the variations in the dependent variable. The

TABLE 4.6 Results Of Estimating The Fallow/Alberta Model

Exogenous Variables	Acreage of Wheat to Flax	Acreage of Barley to Flax	Acreage of Rapeseed to Flax	Acreage of Oats to Flax
	Dependent Variables (natural logs)			
Adjustment Coefficient	.64049	.48716		
Lagged Dependent Variable	.35951*** (3.81)	.51284*** (4.89)		
Income of Wheat to Flax	-4.0461 (-0.92)	-6.2922 (-1.09)	-20.261*** (-3.36)	-5.7053** (-2.23)
Income of Barley to Flax	1.5401 (0.41)	1.3323 (0.37)	15.010*** (2.80)	-2.3899 (-0.92)
Income of Rapeseed to Flax	.54501 (0.70)	1.4327 (1.38)	2.5356 (1.08)	-.49394 (-0.63)
Income of Flax to Oats	-2.0017 (-1.14)	-2.6735 (-0.85)	-1.4581 (-1.01)	-6.4106*** (-2.73)
Income of Wheat to Barley	2.2760 (0.69)	5.5191 (1.12)		
Income of Wheat to Oats	1.4709 (0.86)			3.4650** (2.06)
Income of Wheat to Rapeseed	.21142 (0.29)		16.147*** (3.13)	
Income of Barley to Oats		2.2384 (0.65)		1.8897 (0.86)
Income of Barley to Rapeseed		1.6142* (1.56)	-14.384*** (-2.92)	
Income of Rapeseed to Oats			.98835 (0.70)	.68001 (1.09)
Rapeseed Adoption			.20682*** (6.79)	
LIFT	-.84059*** (-5.71)			
Total Fallow Acreage (million acres)	-.86571*** (-3.25)	-.75359** (-2.47)	-1.1321*** (-3.80)	-.92357*** (-4.05)
Inventory of Flaxseed ('000 bushels)	.39298*** (3.28)	.54783*** (3.86)	.68261*** (3.69)	.46184*** (3.98)
Inventory of Wheat ('000 bushels)	-.01438*** (-4.02)	-.01378*** (-3.55)	-.01816*** (-4.35)	-.01881*** (-5.44)
Intercept	8.8272* (1.64)	3.5691 (0.81)	10.760** (2.64)	17.893*** (4.10)
Adjusted R^2	.70	.56	.84	.44
Durbin-Watson Statistics	2.63	2.73	2.60	2.45
Durbin's h-statistics	-2.04	-2.07		

***, **, and * indicate that the coefficient is satistically significant at the One, five, and ten percent level of confidence respectively.

Adjusted R^2: Coefficient of Multiple Determination adjusted for degree of freedom.

wheat/flaxseed equation also had reasonable explanatory power as indicated by the R value of .70. However, the barley/flaxseed and oats/flaxseed equations had poor explanatory power. The resulting corrected R square were .56 and .44 respectively.

Serial correlation was more of a problem for the estimates of the Fallow/Alberta model than for other estimates. The Durbin-Watson Statistic and Durbin-h Statistic implied that there was autocorrelation in the wheat/flaxseed and barley/flaxseed equations, and it was inconclusive for the rapeseed/flaxseed and oats/flaxseed equations.

4.3 SUMMARY OF RESULTS

Substantially different estimates were obtained for most of the corresponding relative return variables in the stubble and fallow models in all provinces in terms of the magnitude of coefficients and statistical significance. Opposite signs for the same variable in different models were also found in some cases. However, to what extent those differences were accounted for by different response between the allocation of stubble and fallow land and regional differences can not be determined because of multicollinearity among the relative return variables. Although the integrity of some of the estimates might be impaired by the interaction of the relative return variables to a certain extent, the same pattern of intercorrelation among these variables was expected to continue in the period of future forecasting. Thus, good forecasts could still be obtained without being able to untangle the seperate influence of these variables. Since there was no evidence of multicollinearity among other variables, their estimates were not likely to be affected.

The hypothesis of the distributed lag model was statistically supported in all equations in the Stubble/Manitoba model. However, it was justifiable only in the barley/flaxseed and wheat/flaxseed equations in the Fallow/Manitoba model. The coefficient of the lagged dependent variable in the wheat/flaxseed equation was larger in the Fallow model (.52) than in the Stubble model (.34). An extremely large coefficient on the lagged dependent variable was obtained for the barley/flaxseed equation in both stubble and fallow models, .98 and 1.19 respectively. The lagged dependent variable was withdrawn from all but the barley/flaxseed equation in the Stubble/Saskatchewan model. However, it was retained in all but the oats/flaxseed equation in the Fallow/Saskatchewan model. The lagged dependent variable was significant in the barley/flaxseed and wheat/flaxseed equations in the Fallow/Alberta model, and also in the barley/flaxseed and oats/flaxseed equation in the Stubble/Alberta model.

A positive and statistically highly significant coefficient was obtained for the rapeseed adoption variable in the estimation of every model for rapeseed. The magnitude of the estimated coefficient on the rapeseed adoption variable was much larger in the Fallow/Manitoba model than in the Stubble/Manitoba model, and was larger in the Stubble/Alberta than in the Fallow/Alberta model. But there was no significant difference between the coefficient in the Stubble/Saskatchewan and Fallow/Saskatchewan models. These results indicated that the rate of adopting management skills in growing rapeseed varied between stubble and fallow seedbed and among provinces.

The LIFT program appeared to impact on the allocation of fallow acreage with varying degrees of influence among the provinces. However, it had significant impact only on the allocation of stubble acreage in Manitoba.

A negative coefficient was obtained on the inventory of wheat variable in all estimates except the rapeseed/flaxseed and sunflowers/flaxseed equations in the Stubble/Manitoba model. The magnitude of the coefficient of wheat stocks was substantially larger in all corresponding equations in the fallow model than in the stubble model in both Saskatchewan and Alberta. A positive coefficient was obtained on the inventory of flaxseed variable in all estimates except the wheat/flaxseed equation in the Stubble/Saskatchewan model. Generally the magnitude of the coefficient of inventory of flaxseed was larger in corresponding equations in the fallow model than in the stubble model in Manitoba and Alberta.

In terms of the explanatory power, generally the stubble models performed better than the fallow models. Wheat/flaxseed and rapeseed/flaxseed equations generally had satisfactory explanatory power. Oats/flaxseed and barley/flaxseed equations generally had poor explanatory power in all models except the Stubble/Manitoba model.

Chapter V

HISTORICAL SIMULATIONS, PREDICTIONS, AND EVALUATIONS

Based on the results of the estimations in the previous chapter, acreages of the major crops grown on stubble and fallow were simulated for the period 1962 to 1981. The within-estimation period forecasting performance of the model was then evaluated based on the results of historical simulations, and further evaluated in comparison with the results generated from a naive model. Finally, acreages seeded to various crops in 1982, 1983, and 1984 were forecasted and compared with the forecasts obtained by Agriculture Canada and the Canada Grains Council.

5.1 SOURCES OF SIMULATION ERRORS

Based on the simulation procedure presented in Chapter III, the simulation of acreage seeded to each crop depends on the simulated values of endogenous variables in the system of equations as well as total acreage of the six crops seeded on stubble (TAs) and total acreage of the five crops seeded on fallow (TAf). Any error in the simulated endogenous variables of the model would be transmitted into the estimated acreage shares, and thus into the simulation of each acreage. Since the future values of total acreage seeded would not be known and would have to be projected in future simulation, the projected values of TAs and TAf were employed in the historical simulation to maintain consistency between historical simulation and future forecasting. Thus, the success of the acreage allocation model in simulating and forecasting prairie acreages would also depend critically upon successful estimation of total acreage of the six crops seeded on stubble and fallow.

The total acreage of the five crops seeded on fallow (TAf) was assumed to be equal to the total summerfallow acreage in the preceding years minus the acreage seeded to fall rye in the same year. This proxy proved to be fairly accurate, as appendix B showed that estimated values of TAf were generally very close to the actual values. Only in very few instances were large deviations of over 10 percent observed. Therefore, errors which might be transmitted into the simulation of acreages through the projected TAf were negligible in general. Errors in the simulated acreage for crops seeded on fallow were considered solely attributable to the inability of the acreage allocation model to predict acreage shares. The few cases in which large errors occurred in the estimation of TAf will be examined in the evaluation of the simulation results in the next section.

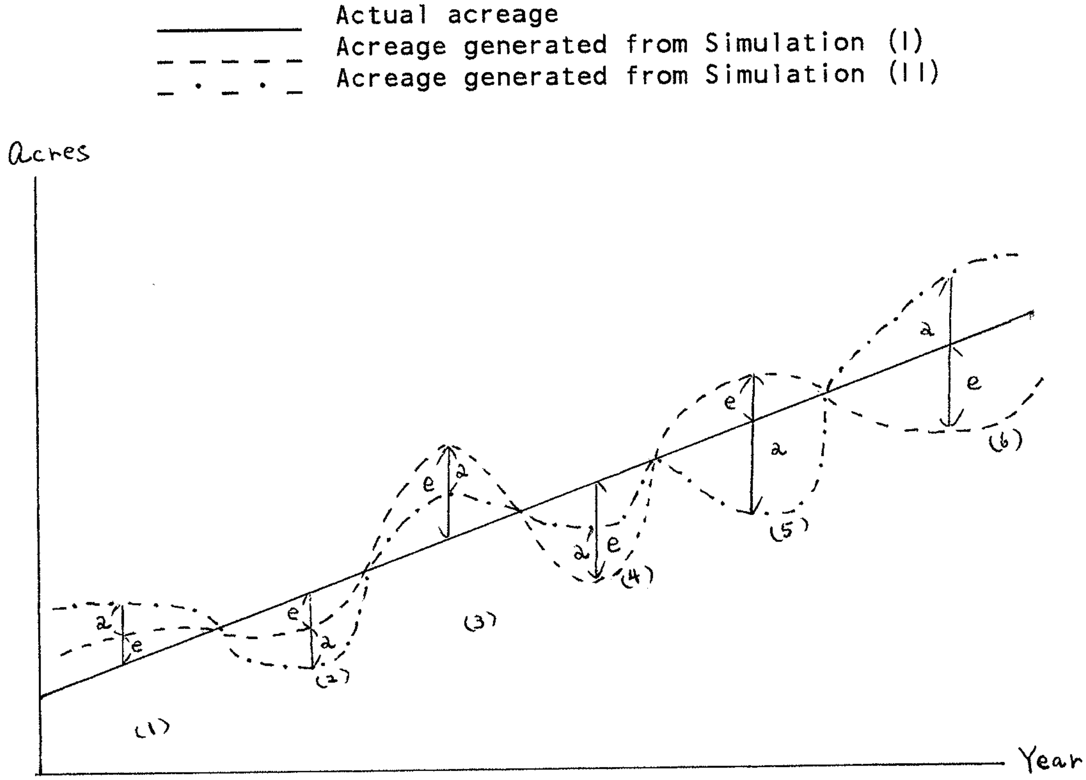
The total acreage of the six crops seeded on stubble (TAs) was assumed to be a linear function of the total area of crops seeded on stubble (STUBBLE) : TAs = b0 + b1*(STUBBLE). This estimation also proved satisfactory as appendix B showed that the estimated values of TAs were very close to actual values. The only large deviation between the estimated and actual value of TAs occurred in 1975 in the estimation of TAs for Alberta. Thus, the magnitude of errors which might be transmitted into simulated acreages through the estimation of TAs was considered negligible in general and acreage simulations depended solely on the performance of the acreage allocation model in predicting acreage shares.

However, the total area seed on stubble (STUBBLE) would not be known if forecasting were extended beyond the current time period. In order to be consistent in the estimation of TAs, estimated values of STUBBLE had to be used in the estimaton of TAs. Thus, the success of simulation and ex-ante forecasting of acreage seeded on stubble would also depend critically on the successful estimation of STUBBLE. The results of the estimation of STUBBLE are also presented in appendix B.

Two sets of acreage simulations were performed using actual and estimated values of total area seeded on stubble (STUBBLE) alternatively in order to identify the sources of simulation errors. Simulation I (SI) was based on actual values of STUBBLE. Errors in SI were mainly attributed to poor performance of the model in predicting acreages shares. Simulation II (SII) was based on estimated values of STUBBLE. Additional errors might be transmitted into SII through the imprecise estimation of STUBBLE which impair the projection of TAs. Segregation of simulation errors attributed to the acreage allocation model and to the estimation of STUBBLE is shown in Diagram (1) in six possible situations. Situation (1) shows a positive deviation from actual acreage in SI due to a positive error (e) in the projected acreage shares. This error together with a positive error (a) transmitted from the projection of TAs results in a larger deviation from actual acreage in SII than in SI. Situation (2) is similar to situation (1) except errors from both projected acreage shares (e) and projected TAs (a) are negative. Situation

DIAGRAM (I)

Sources Of Errors In The Simulation
For Crops Seeded On Stubble Seedbed



Errors in SI mainly attributed to e (error in the estimation of acreage share) :

$$\hat{A} = A + e$$

Components of error in SII include e and a (error attributed to the estimation of total area seeded to stubble) :

$$\hat{A} = A + (e + a)$$

Situation:
1. $e > 0$ and $a > 0$, then $|e + a| > |e|$
2. $e < 0$ and $a < 0$, then $|e + a| > |e|$
3. $e > 0$ and $a < 0$, and $|a| < e$, then $|e + a| < |e|$
4. $e < 0$ and $a > 0$, and $a < |e|$, then $|e + a| < |e|$
5. $e > 0$ and $a < 0$, and $|a| > e$, then $e + a < 0$
   no obvious inequality between $|e|$ and $|e + a|$
6. $e < 0$ and $a > 0$, and $a > |e|$, then $e + a > 0$
   no obvious inequality between $|e|$ and $|e + a|$

Note: If $e = 0$ then SI overlap actual acreage
If $a = 0$ then SI and SII are the same

(3) shows a positive error (e) in SI. However, in SII, a negative error ((a), with $|a| < e$) transmitted from the estimation of TAs partially cancels the positive error (e) attributed to the estimation of acreage shares, thus resulting in a smaller deviation from actual acreage than in SI. Situation (4) differs from situation (3) only in that (e) is negative and (a) is positive. Situation (5) shows a positive deviation from actual acreage in SI due to a positive error (e). In SII, however, (e) is offset by a negative deviation from the actual acreage; that SII deviates more from actual acreage than SI in magnitude depends on the absolute value of (a) being at least twice as large as (e). Situation (6) is similar to situation (5) except (e) is negative and (a) is positive.

5.2 SIMULATION RESULTS FOR CROPS SEEDED ON STUBBLE

This section provides a comparison between actual and simulated values of acreage of wheat, oats, barley, rapeseed, flaxseed, and sunflowers grown on stubble in Manitoba, Saskatchewan, and Alberta. The simulated values of acreage of each crop in each province, along with the actual values, are plotted graphically in Figure (5.1.1) to Figure (5.6.3) for the period 1962 to 1981. These values are also presented in appendix C.

Two sets of simulation results were evaluated in an attempt to identify the net errors attributable to imprecise projection of the total stubble acreage and errors attributable to the acreage allocation model which had been discussed in the provious section. The simulation results were evaluated in terms of their ability to explain the movements of acreages seeded to various crops, i.e., how closely they tracked the corresponding historical data series, and their ability to reflect changes in the direction of actual acreage. Table 5.1 summarized the performance of the acreage simulation in terms of mean absolute percentage error[35] and turning point errors in the simulation.

5.2.1 Wheat Acreage

5.2.1.1 Manitoba

Figure(5.1.1.) shows that simulated values of wheat acreage generated from SI generally tracked the actual values closely over the period 1962 to 1981.

The simulation picked up 17 out of 20 turning points in actual wheat acreage, with low mean absolute percentage error of 9.80%. For the most recent five years, the simulation had even smaller errors. The average absolute percentage error was 5.51% for this period.

SII, however, generally deviated more from actual wheat acreage although it also correctly reflected 17 out of 20 turning points in actual wheat acreage. The mean absolute percentage error of SII was 16.76%. The average absolute percentage error for the most recent five year period remained fairly low at 7.8%. The results implied that, on the average, about 60% of errors in SII over the period 1962 to 1981 were

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[35] This measure was chosen for evaluating the magnitude of simulation errors instead of the more commonly used root mean square percentage error because it was readily available in a software package requiring no further programming. They differ only in that the latter statistics penalize larger errors more heavily.

TABLE 5.1

Performance Of Historical Simulation Of Seeded Acreages
Based On The Acreage Allocation Model

		STUBBLE ACREAGES						FALLOW ACREAGES		
		SIMULATION I			SIMULATION II					
		Man.	Sask.	Alta	Man.	Sask.	Alta.	Man.	Sask.	Alta.
Wheat	1.	1307	3190	1415	1307	3190	1415	1773	13428	3849
	2.	9.80	8.92	18.45	16.76	22.92	43.8	4.16	3.65	4.95
	3.	3	5	5	3	7	7	1	2	3
Oats	1.	1054	1027	1262	1054	1027	1262	186	683	608
	2.	13.69	11.41	5.48	14.82	10.42	7.01	15.57	11.13	5.21
	3.	8	7	5	9	4	5	3	1	1
Barley	1.	1074	1497	3189	1074	1497	3189	355	1570	1494
	2.	10.28	12.91	5.47	11.72	14.54	5.81	15.4	12.92	8.87
	3.	3	4	3	3	4	2	5	3	3
Rape-seed	1.	256	185	447	256	185	447	174	1155	824
	2.	14.90	18.01	15.52	21.10	23.60	19.76	19.57	22.05	22.65
	3.	2	2	3	2	3	4	4	4	2
Sun-flower	1.	117			117					
	2.	17.36			31.17					
	3.	4			5					
Flax-seed	1.	674	172	63	674	172	63	153	397	197
	2.	9.44	20.60	32.69	10.94	18.96	35.49	9.64	20.68	22.89
	3.	5	4	5	4	3	6	2	4	3

1. Mean value of actual seeded acreage (in thousand acres)

2. Mean absolute percent error = $(1/n) \sum_{i}^{n} ((|\hat{A} - A|) / A)$

   where n is the number of years equal to 20.
   $\hat{A}$ is simulated acreage, A is actual acreage.

3. The number of turning point errors.

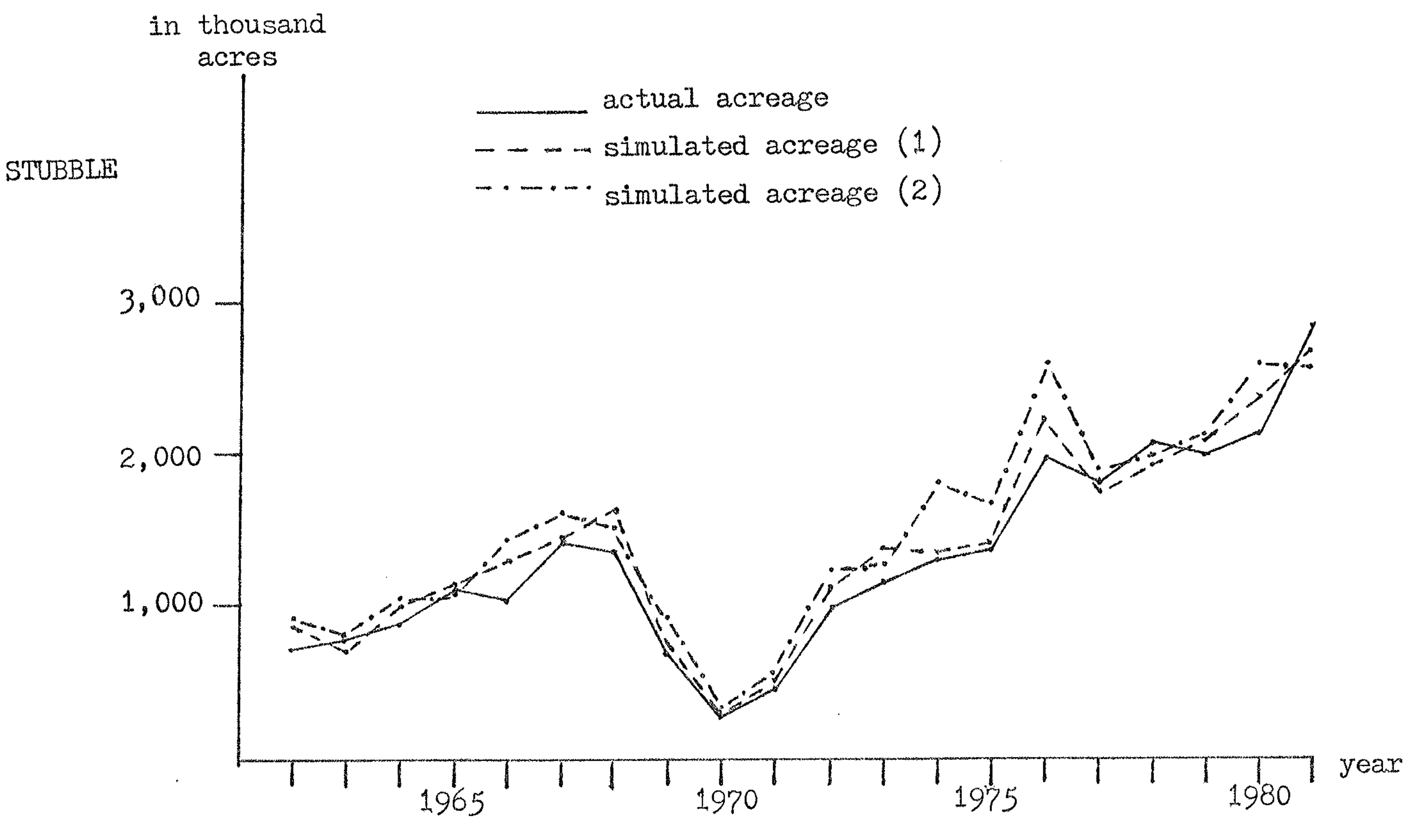

FIGURE 5.1.1.
Actual and Simulated Wheat Acreage - Stubble and Fallow, Manitoba

attributable to the inability of the acreage allocation model to explain the movement of wheat acreage, while the imprecise estimation of total stubble acreage was responsable for the remaining errors.[36]

Over the 20 years there was no particularly large deviation between actual and predicted values. However, in SII, errors exceeded half a million acres in 1974 and 1976 where upturns in wheat acreage were overestimated. The large error in 1976 was attributed about equally to poor performance of the acreage share model and the estimated total stubble acreage (STUBBLE). However, the error in 1974 was largely attributed to a .8 million acres overestimation of total stubble acreage. The overestimation of total stubble acreage in 1974 might be a result of very late seeding caused by unfavorable weather conditions in the spring which prevented farmers from seeding as many acres as they intended to.

5.2.1.2 Saskatchewan

The acreage of wheat seeded on stubble in Saskatchewan rose with little fluctuation from 1962 till 1967, then experienced a drastic drop which bottomed out in 1971 before an upturn in 1972. This was followed by gradual recovery. In Figure(5.1.2.) the simulated values of wheat acreage are compared with the actual values.

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[36] Mean absolute percentage error of SI was 9.8%, which was equivalent to about 60% of the mean absolute percentage error in SII. Therefore, 60% of average error in SII was considered to be attributed to the model. However, it should be noted that, positive and negative errors attributable to alternative sources might offset each other. Therefore, the remaining errors were the 'net' errors added to SII as a result of the estimation of total stubble acreage.

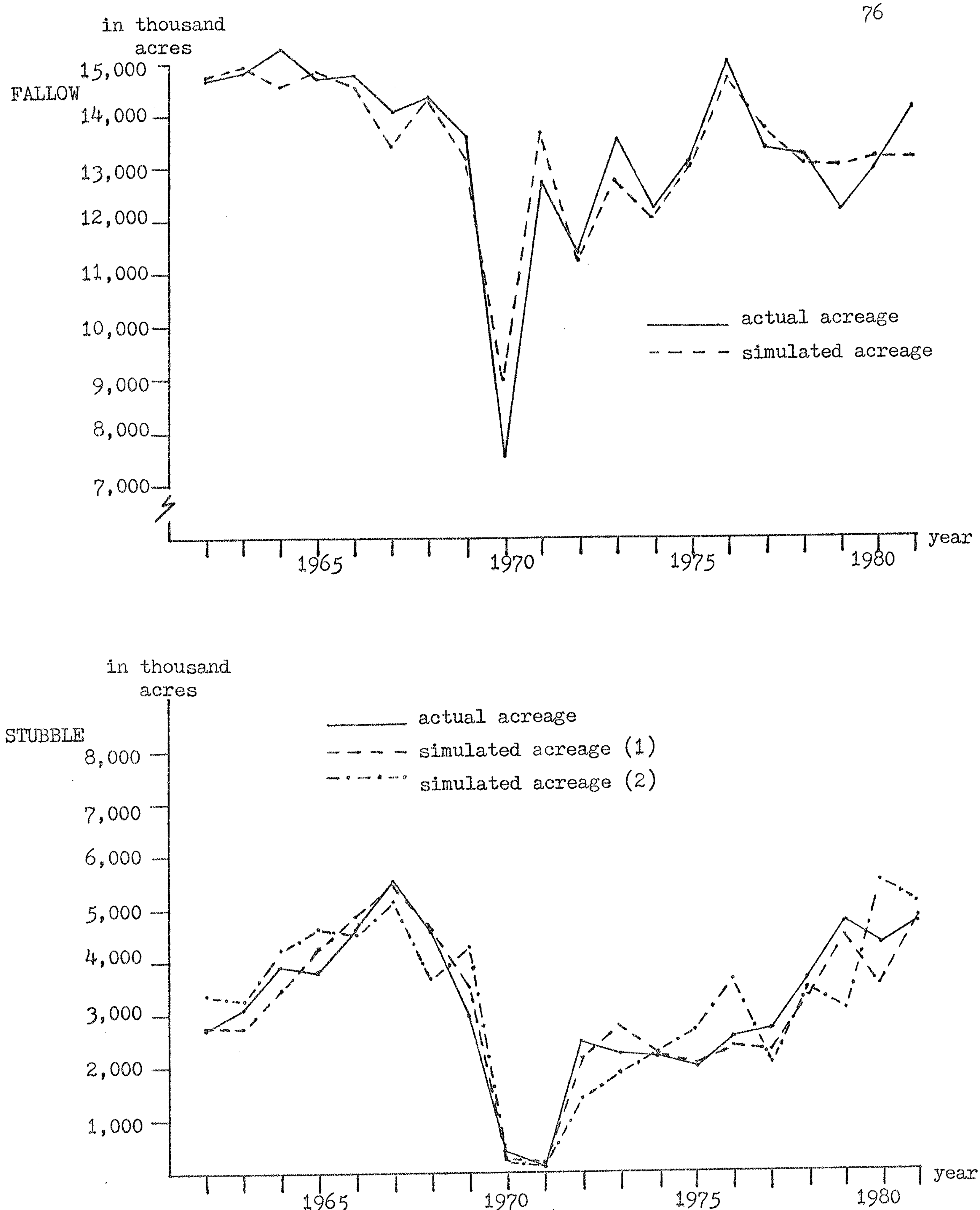


FIGURE 5.1.2.

Actual and Simulated Wheat Acreage - Stubble and Fallow, Saskatchewan

SI failed to pick up 5 out of 20 turning points in actual wheat acreage. However, it managed to account for the major turning points over the years of wide fluctuation and came very close to actual wheat acreage. The simulation tracked the actual wheat acreage closely except in 1969 and 1973 where errors exceeded 20%. The mean absolute percentage error of the simulation was fairly small at 8.92%

SII, however, generally deviated considerably wider from the actual wheat acreage and performed badly in simulating changes in the direction of wheat acreage. Turning point errors occurred in 7 of 20 years. Absolute errors exceeded a million acres in 5 years. The downturn in wheat acreage in 1969 was simulated correctly, but the magnitude of the decline was not captured as shown by a 44% overestimation of wheat acreage (1.3 million acres) which was attributed about equally to the acreage allocation model and the estimated total stubble acreage. The upturn in wheat acreage was underestimated in 1972 and overestimated in 1976. Both showed about 43% error (1.1 million acres). Imprecise estimation of total stubble acreage was responsiable for both errors in 1972 and 1976. SII failed to predict the surge in wheat acreage which occurred in 1979, which was successfuly reproduced in SI. This miss produced the largest deviation of about 1.7 million acres due to huge underestimation of total stubble acreage. SII also failed to predict the downturn in wheat acreage in 1980 and resulted in a 1.2 million acres overestimation. This error was solely attributed to overestimation of total stubble acreage, which might be because farmers seeded less acres than they desired as a result of late seeding due to severe drought.

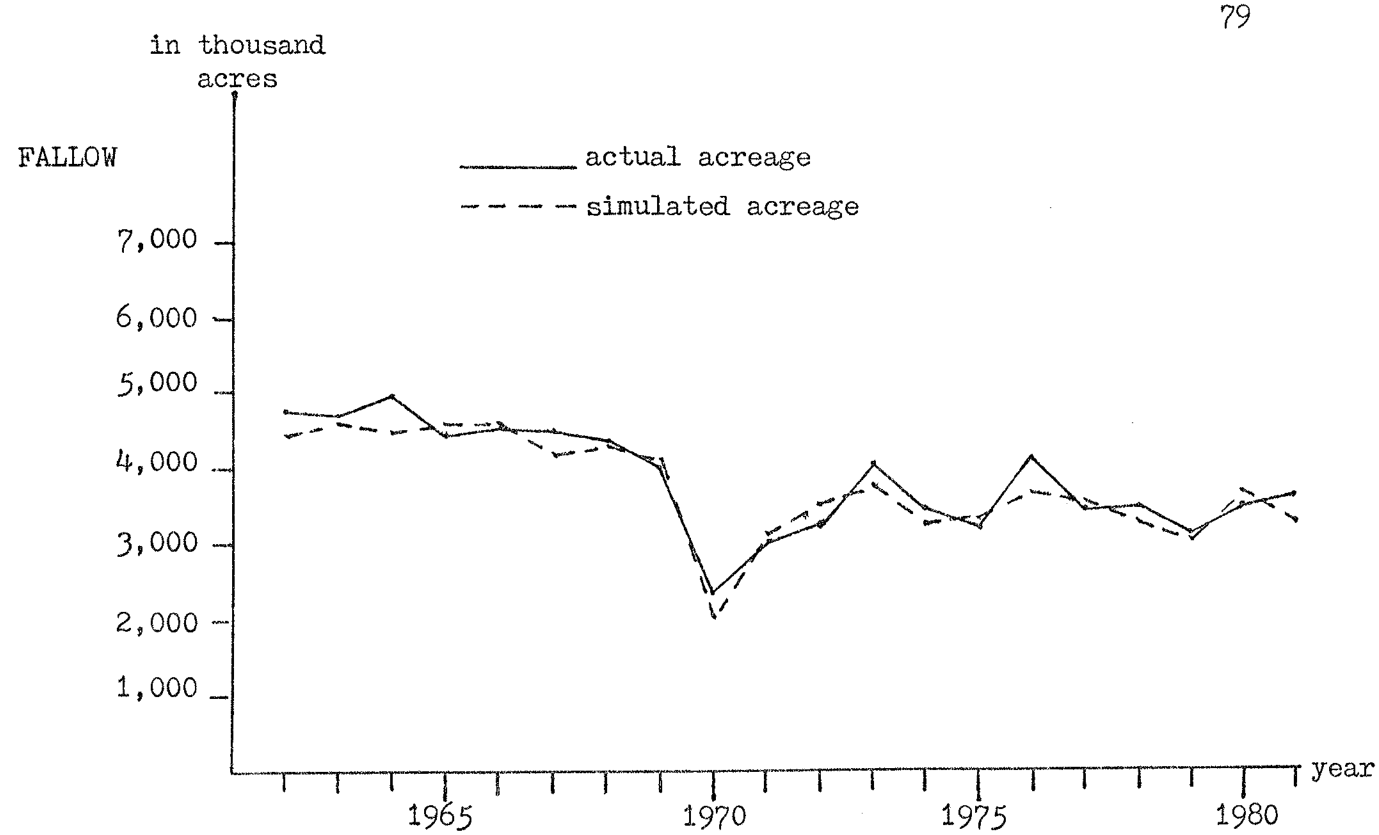
The mean absolute percentage error of SII was 22.92, which was more than twice as large as that of SI. This implied that, on the average, the acreage model was responsiable for less than 40 percent of the errors in SII.

5.2.1.3 Alberta

Figure(5.1.3.) represents actual and simulated values of wheat acreage seeded on stubble in Alberta.

SI picked up 15 out of 20 turning points in actual wheat acreage over the period of analysis and generally tracked actual wheat acreage closely except in 1968, 1973, and 1975, where turning point errors occurred. The mean absolute percentage error of the simulation was 18.45%. However, this was in part influenced by a very large error in 1975 where a surge in wheat acreage to almost 1.7 million acres was simulated in contrast to an actual decline of wheat acreage to .6 million acres. However, a 1.15 million acre overestimation of total stubble acreage was to a certain extent responsiable for this extremely large error. Excluding this year of extreme deviation, the average absolute percentage error of the simulation dropped to 10.01%.

The results of SII, however, were very disappointing. The simulated wheat acreage began to deviate widely from the actual wheat acreage from 1974 through 1980. The error in 1975 was largely due to overestimation of the acreage share of wheat as the result of a huge overestimation of total stubble acreage. All other errors during this period were attributed solely to overestimation of total stubble acreage. The reason for



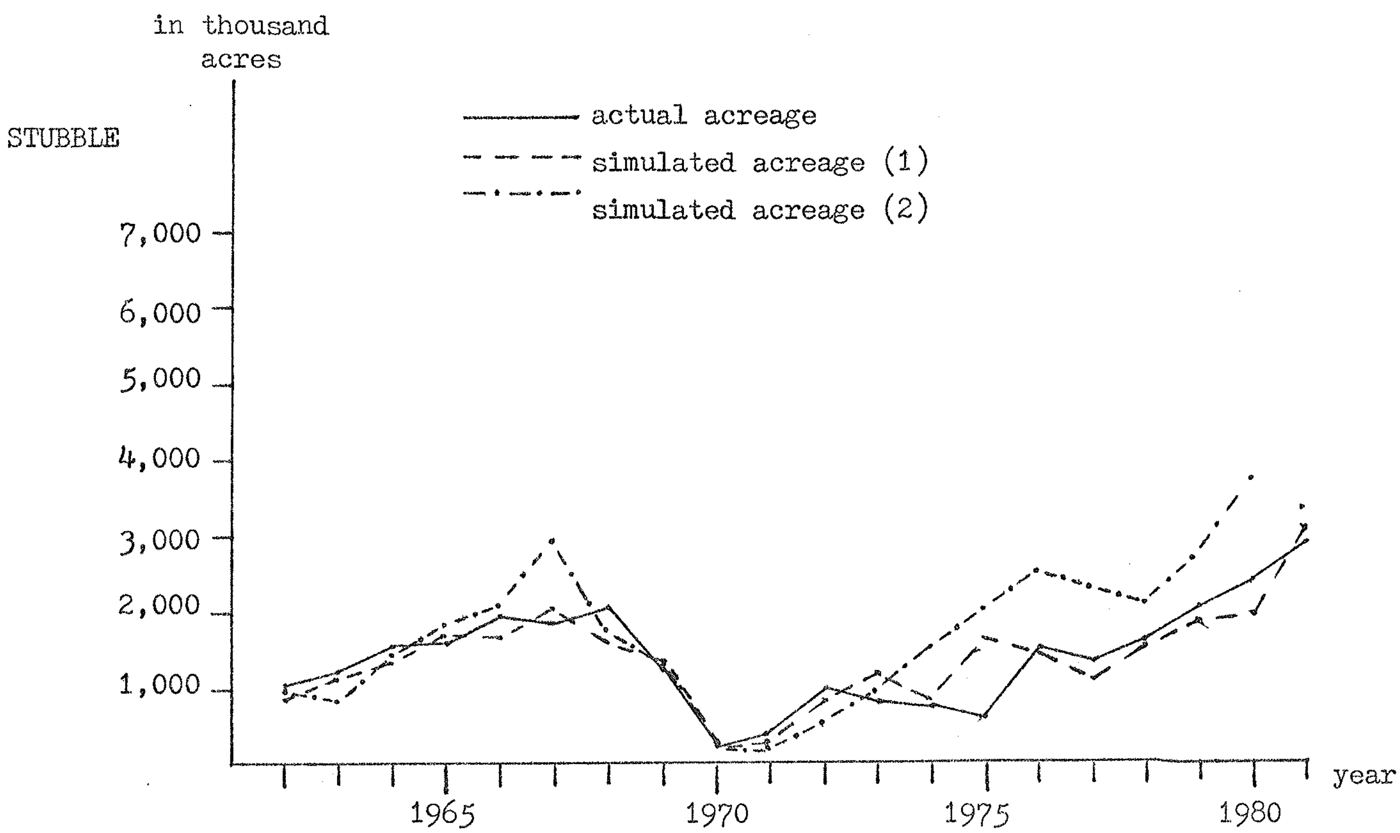


FIGURE 5.1.3.
Actual and Simulated Wheat Acreage - Stubble and Fallow, Alberta

this overestimation since 1974 was not at all clear. However, the estimaton of total stubble acreage imposed serious limitations on the simulation.

SII missed 7 out of 20 turning points and produced a very large mean absolute percentage error of 43.77%.

5.2.2 Oats Acreage

5.2.2.1 Manitoba

In Figure(5.2.1.) the simulated values of oats acreage grown on stubble in Manitoba are compared with the actual values. The results of SI showed that actual oats acreage, other than in 1963 and 1965, was underestimated through the years from 1962 to 1981. The simulation performed badly in predicting changes in the direction of actual oats acreage. Turning point errors occurred in 8 of 20 years, although there was no large deviation.

The values of oats acreage genearated from SII were very close to those generated from SI. In terms of simulating changes in direction in the actual oats acreage, SII differed from SI only in that it missed the downturn in oats acreage in 1963 which was correctly reflected in SI. There was no large deviation between the simulated values of oats acreage derived from SI and from SII, which indicated that the estimation of total stubble acreage added very little error to SII. The mean absolute percentage error of SII was 14.82% compared to 13.69% for SI.

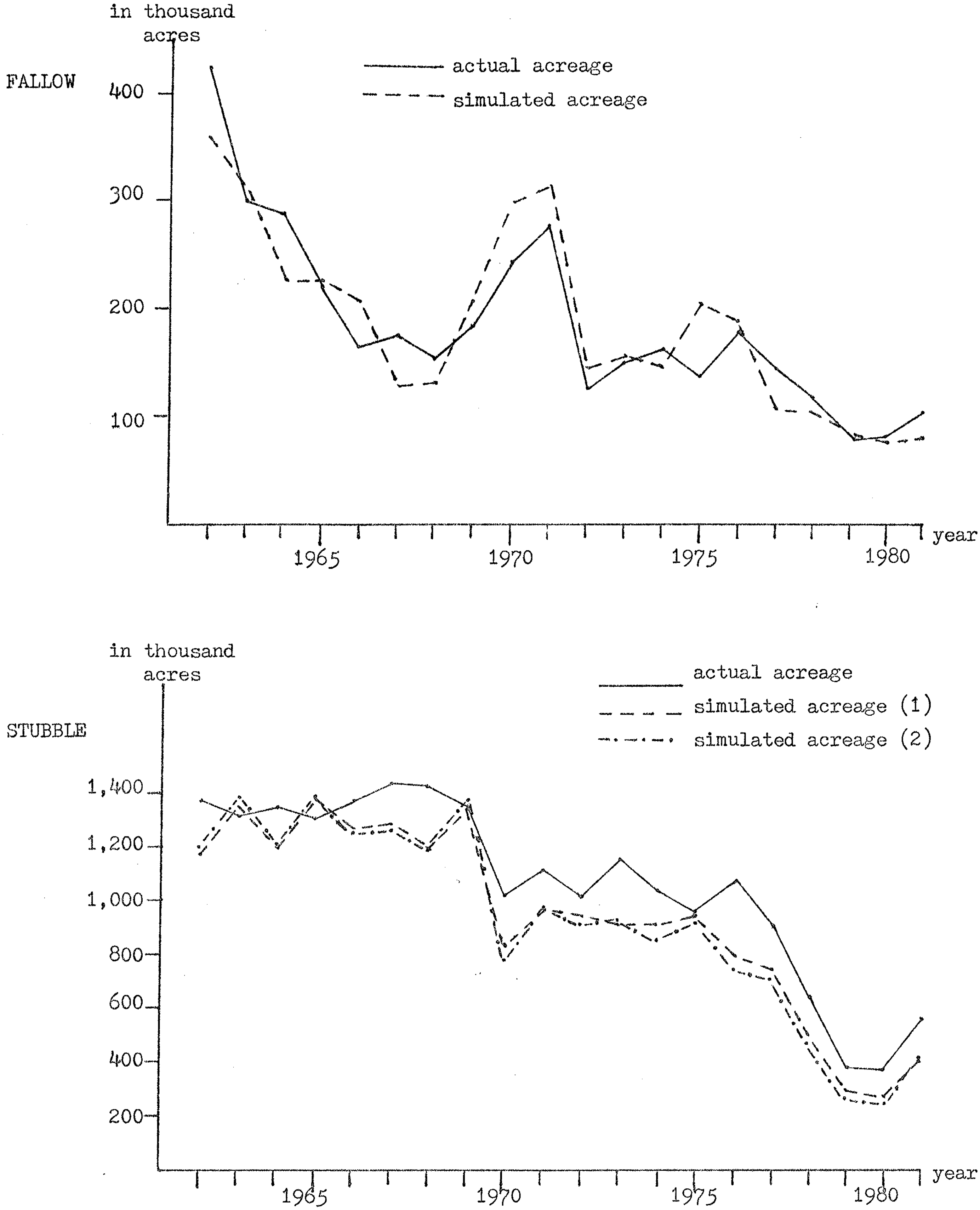
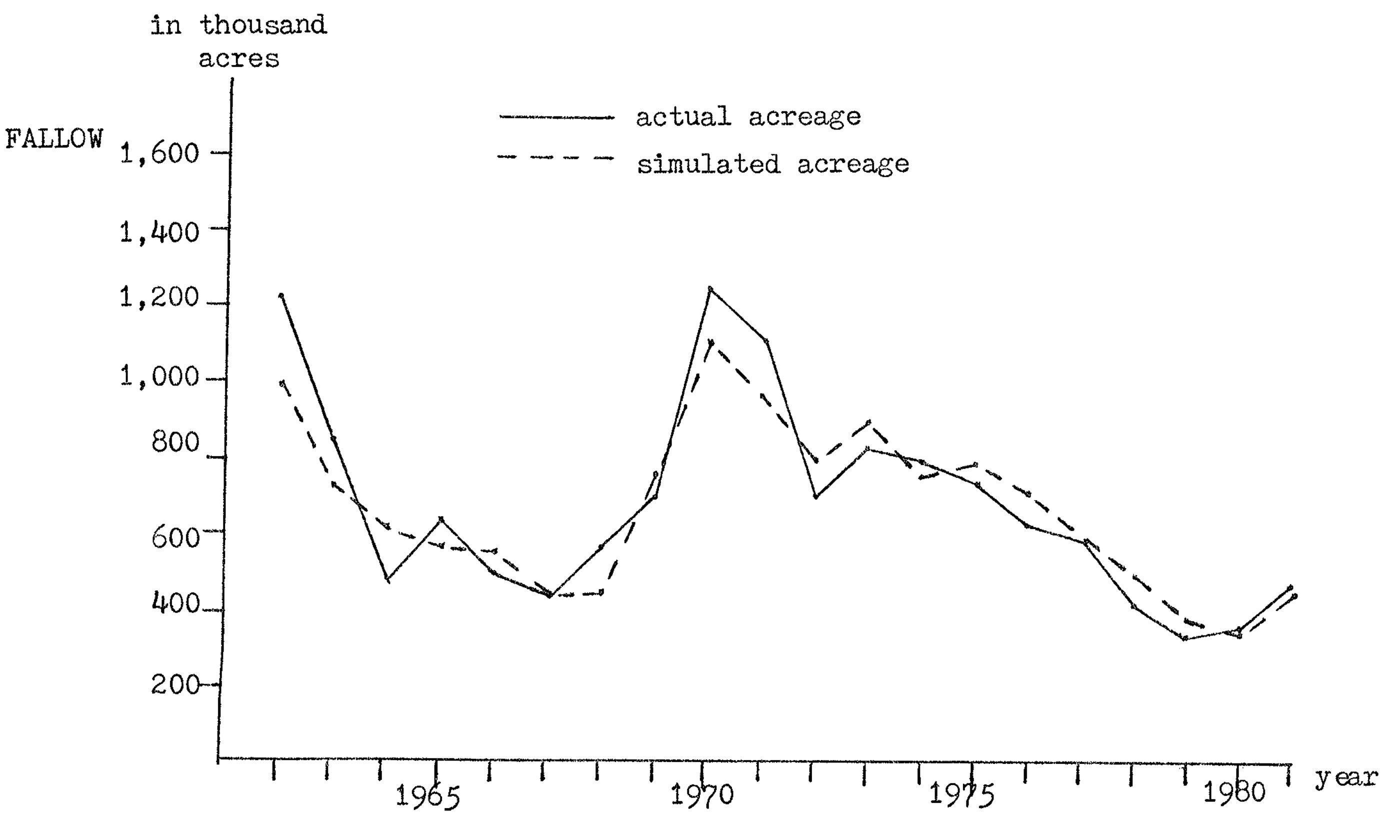


FIGURE 5.2.1.
Actual and Simulated Oats Acreage - Stubble and Fallow, Manitoba



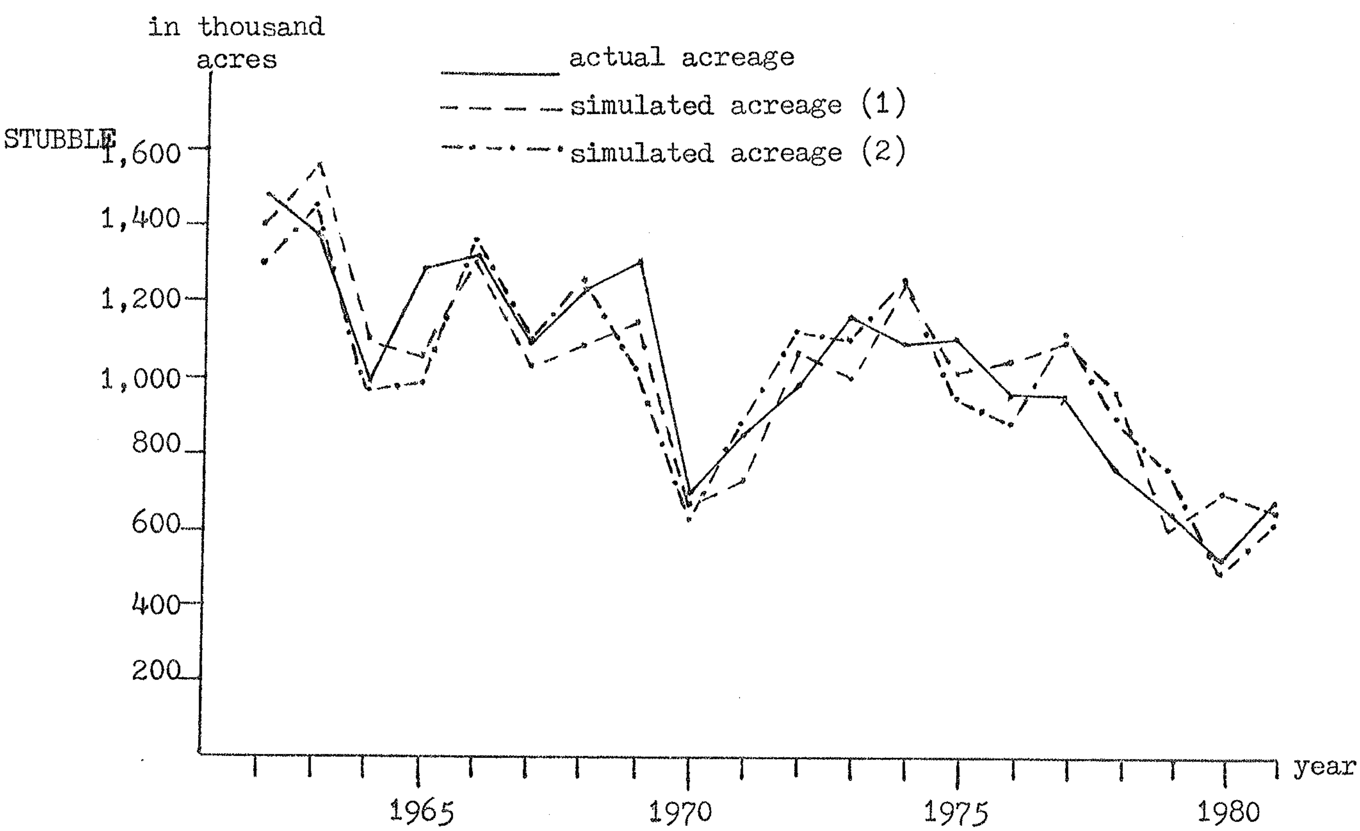


FIGURE 5.2.2.

Actual and Simulated Oats Acreage - Stubble and Fallow, Saskatchewan

5.2.2.2 Saskatchewan

In Figure(5.2.2.) the simulated values of oats acreage in Saskatchewan are compared with the actual values. The results showed that SI performed reasonably well in terms of the magnitude of simulation errors. Errors exceeded 20% only in 1978 and 1980 over the period 1962 to 1981. The mean absolute percentage error of SI was 11.41%. However, the simulation had poor performance in terms of its ability to predict turning points in actual oats acreage, turning point errors occurred in 7 out of 20 years.

The results of SII showed some improvements over those of SI. Although imprecise estimates of total stubble acreage introduced substantial errors into SII in many of the years between 1962 and 1981, most of these errors, to a certain extent were offset by errors attributed to the simulated acreage share of oats derived from the allocation model. This was most noticed in 1980, when a very large negative error due to estimated total stubble acreage more than offset the 31% error due to the model and resulted in a net error of -6.7%. Consequently, net errors in SII were, on the average, slightly smaller than those in SI. The mean absolute percentage error of SII was 10.42% compared with the 11.41% of SI. As a result of the neutralization of positive and negative errors from alternative sources, the number of turning point errors was reduced significantly to 4 in SII.

5.2.2.3 Alberta

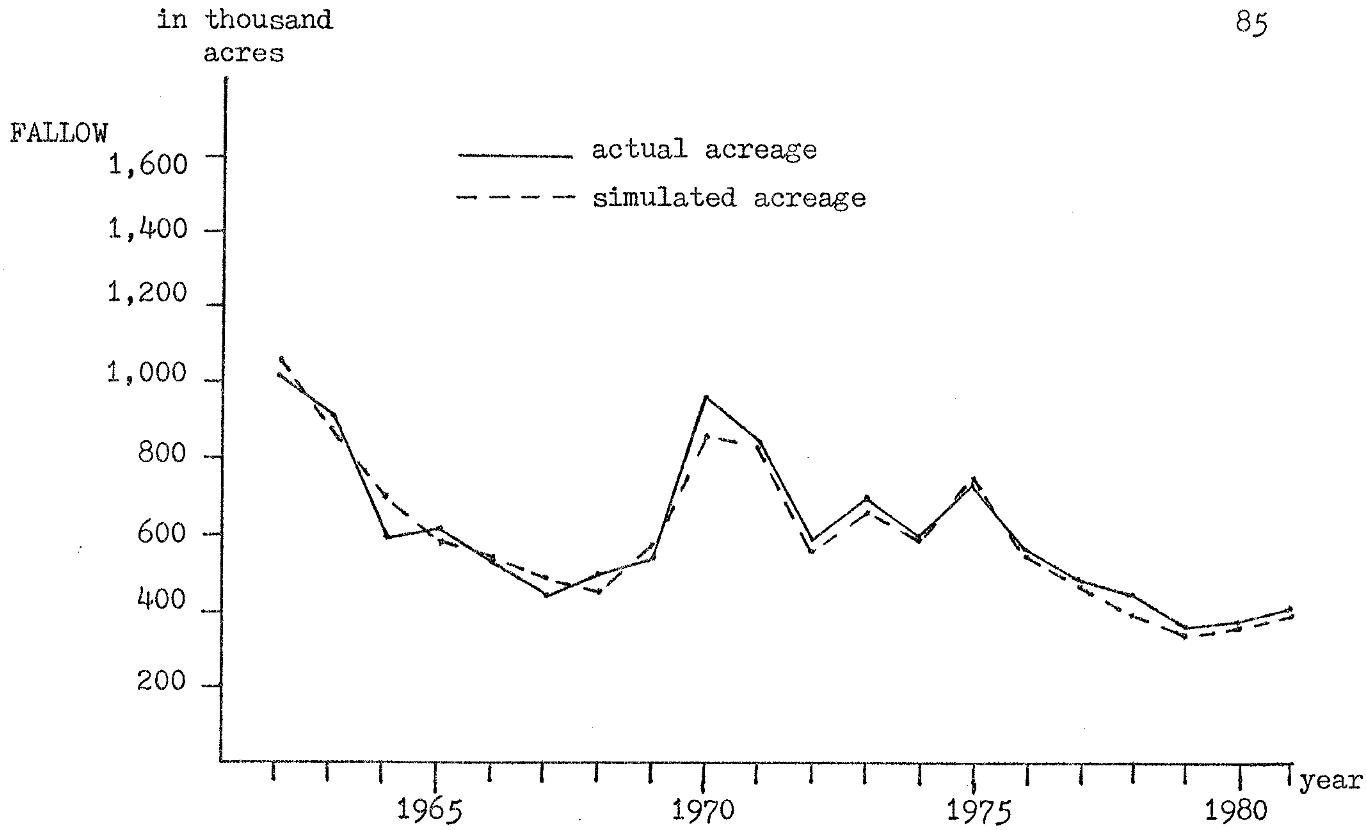
Figure(5.2.3.) presents actual and simulated values of oats acreage in Alberta. The simulation of oats acreage in Alberta was more satisfactory than that in Manitoba and Saskatchewan. SI picked up 15 out of 20 turning points in actual oats acreage and tracked actual oats acreage rather closely. The deviations between simulated and actual oats acreage were less than 10% over the period 1962 and 1981 except in 1964 and 1974. The mean absolute percentage error of the simulation was satisfactorily low at 5.48%.

SII also captured 15 out of 20 turning points in the oats acreage and reproduced the time path of actual oats acreage closely in general. The mean absolute percentage error of SII was 7.01%. The results implied that, on the average, the estimated total stubble acreage was responsable for about 20% of the net errors in SII.

5.2.3 <u>Barley Acreage</u>

5.2.3.1 Manitoba

Simulated values of barley acreage along with the actual values re presented in Figure(5.3.1.a). SI tracked the time path of actual barley acreage very closely in the most recent ten years with the exception of 1978 where a surge of barley acreage to 1.9 million acres was simulated, while actual barley acreage declined to about 1.5 million acres. In all other years during the most recent 10 years period, absolute percentage errors were less than ten percent, and average absolute percentage error for this period was 5.16%. The simulation was not as successful in the earlier years. Overall, 17 out of 20 turning points in the



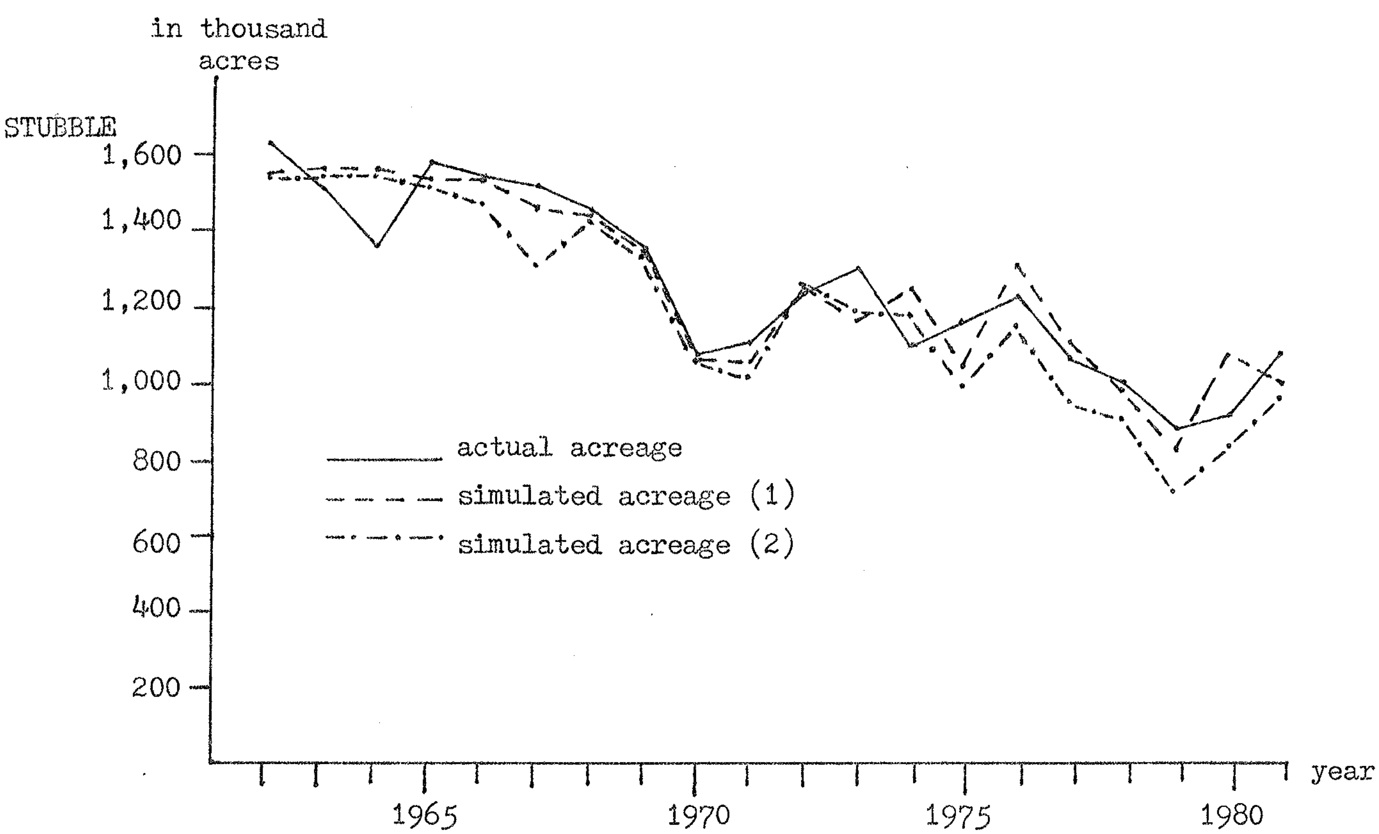
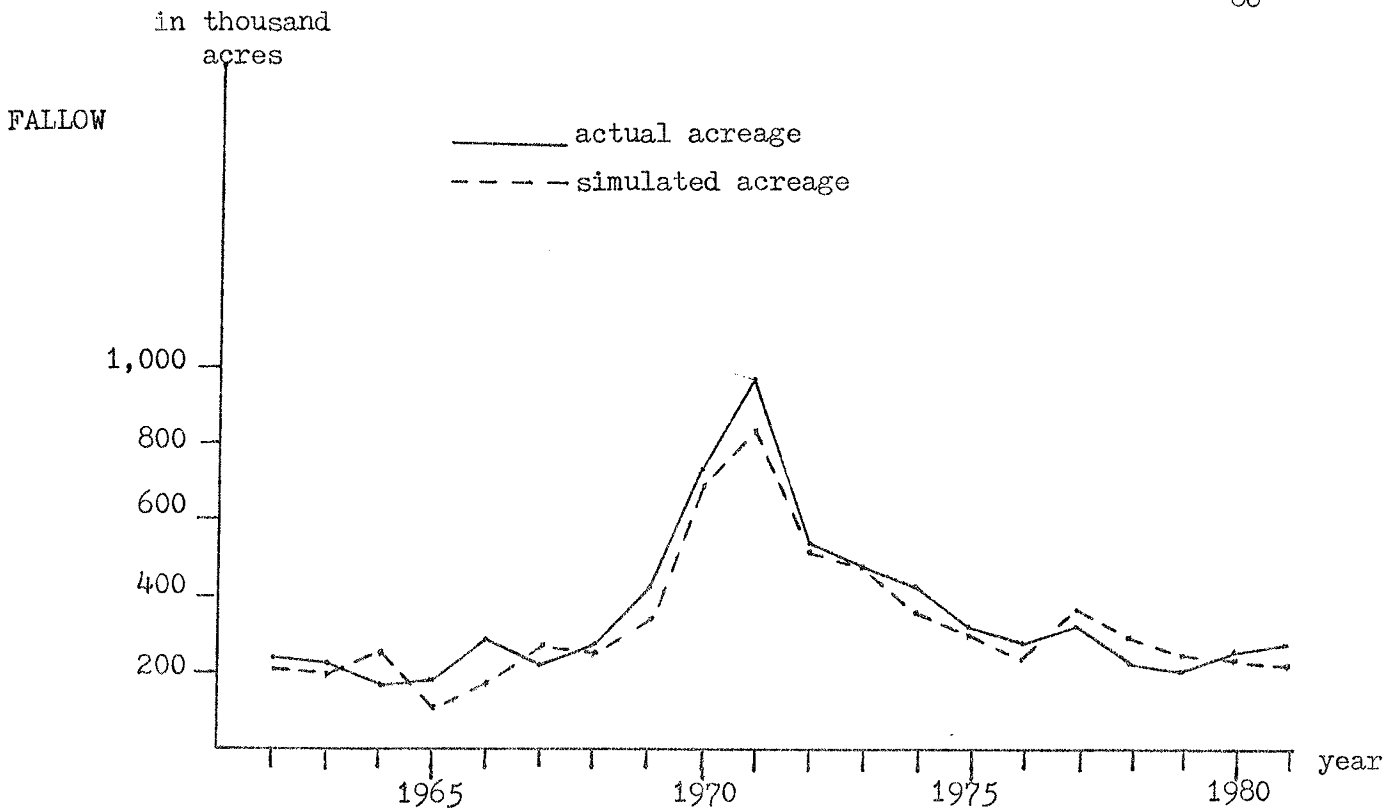


FIGURE 5.2.3.

Actual and Simulated Oats Acreage - Stubble and Fallow, Alberta



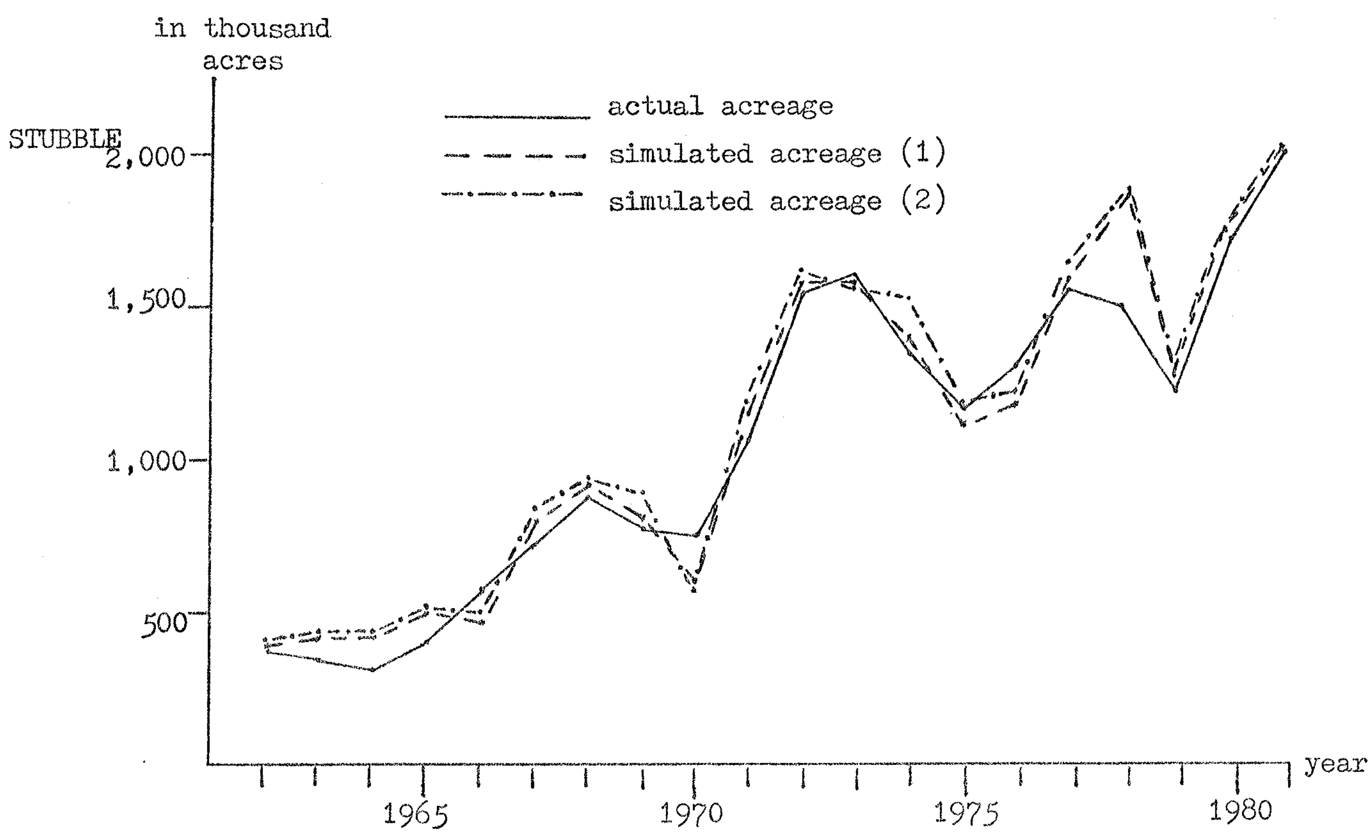


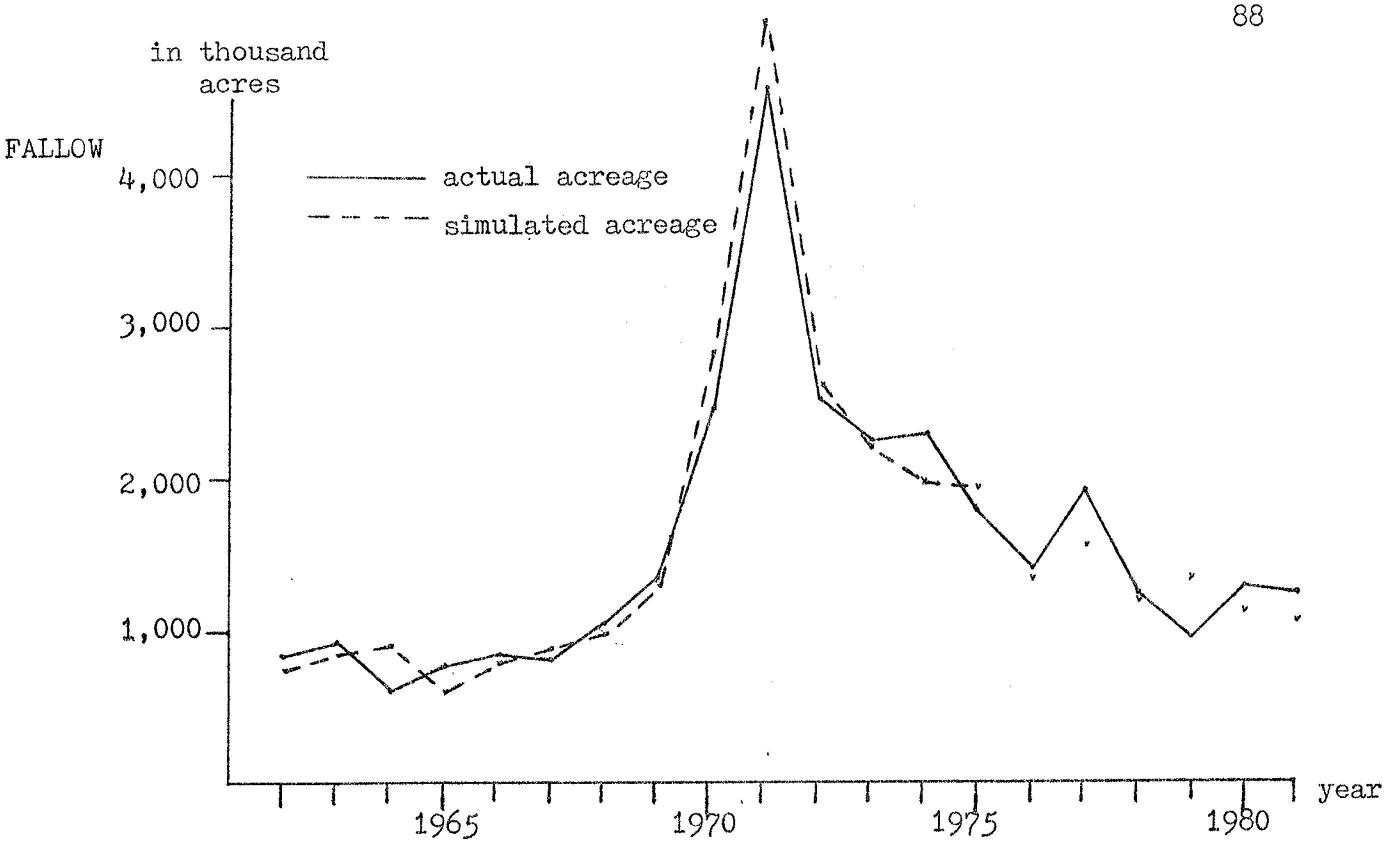
FIGURE 5.3.1.

Actual and Simulated Barley Acreage - Stubble and Fallow, Manitoba actual barley acreage were captured and the mean absolute percentage error of the simulation was 10.28% for the period 1962 to 1981.

The results of SII were very close to those of SI. The direction of simulated barley acreage generated from SII was the same as that generated from SI through the simulation period. The results of SII showed that during the most recent ten-year period absolute errors exceeded 10% only in 1974 and 1978. Simulation error of .4 million acres in 1978 was solely attributed to overestimation of the percentage share of barley, while overestimation of total stubble acreage was mainly responsiable for the .2 million acres overestimation of barley acreage in 1974. Prior to 1971, all simulation errors but the one in 1969 were mainly attributed to poor performance of the allocation model. The mean absolute percentage error of SII was 11.72%. The results implied that, on the average, the acreage allocation model accounted for almost 90% of the simulation errors in SII.

5.2.3.2 Saskatchewan

The actual values of barley grown on stubble in Saskatchewan, compared with the simulated values, are presented in Figure(5.3.2.). The results of SI showed that the actual and simulated values of barley acreage were reasonsbly close. Absolute percentage deviations of simulated from actual acreage for the period 1962 to 1981 ranged from .97% to 18.14% except in 1964. Although turning point errors occurred in 4 of 20 years, the trend of the simulated barley acreage was quite consistent with that of the actual barley acreage. The mean absolute percentage error of the simulation was 12.91%.



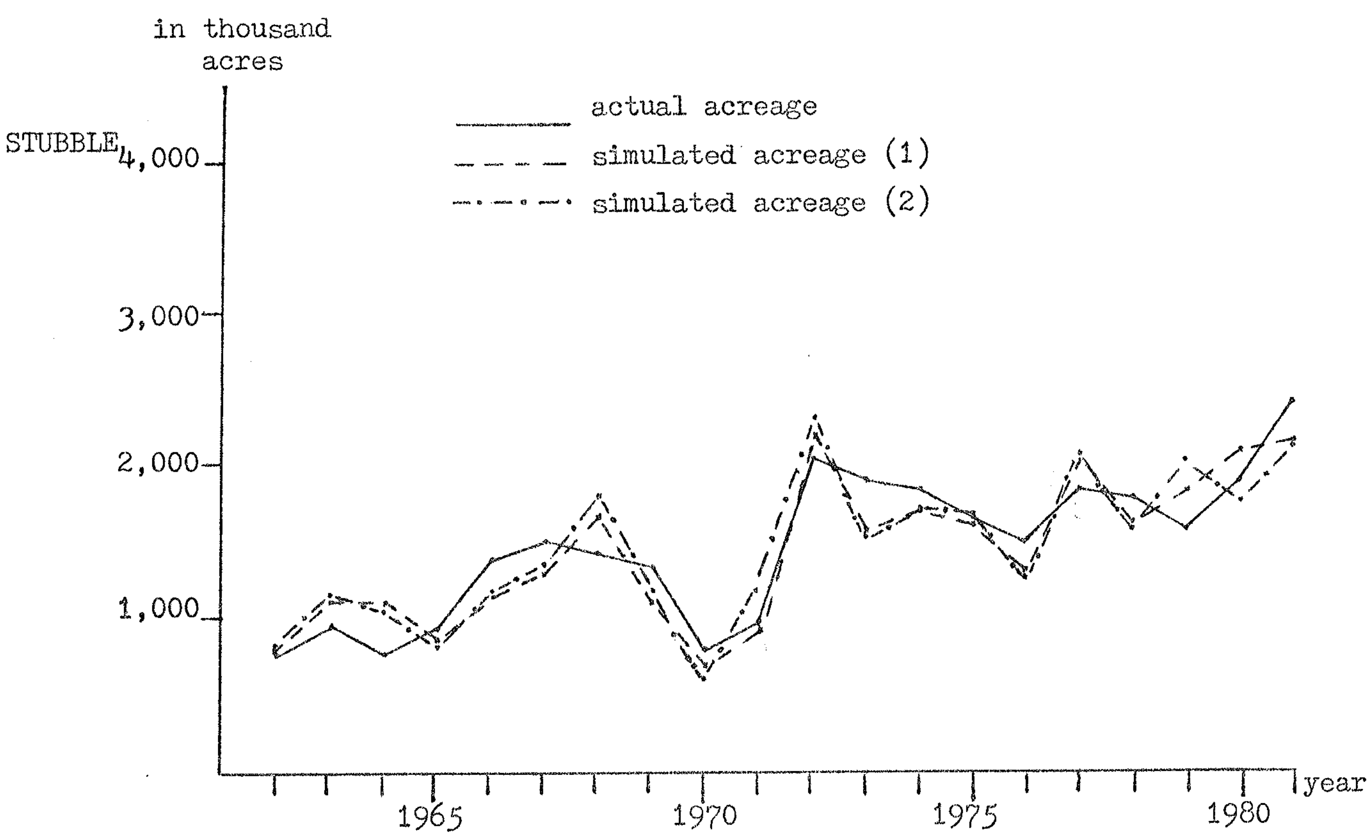


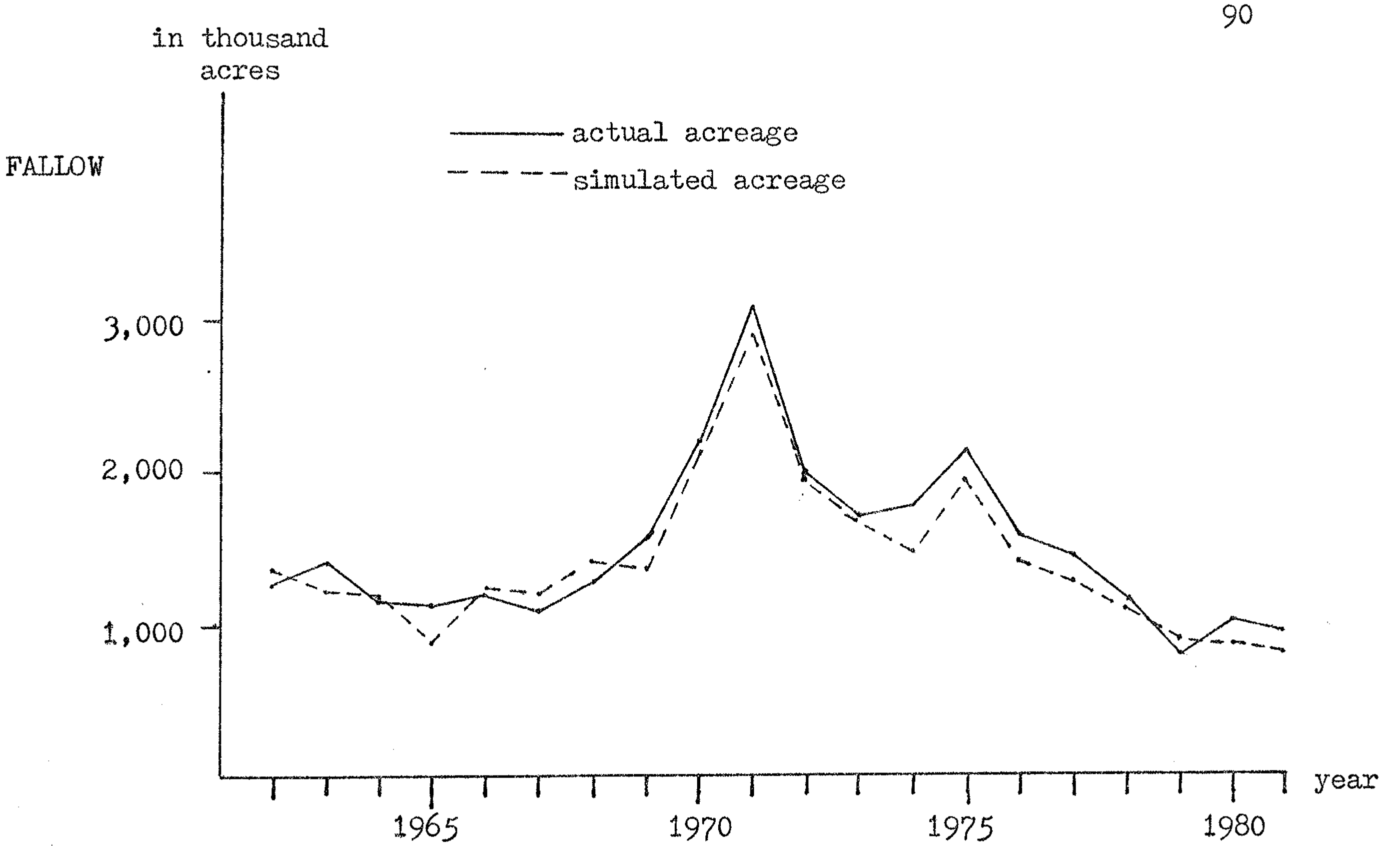
FIGURE 5.3.2.

Actual and Simulated Barley Acreage - Stubble and Fallow, Saskatchewan

The results of SII were similar to that of SI, with slightly larger errors on the average for SII. The mean absolute percentage error of SII was 14.54%. Overall, 16 out of 20 turning points in actual barley acreage were correctly reflected. The simulated values of barley acreage between SI and SII differed significantly only in 1971 and 1980. In 1971, imprecise estimation of total stubble acreage caused an overestimation in the barley acreage which offset the -3.84% error attributed to the model, and resulted in a 23.11% net error of .23 million acres. In 1980, the estimated total stubble acreage caused an underestimation of barley acreage which cancelled out the 10.79% error attributed to the model and resulted in a net error of -6.37%. On the average, net errors transmitted from estimated total stubble acreage accounted for about 11% of the errors in SII.

5.2.3.3 Alberta

Figure(5.3.3.) presents simulated values of barley acreage seeded on stubble in Alberta compared with the actual values. Values of barley acreage generated from SI were generally remarkable close to the actual values through the period of simulation. 17 out of 20 turning points in actual barley acreasge were successfully captured. The largest deviation between actual and simulated barley acreage was in 1979 where the simulation missed the downturn in barley acreage and predicted an upswing of barley acreage to 4.3 million acres, which was .58 million acres above the actual barley acreage of 3.72 million acres.



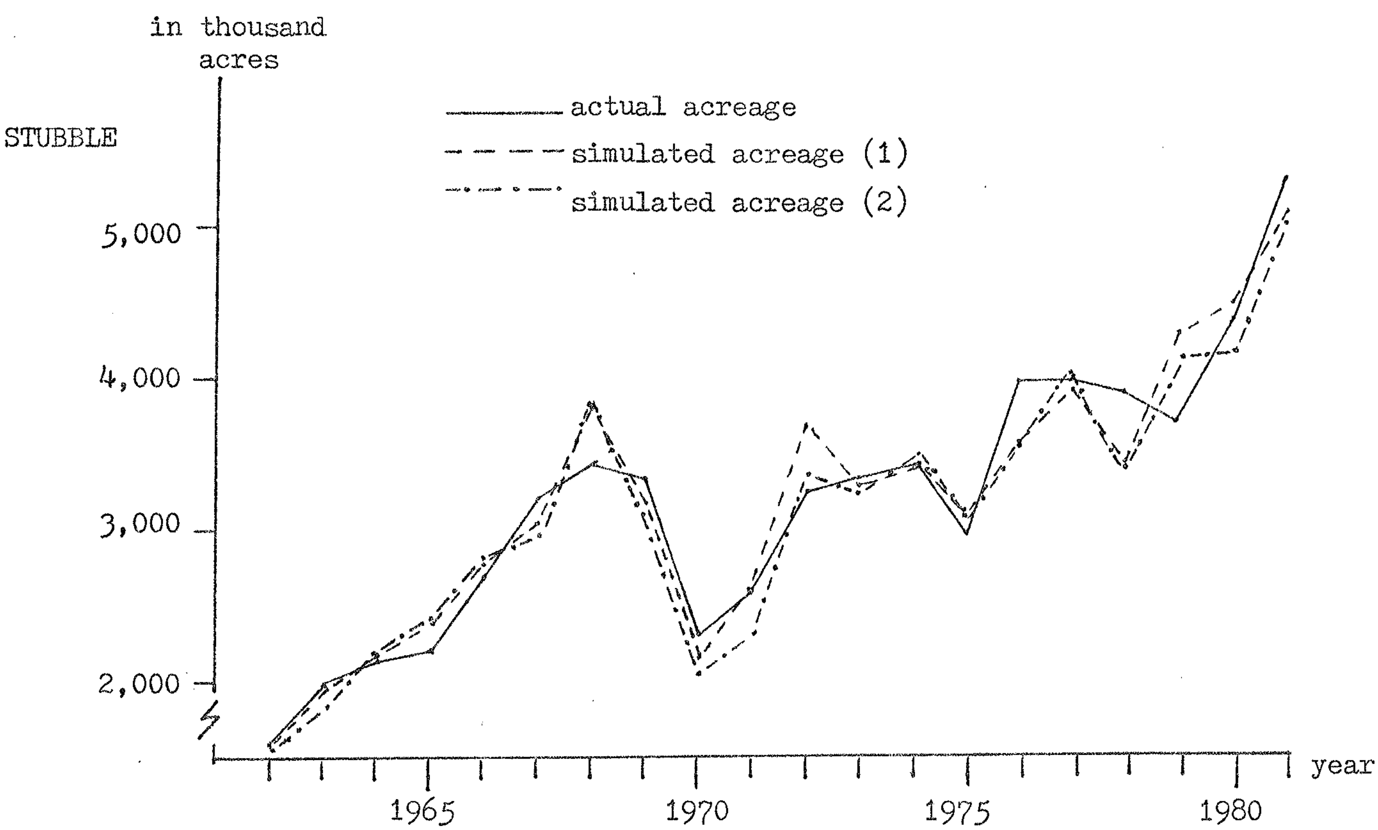


FIGURE 5.3.3.

Actual and Simulated Barley Acreage - Stubble and Fallow, Alberta

The performance of SII was also satisfactory. The results showed that SII captured 18 out of 20 turning points in the barley acreage. SII correctly reflected upturns of barley acreage in 1974 and 1977 which were not captured in SI because underestimation of barley acreage in these years were offset by a corresponding overestimation of barley acreage due to errors in the estimated total stubble acreage. The mean absolute percentage error in SII was 5.81% compared to 5.47% in SI. The results implied that, on the averae, the net error transmitted from estimated total stubble acreage accounted for only 6% of the net errors in SII.

5.2.4 Rapeseed Acreage

5.2.4.1 Manitoba

In Figure(5.4.1.) the simulated values of rapeseed acreage grown on stubble in Manitoba are compared with the actual values. SI successfully captured 18 out of 20 turning points in rapeseed acreage between 1962 and 1981. The simulation performed fairly well with low errors during the earlier years prior to 1970. However, this was not the case for the more recent years after 1970.

SII also successfully reflected 18 out of 20 turning points in rapeseed acreage, although the deviations of simulated from actual rapeseed acreage were generally larger than those in SI. The largest error occurred in 1974 where the simulated value of 460 thousand acres was 185 thousand acres over the actual value of 275 thousand acres, with a resultant error of 67.52%. Imprecise estimation of total stubble acreage

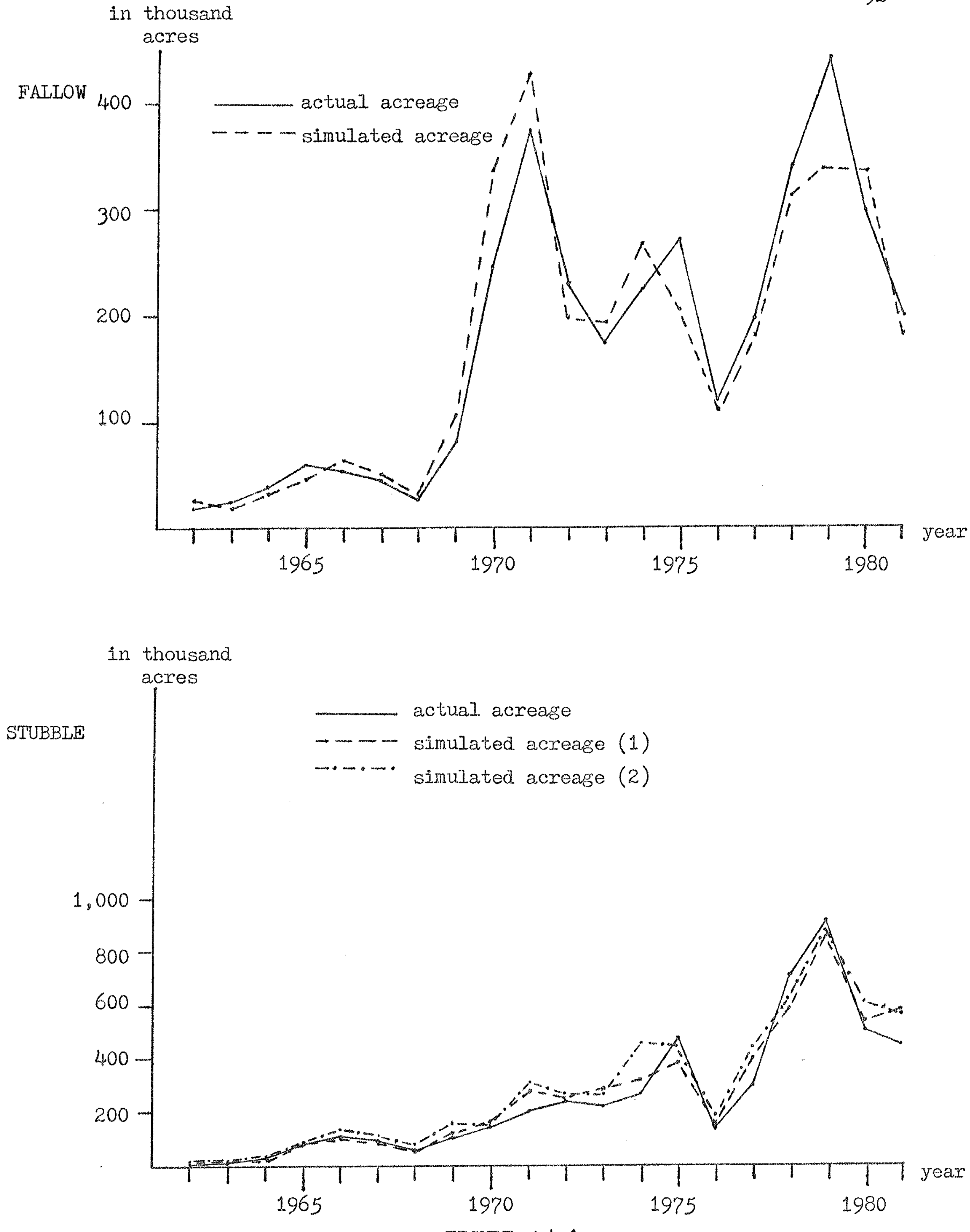


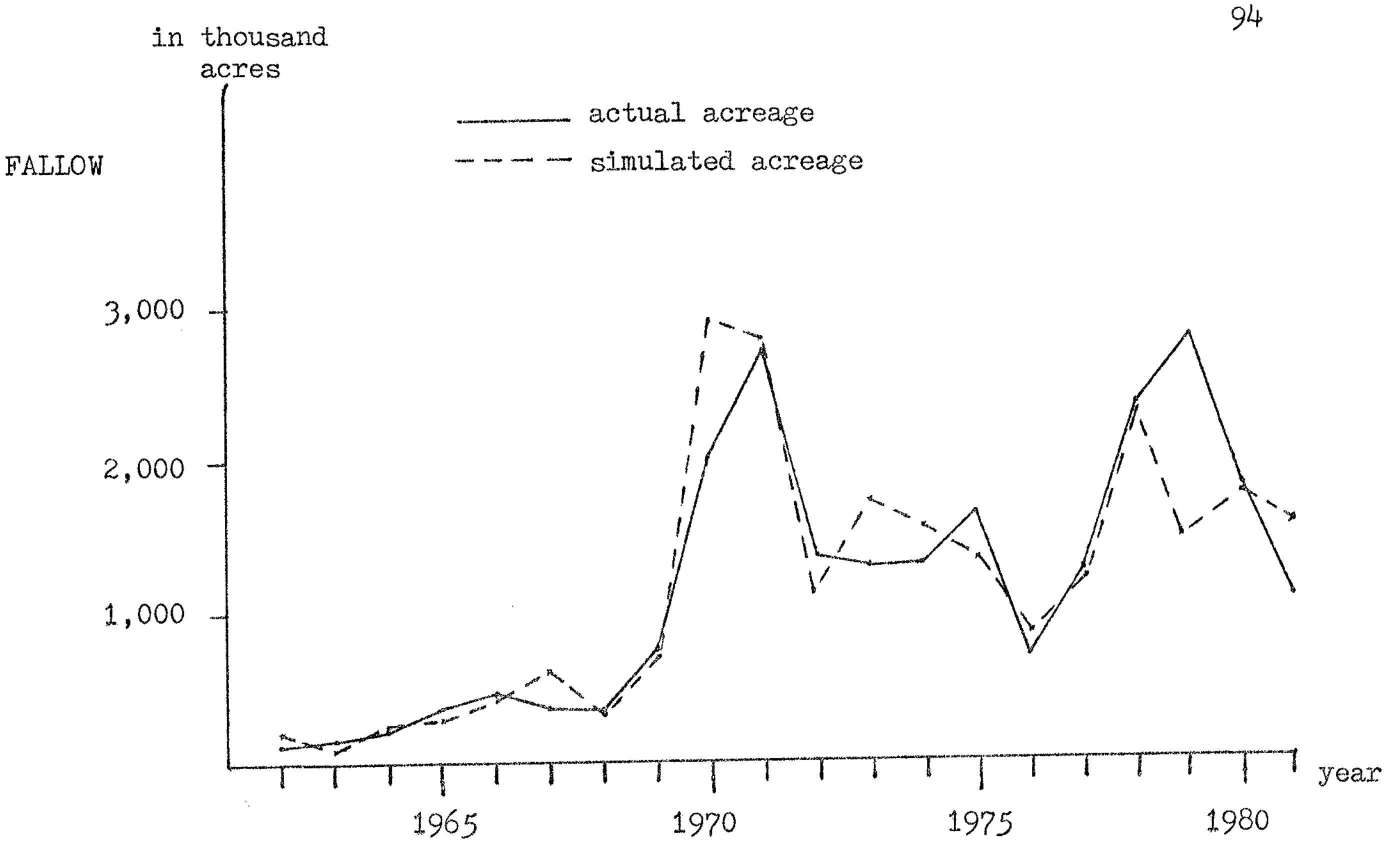
FIGURE 5.4.1.

Actual and Simulated Rapeseed Acreage - Stubble and Fallow, Manitoba accounted for about 70% of this error. The mean absolute percentage error of SII was 21.1% compared with 14.90% for SI. On the average, net errors transmitted from estimated total stubble acreage accounted for about 30% of the errors in SII.

5.2.4.2 Saskatchewan

Figure(5.4.2.) presents the simulated values of rapeseed acreage compared with the actual values. The results of SI were not satisfactory in terms of the magnitude of simulaton errors, especially during the more recent period. Simulation errors exceeded 20% in 4 out of 6 years since 1976. The mean absolute percentage error of the simulation was 18.01%. In spite of relatively large simulation errors, the simulation successfully predicted 18 out of 20 turning points in rapeseed acreage.

The results of SII indicated that during the most recent ten-year period, 1975 and 1981 were the only years showing absolute errors less than 20%. 17 out of 20 turning points in rapeseed acreage were reflected correctly. The largest deviaton from actual rapeseed acreage occurred in 1979 where the simulated value was 216 thousand acres under the actual value of 516 thousand acres as a result of combined errors from simulated acreage share and estimated total stubble acreage. The mean absolute percentage error of SII was 23.60%. On the average, poor performance of the model in simulating acreage share was responsable for about 75% of simulation errors in SII.



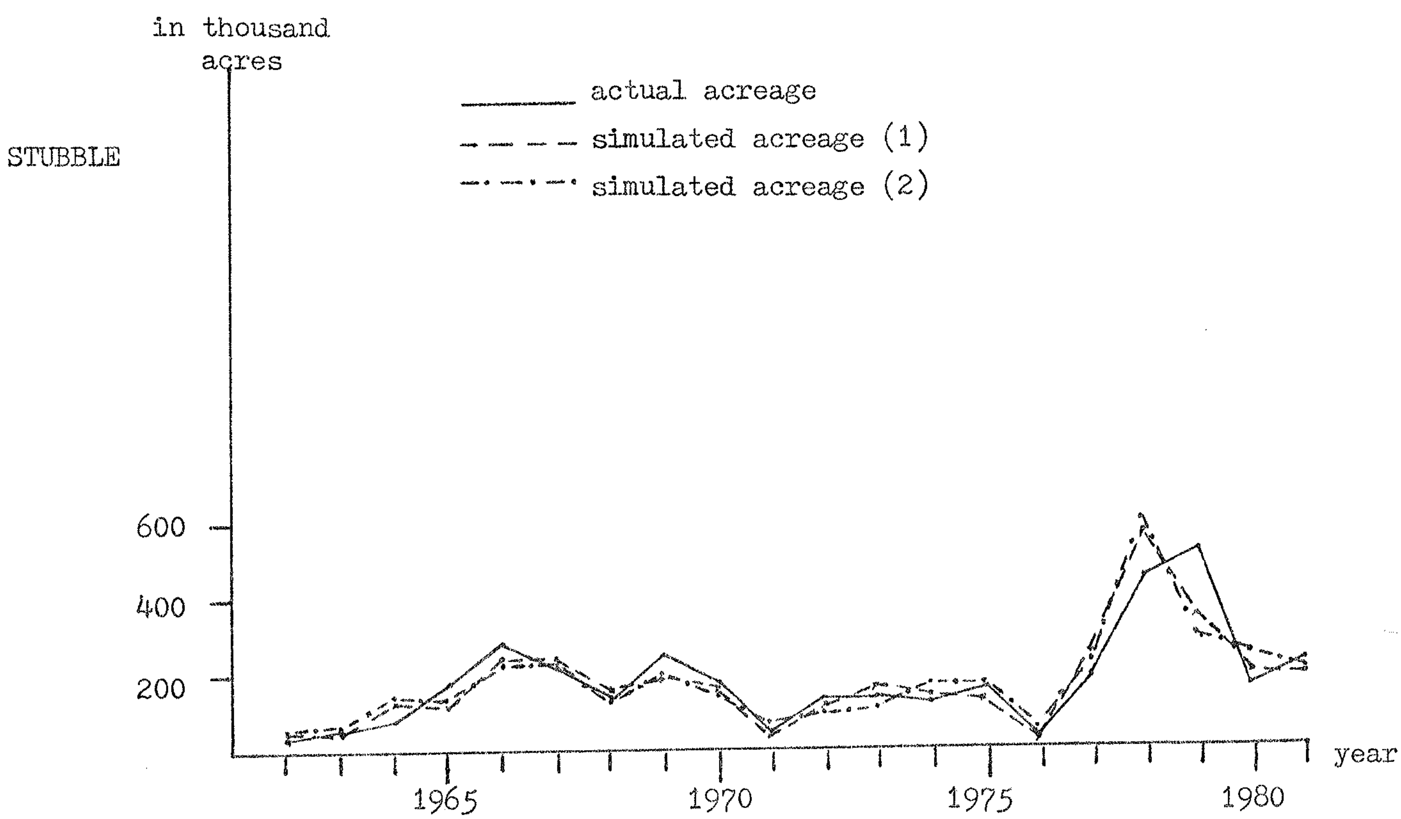


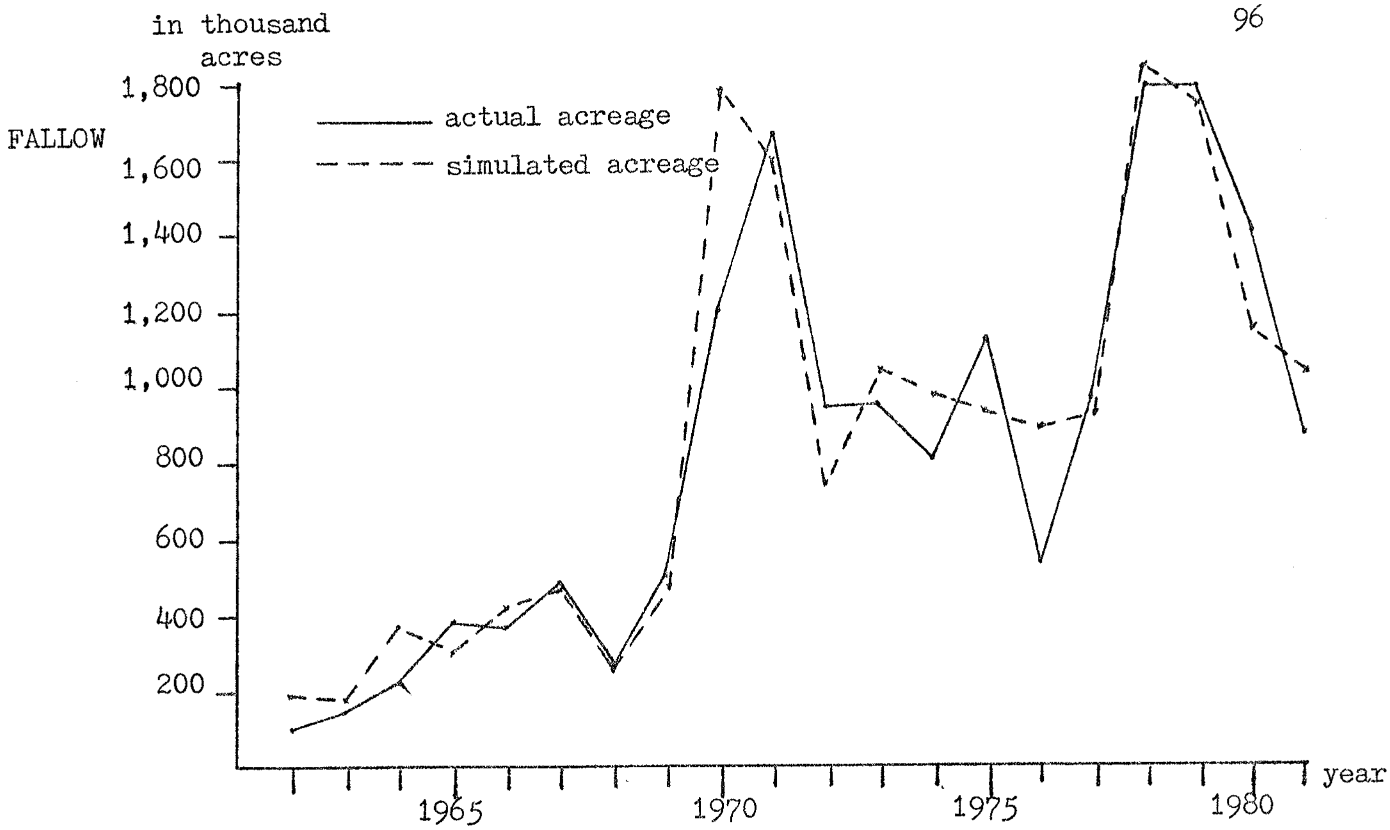
FIGURE 5.4.2.

Actual and Simulated Rapeseed Acreage - Stubble and Fallow, Saskatchewan

5.2.4.3 Alberta

Simulated and actual values of rapeseed acreage grown on stubble in Alberta are presented in Figure(5.4.3.). The results for Manitoba and Saskatchewan were similar to Alberta as SI tracked actual rapeseed acreage well in the earlier years prior to 1970. Absolute errors of the simulation ranged from 0.90% to 16.89% between 1962 and 1969. All turning points in rapesed acreage during this period were captured. However, the simulation did not perform as well after 1970. Errors exceeded 20% in 7 years and 3 turning point errors occurred during the most recent 10 year period. The 1980 and 1981 rapeseed acreage, however, were explained very well.

The results showed that errors in SII were smaller than those found in SI in most of the years prior to 1970 because errors attributed to the model were partially cancelled out by corresponding errors of opposite sign due to imprecise estimation of total area seed to stubble. However, simulated values of rapeseed acreage generated from SII deviated more from the actual values through the years from 1970 to 1981 (except for 1973 and 1979) as a result of compound errors transmitted from the model and from estimated area seeded to stubble. Turning points were not reflected correctly in 4 years during this period. The mean absolute percentage error in SII was 19.76%, compared with 15.52% in SI. The results implied that net errors attributed to the estimation of total area seeded to stubble accounted for about 20% of the average error in SII.



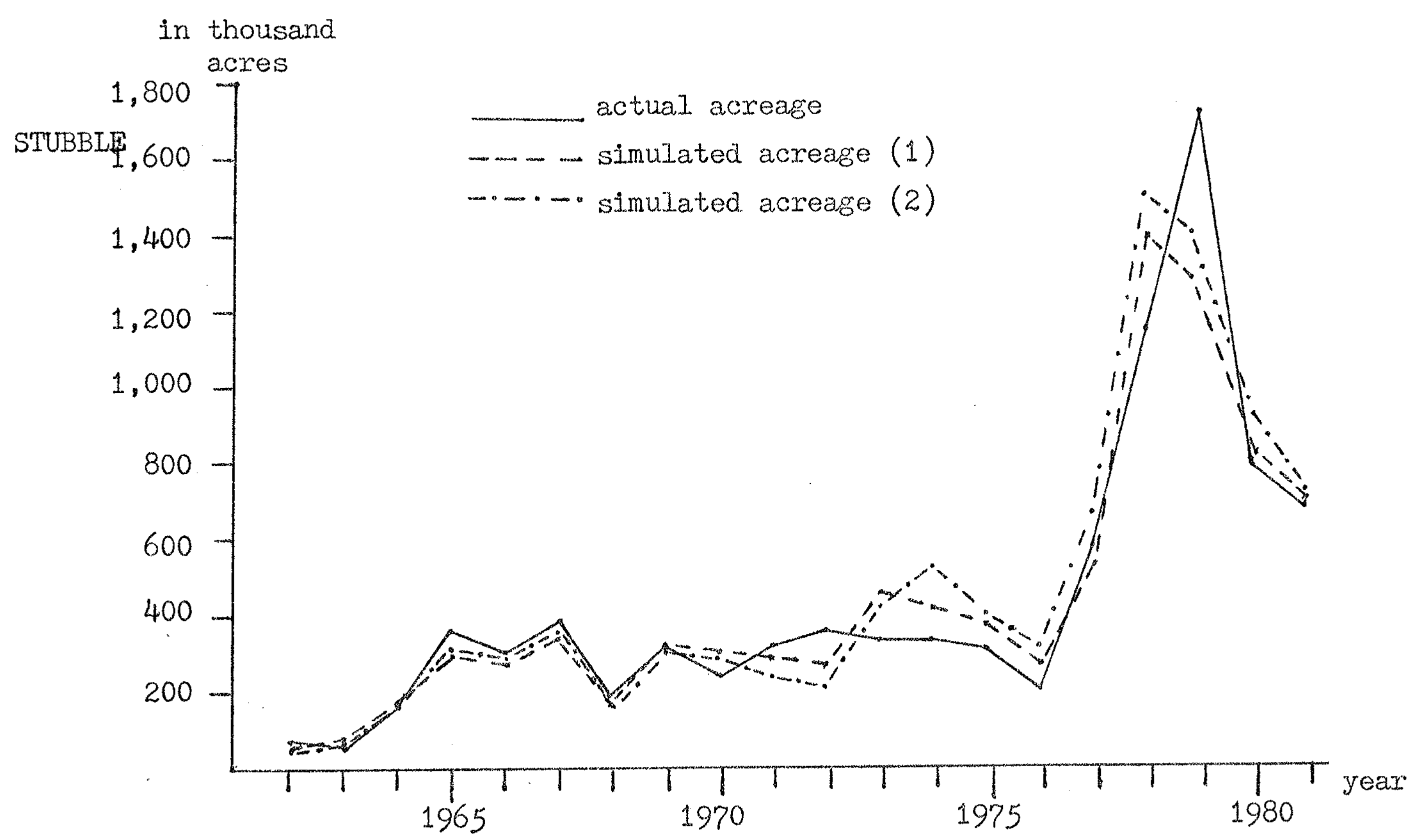


FIGURE 5.4.3.

Actual and Simulated Rapeseed Acreage - Stubble and Fallow, Alberta

5.2.5 Sunflowers Acreage

Actual and simulated values of sunflowers acreage in Manitoba are presented in Figure(5.5). Sunflower acreage remained very small and relatively stable before 1970. A large upswing in acreage occurred in 1971 and 1972 with a subsequent fall-back in 1973 and 1974. The acreage climbed rapidly after 1974 before its decline in 1980 and 1981.

SI picked up 16 out of 20 turning points in sunflower acreage between 1962 and 1981, which accounted for all major changes in the direction of acreage except in 1980, when the decline in sunflower acreage was not reflected. Simulation errors were relatively large in terms of percentage error, although absolute errors were relatively small ranging between 1.5 to 74 thousand acres. This is because sunflower acreage was very small over the period of analysis. The mean absolute percentage error of the simulation was 17.36%, which seems reasonable considering the small size and wide fluctuations of sunflower acreage.

Simulated values of sunflower acreage generated from SII generally deviated considerably more from the actual values than the values generated from SI. The most noticeable deviation was in 1980 where simulated value of 496 thousand acres exceeded actual value by 176 thousand acres, of which about 60% was attributed to inaccurate estimation of total stubble acreage. Overall, 15 out of 20 turning points in sunflower acreage were reflected. Mean absolute percent error of SII was 31.17% compared to 17.36% in SI, which implied that the estimation of total stubble acreage was responsiable for almost 45% of net errors in SII.

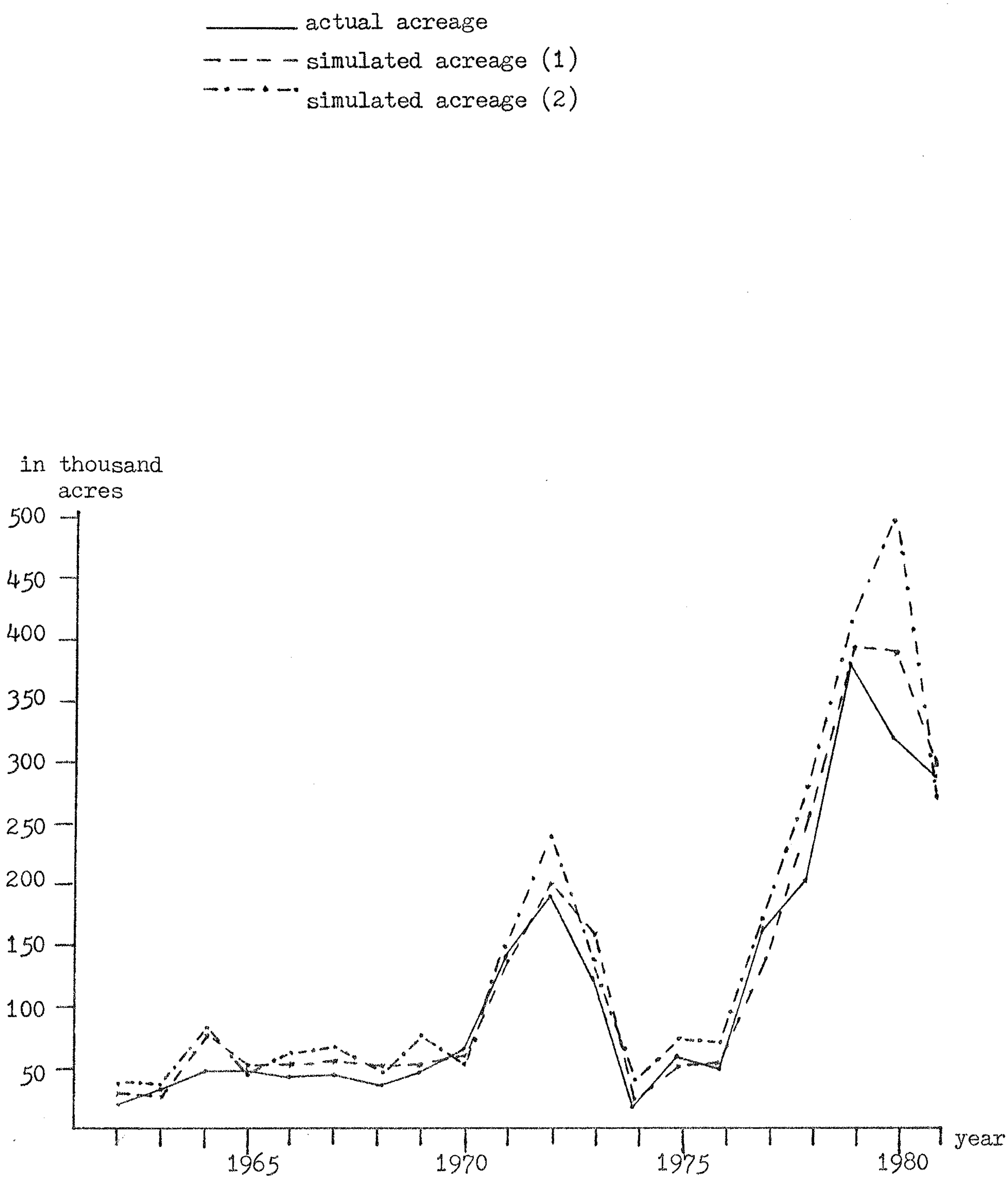
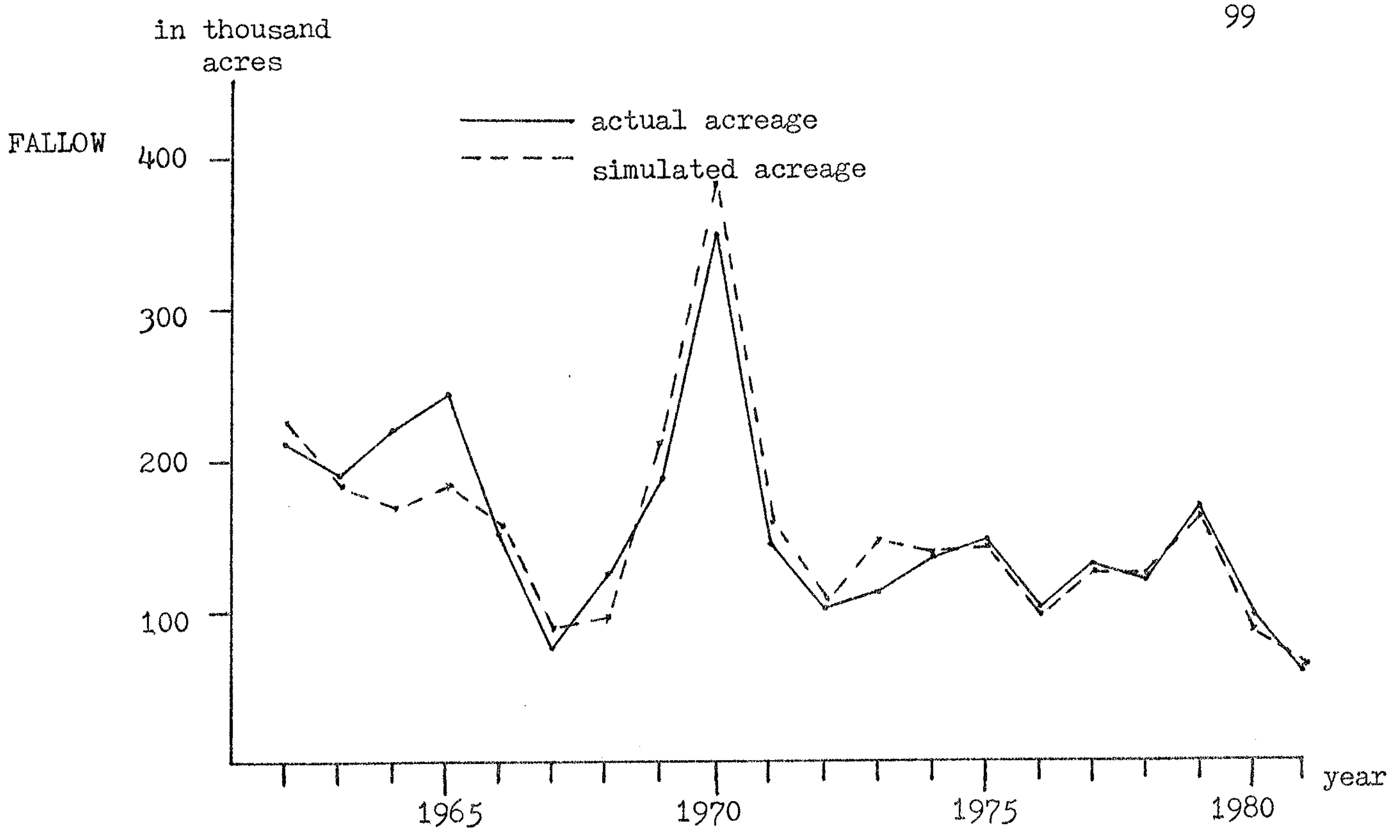


FIGURE 5.5

Actual and Simulated Sunflower Acreage - Stubble, Manitoba



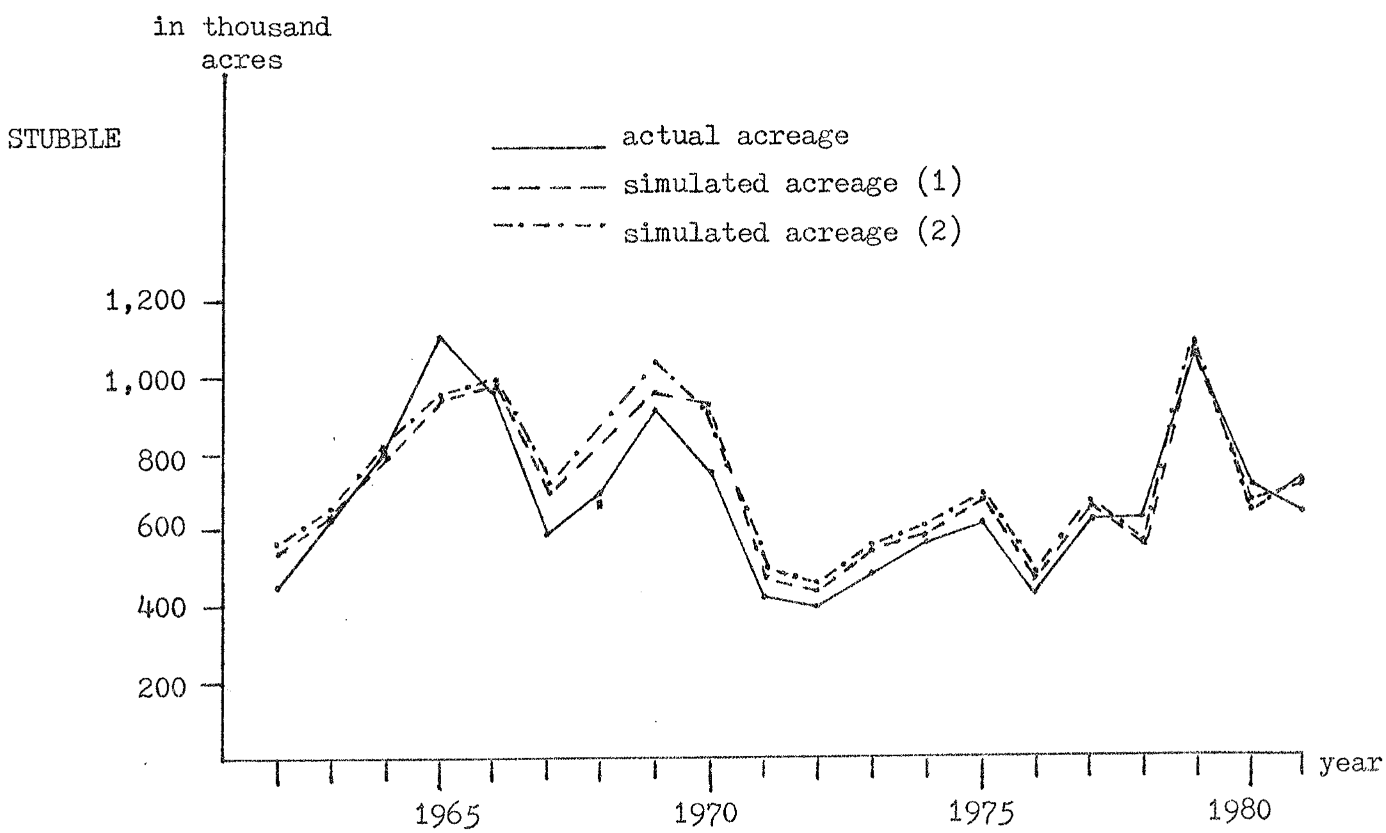


FIGURE 5.6.1.

Actual and Simulated Flaxseed Acreage - Stubble and Fallow, Manitoba

5.2.6 Flaxseed Acreage

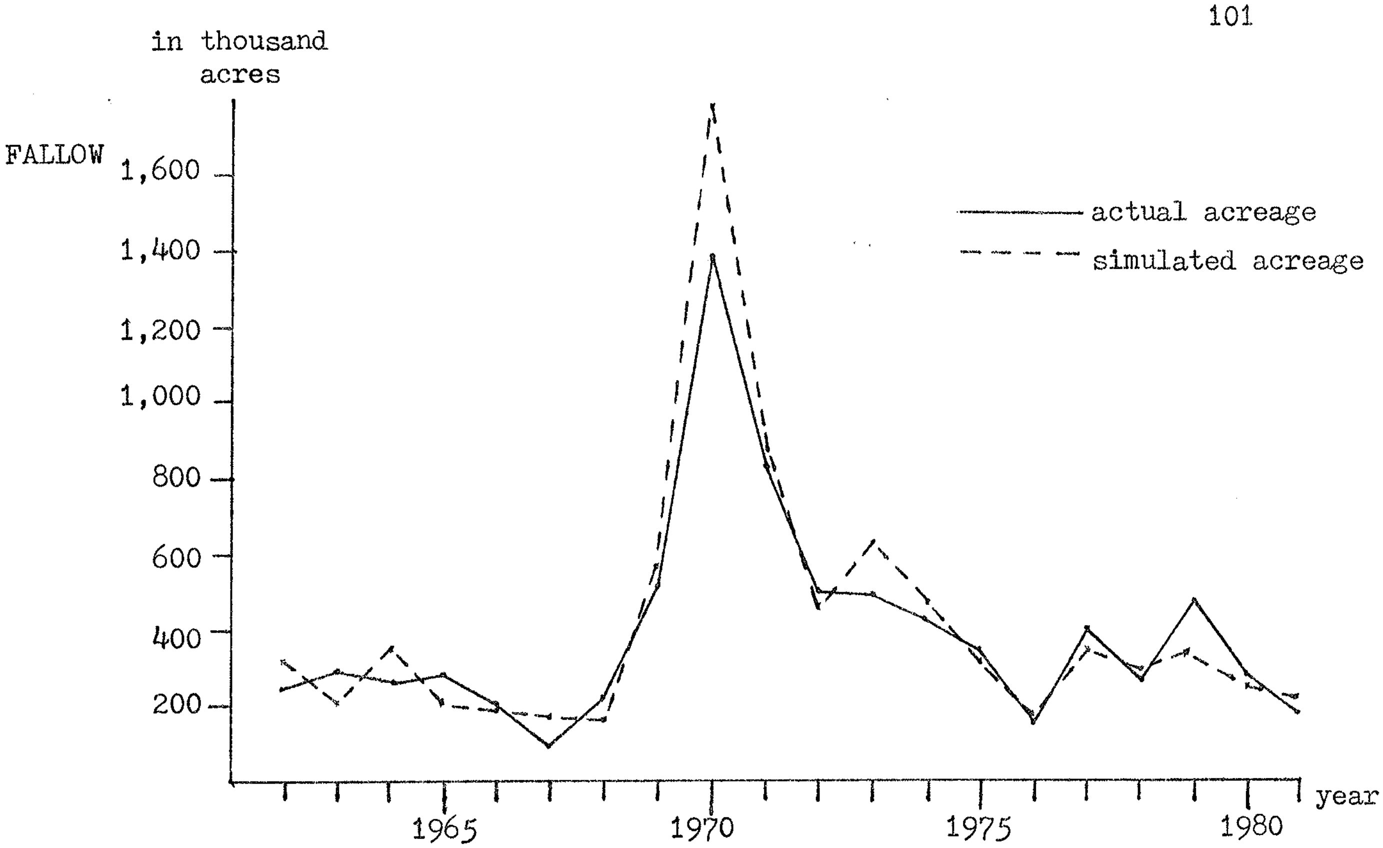
5.2.6.1 Manitoba

Actual, along with simulated values of flaxseed acreage in Manitoba are presented in Figure(5.6.1.). The results of SI showed that the trend in the simulated flaxseed acreage was quite consistent with that of the actual flaxseed acreage. Overall, 15 out of 20 turning points in actual flaxseed acreage were reflected correctly. Deviation between actual and simulated flaxseed acreage exceeded 20% only in 1962 and 1970. The mean absolute percentage error of the simulation, 9.44%, was satisfactorily low considering the 'residual' nature of flaxseed acreage in the simulation.

The results of SII were very close to the results of SI. 16 out of 20 turning points in flaxseed acreage were successfully captured. The downturn in flaxseed acreage in 1970 which was not captured in SI was picked up in SII although the magnitude of the decline was not reflected. The mean absolute percentage error of SII was 10.94%.

5.2.6.2 Saskatchewan

Figure(5.6.2.) presents simulated values of flaxseed acreage seeded on stubble in Saskatchewan compared with the actual values. SI picked up 16 out of 20 turning points in flaxseed acreage, although simulated values of flaxseed acreage generally deviated considerably from actual values. The mean absolute percentage error of the simulation was 20.60%. In view of the 'residual' nature of flaxseed acreage in the simulation, its very small percentage share (average about 3% over the



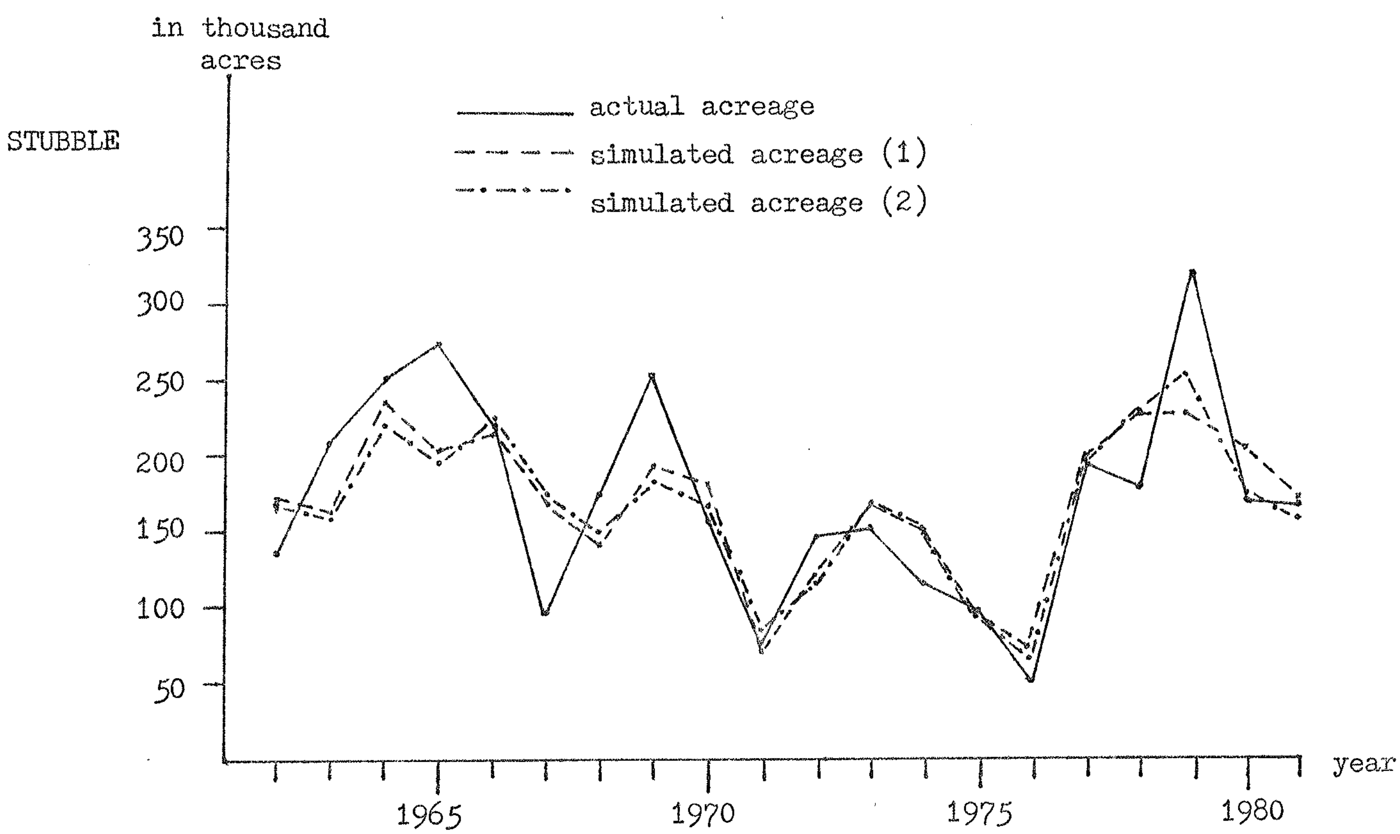


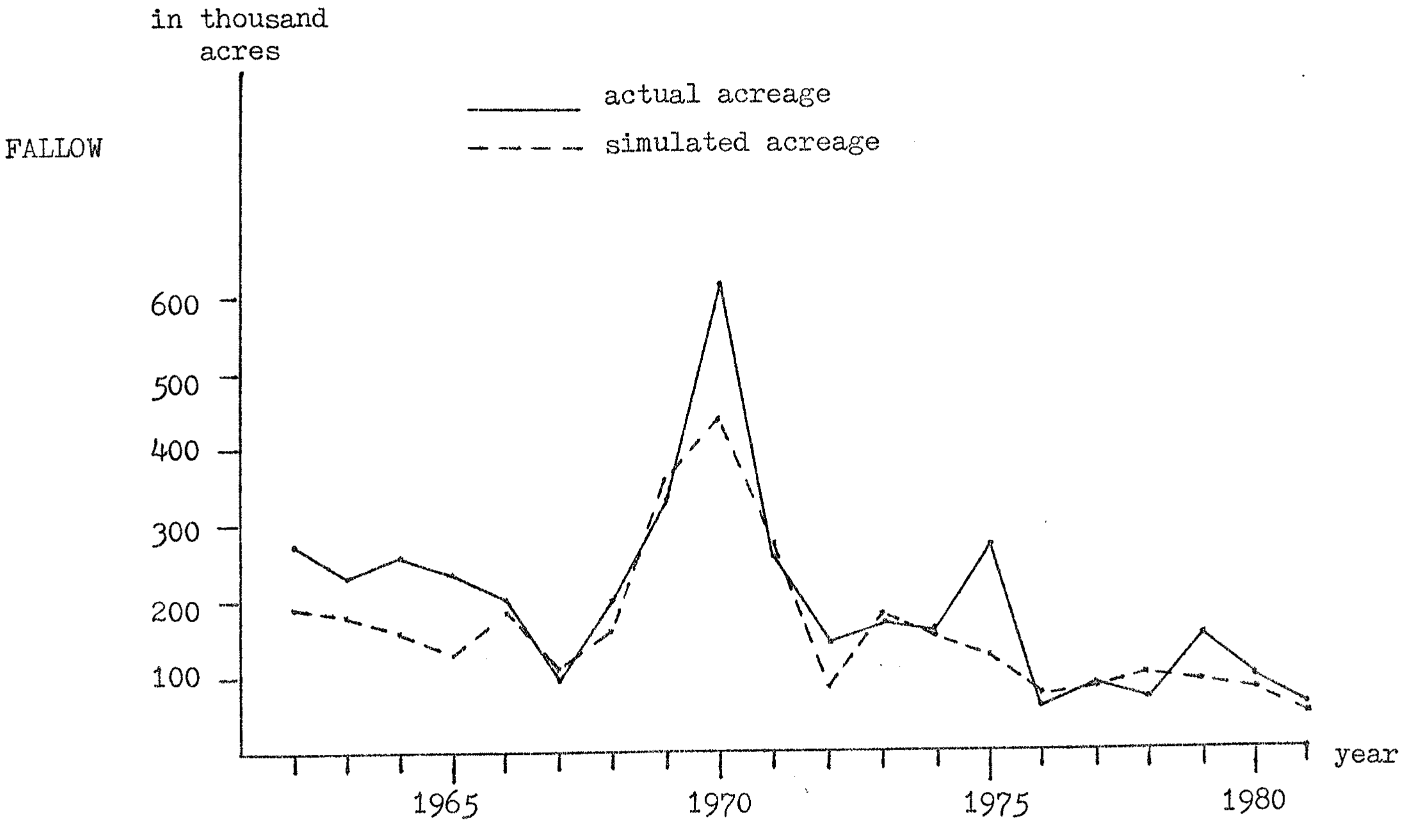
FIGURE 5.6.2.

Actual and Simulated Flaxseed Acreage - Stubble and Fallow, Saskatchewan period of analysis), and wide fluctuation in flaxseed acreage, these results were considered reasonable.

The results of SII were very close to the results of SI. Significant difference between simulated values generated from SII and SI occurred only in 1974, 1979, and 1980. SII picked up the downturn in flaxseed acreage in 1981 which was not reflected correctly in SI. Other turning point errors in SI remained unchanged. The mean absolute percentage error of SII was 18.96%.

5.2.6.3 Alberta

The acreage of flaxseed, which ranged between 13 and 146 thousand acres over the period 1962 to 1981, was very small relative to the acreage of other major crops grown on stubble in Alberta. The average share of flaxseed acreage was only 1% over the period of analysis. Since flaxseed acreage was treated as a residual in the simulation, positive and negative errors in simulated acreages of other crops and total acreage of the six crops seeded on stubble (TAs) which did not offset one another all contributed error in the simulated flaxseed acreage. As well, since flaxseed acreage accounted for such a negligible share of TAs, even very small net errors in the simulation of the acreages of other crops and of TAs would translate into considerably larger errors in the simulation of flaxseed acreage. Therefore, it was not surprising that the simulated values of flaxseed acreage generally deviated widely from the actual values. The results showed that SI picked up 15 out of 20 turning points in flaxseed acreage, and the mean absolute percentage



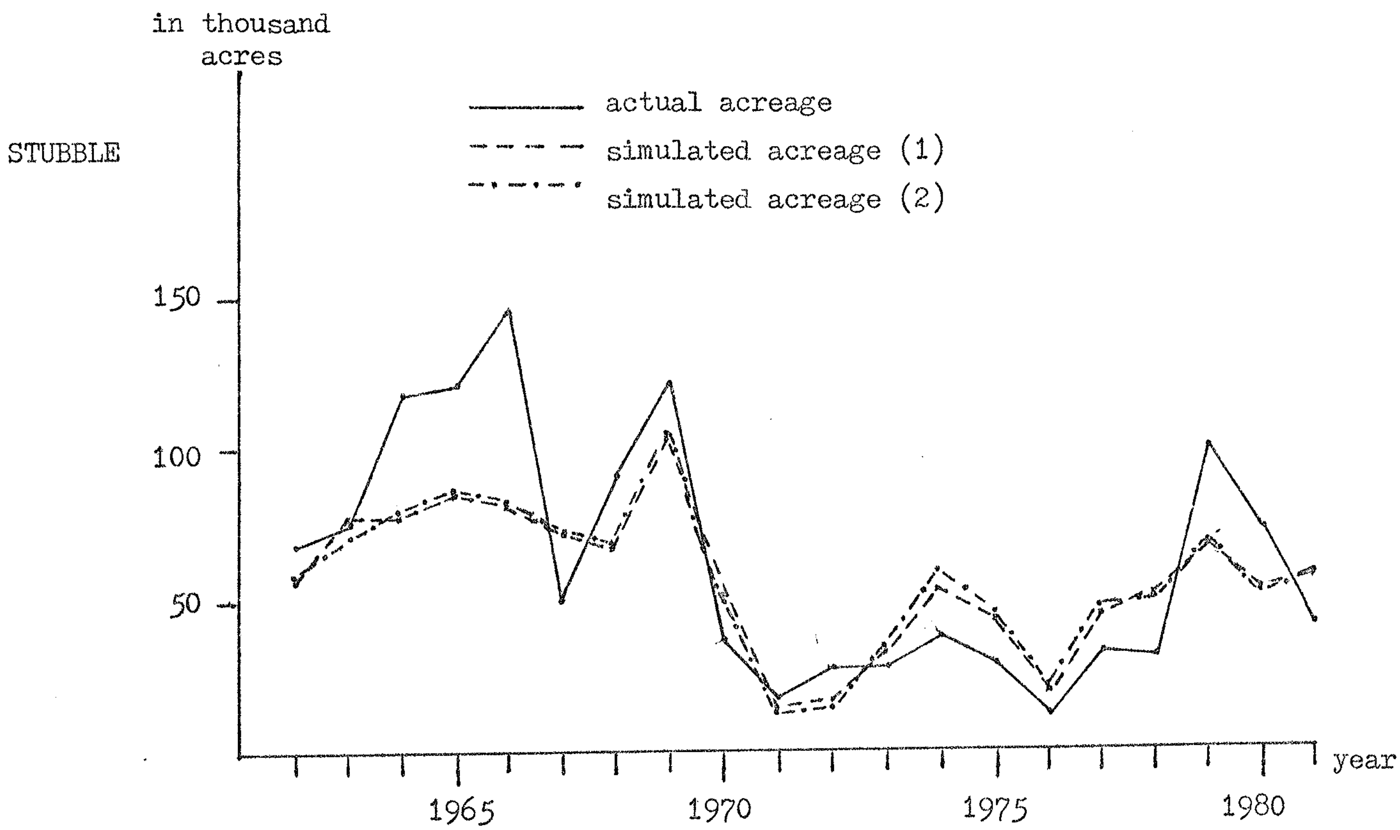


FIGURE 5.6.3.

Actual and Simulated Flaxseed Acreage - Stubble and Fallow, Alberta error of the simulation was 32.69%. The results of SII were very close to that of SI. The largest deviation between SII and SI was in 1974, where the simulated value of flaxseed acrege was 59 thousand acres in SII compared to 52 thousand acres in SI. The mean absolute percentage error was 35.49% and turning point errors occurred in 6 out of 20 years in SII.

5.3 SIMULATION RESULTS FOR CROPS SEEDED ON FALLOW

This section includes a comparison between the actual and simulated acreage of wheat, oats, barley, rapeseed, and flaxseed grown on fallow. The simulated values of acreages of each crop in each province are also compared with the actual values in Figure(5.1.1.) to (5.6.3.) for the period 1962 to 1981. All numerical results are presented in appendix C. The mean absolute percentage errors and the number of turning point errors are also summarized in Table 5.1.

5.3.1 Wheat Acreage

5.3.1.1 Manitoba

The actual and simulated values of wheat acreage seeded on fallow in Manitoba are shown in Figure(5.1.1.). The results showed that the simulation performed excellently from 1962 through 1980. The simulated values of wheat acreage tracked the actual values very closely and the simulation captured all turning points in actual wheat acreage during this period. However, the simulation failed to predict the upturn of wheat acreage to 1.3 million acres in 1981. Instead, a decline of wheat acreage to one million acres was predicted. This error was partly due to a .4 million acres underestimation of total acreage of the five crops seeded on fallow (TAf) as shown in appendix B. The mean absolute percentage error of the simulation was satisfactorily low at 4.16%.

5.3.1.2 Saskatchewan

The actual, along with the simulated values of wheat acreage seeded on fallow in Saskatchewan are presented in Figure(5.1.2.). The simulation performed very well in tracking the time path of actual wheat acreage, as 18 out of 20 turning points in the atual wheat acreage were captured. The simulation errors were generally very low as indicated by the mean absolute percentage error of the simulation, 3.65%. For the years 1962 through 1981, all the absolute errors were less than 10% except in 1970. In 1970 the actual wheat acreage declined sharply to 7.5 million acres from 13 million acres in the previous year as a result of the LIFT program. The simulation, although it successfully picked up this acreage fall, failed to match the magnitude of the decline with a resultant 19% error of 1.5 million acres. The large overestimation of TAf, (about 3 million acres) shown in appendix B, was largely responsiable for this error.

5.3.1.3 Alberta

The simulation of wheat acreage grown on fallow in Alberta also proved satisfactory. The simulated values were generally remarkably close to the actual values throughout the simulation period, as shown in

Figure(5.1.3.). The simulation errors were very low as indicated by the 4.95% mean absolute percentage error of the simulation. The simulation picked up 17 out of 20 turning points in the actual wheat acreage.

5.3.2 <u>Oats Acreage</u>

5.3.2.1 Manitoba

The actual and simulated values of oats acreage seeded on fallow in Manitoba are presented in Figure(5.2.1.). The simulation reproduced changes in the direction of the movement in oats acreage in all but three years. However, it failed to reflect the extent of the increase and fall in oats acreage in a number of years over the simulation period. The mean absolute percentage error of the simulation was 15.57%.

5.3.2.2 Saskatchewan

The simulation of oats acreage seeded on fallow in Saskatchewan performed well. The actual and simulated values of oats acreage, as presented in Figure(5.2.2.), were reasonably close, in general. The deviations exceeded 20% only in 1964 and 1968. The mean absolute percentage error of the simulation was reasonably low at 11.13%. All turning points in actual oats acreage, except in 1962, were picked up successfully.

5.3.2.3 Alberta

The simulation of oats acreage seeded on fallow in Alberta also had very good performance in explaining the movements of actual oats acreage. The simulated values of oats acreage tracked remarkably close to the actual values, as shown in Figure (5.2.3.), and picked up all but one turning point in the actual oats acreage in the years 1962 through 1981. The mean absolute percentage error of the simulation was 5.21%.

5.3.3 Barley Acreage

5.3.3.1 Manitoba

The results of the simulation of barley acreage in Manitoba showed that the trend of the simulated barley acreage was quite consistent with that of the actual barley acreage even though five turning points were missed. Turning point errors occurred in three consecutive years from 1964 to 1966, incurring simulation errors of 51, 17, and 38 percent respectively. There were no other large errors in the simulation. The resulting mean absolute percentage error of the simulation was 15.4%

5.3.3.2 Saskatchewan

The simulation of barley acreage in Saskatchewan reproduced the time path of the actual barley acreage reasonably well except in 1964 and 1979, where barley acreage was 53% and 41% respectively overestimated. Overall, 17 out of 20 turning points in barley acreage were reflected correctly and the mean absolute percentage error of the simulation was 12.92%.

5.3.3.3 Alberta

The simulation of barley acreage in Alberta was more successful than that in Manitoba and Saskatchewan. Although the barley/flaxseed equation did not have good explanatory power (56%), the simulated barley acreage generally tracked actual values very well. The increase of barley acreage between 1969 an 1971 and subsequent rapid decline of barley acreage between 1971 and 1973 were tracked remarkably closely. 17 out of 20 turning points in barley acreage were reproduced and simulation errors were satisfactorily small. The mean absolute percentage error of the simulation was 8.87%.

5.3.4 Rapeseed Acreage

5.3.4.1 Manitoba

As shown in Figure(5.4.1.), rapeseed acreage in Manitoba was very small and relatively stable prior to 1968, rose sharply from 1968 to 1971, and then fluctuated widely through the years 1971 to 1981. The simulation was not very satisfactory in tracking the fluctuations in the rapeseed acreage. While it managed to pick up 16 out of 20 turning points in actual rapeseed acreage, the deviation of the simulated from the actual rapeseed acreage was large in some years. The mean absolute percentage error of the simulation was relatively large at 19.57%.

5.3.4.2 Saskatchewan

The movement of rapeseed acreage in Saskatchewan was similar to that in Manitoba. Figure(5.4.2.) presents the simulated values of rapeseed acreage compared with the actual values. The simulation also managed to pick up 16 turning points in actual rapeseed acreage, and, similar to the Manitoba simulation, the deviation from the actual rapeseed acreage was large for a number of years. The mean absolute percentage error of the simulation was 22.05%.

5.3.4.3 Alberta

The simulation of rapeseed acreage in Alberta did not perform well in terms of the magnitude of simulation errors. Although the simulation successfully reproduced the direction of changes in actual rapeseed acreage that occurred in all the years except 1966 and 1974, the deviation of the simulated from the actual rapeseed acreage was large in some of the years. The largest percentage deviation was 87.05% in 1962 where the simulated value was 90 thousand acres above the actual value of 104 thousand acres. The mean absolute percentage error of the simulation was 22.55%.

5.3.5 Flaxseed Acreage

5.3.5.1 Manitoba

The actual, along with the simulated values of flaxseed acreage in Manitoba are presented in Figure(5.6.1.). The results showed that the simulation tracked the time path of the actual flaxseed acreage rather closely throughout the simulation period except in 1964 and 1965, when consecutive declines in flaxseed acreage were simulated in contrast to the actual rises which occurred. These declines resulted in deviations of about 24%. All turning points other than those in 1964 and 1965 were picked up. The performance of the simulation in the most recent five years was excellent, with an average absolute percentage error of 3.32% for this period. The mean absolute percentage error for the simulation was fairly low at 9.64%.

5.3.5.2 Saskatchewan

The acreage of flaxseed in Saskatchewan exhibited a period of relative stability between 1962 and 1967. Then it started an upturn in 1968 and climbed sharply in 1969 and 1970 before falling off for the next six consecutive years. Figure (5.6.2.) presents the simulated values of flaxseed acreage compared with the actual values. The simulation captured 16 out of 20 turning points in flaxseed acreage although the simulated values of flaxseed acreage deviated considerably from actual values. The mean absolute percentage error of the simulation was 20.68%. Considering that flaxseed acreage was the 'residual' in the simulation, being very small in size, and having generally very wide fluctuation relative to its size, these results were more satisfactory than they appeared.

5.3.5.3 Alberta

In Figure (5.6.3.) the simulated values of flaxseed acreage in Alberta are compared with the actual values. The simulated flaxseed acreage deviated considerably from the actual flaxseed acreage in the years 1962 through 1965 and in a few other years, although 17 out of 20 turning points in the actual flaxseed acreage were successfully captured. The resulting mean absolute percentage error of the simulation was 22.89%. The flaxseed acreage was usually underestimated when large errors occurred. This is probably because total acreage of the five crops seeded on fallow (TAf) was consistently underestimated in Alberta. Although the estimation of TAf was reasonably good, with no error exceeding 5%, since flaxseed acreage had a very small percentage share, even a very small error in the estimated TAf which was not balanced by errors in the simulation of other acreages would translate into a large error in the simulated flaxseed acreage.

5.4 COMPARISON OF PERFORMANCE BETWEEN THE ACREAGE ALLOCATION MODEL AND A NAIVE MODEL IN ACREAGE SIMULATIONS

To further evaluate the forecasting ability of the acreage allocation model, historical simulations of the acreage seeded on stubble and on fallow seedbed for Manitoba, Saskatchewan, and Alberta were performed based on a single-equation naive model. The simulation results obtained from the acreage allocation model and from the naive model were compared in terms of the magnitude of simulation errors and the number of turning point errors.

The naive model consisted of an independent equation for the acreage of each crop. The lagged dependent variable and a dummy variable, LIFT, were included in each equation in linear form. The equations were estimated for the period 1961 to 1981 using the OLS method. The acreage of each crop was then forecast by inserting relevant values of the exogenous variables into the corresponding estimated equation. The regression results of the naive model are presented in appendix D. Table 5.2

presents the mean absolute percentage error and the number of turning point errors in the naive acreage simulation.

As can be seen in Table 5.1 and Table 5.2, on the basis of the mean absolute percentage errors and turning point errors, it was apparent that the results obtained from the acreage allocation model were more satisfactory than those obtained from the naive model - especially the results for oilseeds acreages.

For the acreages of crops seeded on stubble seedbed, both SI and SII based on the acreage allocation model performed remarkably better than the naive acreage simulation for oilseeds acreages in all three provinces. The mean absolute percentage errors of simulated oilseeds acreages based on the naive model were generally 2 to 4 times as large as those based on the acreage allocation model. The simulated oilseeds acreages based on the naive model generally had 1 to 5 more turning point errors than those based on the acreage allocation model. As for the cereal grains acreages, the results of SI obtained from the acreage allocation model were generally appreciably better than the simulation results obtained from the naive model with smaller simulation errors and less turning point errors. The only exception was that the simulation of oats acreage in Manitoba from the acreage allocation model had a slightly larger mean absolute percentage error than the naive model. The results of SII, however, were not as satisfactory in terms of simulation errors. The mean absolute percentage errors of simulated wheat and oats acreage in Manitoba and Alberta, and the simulated barley acreage in Saskatchewan obtained from SII were larger than those obtained from the

TABLE 5.2

Performance Of Historical Simulation Of Seeded Acreages
Based On The Naive Model

		STUBBLE ACREAGES			FALLOW ACREAGES		
		Man.	Sask.	Alta.	Man.	Sask.	Alta.
Wheat	1.	1307	3190	1415	1773	13428	3849
	2.	15.96	62.62	20.87	12.84	5.55	7.21
	3.	5	7	7	5	8	6
Oats	1.	1054	1027	1262	186	683	608
	2.	12.90	12.72	6.82	20.04	18.32	12.43
	3.	8	9	5	4	5	4
Barley	1.	1074	1497	3183	355	1570	1494
	2.	15.95	13.37	8.44	19.61	22.60	14.80
	3.	7	7	4	4	8	7
Rapeseed	1.	256	185	447	174	1155	824
	2.	87.36	65.84	48.53	54.57	55.02	47.28
	3.	4	6	8	9	8	7
Sunflower	1.	117					
	2.	63.21					
	3.	6					
Flaxseed	1.	674	172	63	153	397	197
	2.	21.69	39.90	53.89	29.48	37.29	47.63
	3.	5	9	9	4	4	5

1.Mean value of actual seeded acreage (in thousand acres)

2.Mean absolute percent error = $(1/n) \sum_{1}^{n} ((|\hat{A} - A|) /A)$

where n is the number of years equal to 20
$\hat{A}$ is simulated acreage, A is actual acreage

3.The number of turning point errors.

naive model. Nonetheless, SII performed better than the naive acreage simulation in reflecting turning points in actual grains acreages except for oats acreage in Manitoba.

For the acreages of crops seeded on fallow seedbed, the simulation based on the acreage allocation model had smaller mean absolute percentage errors and fewer turning point errors than those based on the naive model for acreages of all crops under study in all three provinces. Similar to the results for stubble acreages, the acreage allocation model performed remarkably better than the naive model in the simulation of oilseeds acreages in terms of simulation errors.

These results suggest that, in general, the acreage allocation model had much better forecasting ability than the naive model regarding farmers' acreage allocation patterns. However, the estimation of total stubble acreage (STUBBLE) posed a set-back for the ability of the acreage allocation model to forecast acreages of crops grown on stubble seedbed.

5.5 COMPARISON OF PREDICTIVE PERFORMANCE ON SEEDED ACREAGE FOR SELECTED STUDIES

This section provides a comparison of acreage forecasts obtained from the multinomial logit acreage allocation model employed in this study,[37]

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[37] T. Reynolds re-estimated this model using revised data which were updated after the analysis of this study was done. There are also minor changes in variable specifications in Reynolds' re-estimation. The forecasts of this study are based on the estimated coefficients obtained by Reynolds. For details on the changes in Reynolds' re-estimation, see Reynolds T., Western Producer Response During The 1970's, M.Sc. thesis, University of Manitoba, to be released in 1984.

Agriculture Canada, and Canada Grains Council for 1982, 1983, and 1984.[38] The comparison is performed at the Prairie level because acreage forecasts from Agriculture Canada and the Canada Grains Council are available only for the Prairies as a whole. Table 5.3 presents actual acreages of wheat, oats, barley, rapeseed, and flaxseed,[39] and forecasted acreages of these crops from alternative studies with corresponding percentage errors for 1982, 1983, and percentage changes for 1984.[40]

As can be seen in Table 5.3, all three studies performed very well in predicting seeded acreage of wheat. A very precise prediction on wheat acreage in 1982 was achieved by Agriculture Canada with a trivial error of -.15 million acres (-.49%). Agriculture Canada's prediction of wheat acreage in 1983, although still reasonable, was not as successful, producing the largest forecasting error (2.35 million acres, -7.14%) among the three studies. Both the Canada Grains Council and this study proved successful in predicting wheat acreage in 1982 and 1983 as indicated by the respective forecasting errors of -2.26 and -3.11 percent in 1982, and -3.34 and -3.98 percent in 1983.

The seeded acreage of oats in the Prairies was 3.15 million acres in 1982 and was reduced by almost 20 percent to 2.55 million acres in 1983. This study forecast oats acreage of 2.68 million acres in 1982, which

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[38] Direct comparison of the predictive performance of this study and Colman's study is difficult because Colman provided only forecasted percent shares of acreages in 1978/9. See Colman D. (1979) p.55.

[39] Sunflower acreage is omitted from this comparison because Agriculture Canada and the Canada Grains Council did not predict sunflower acreage.

[40] Actual values of seeded acreages in 1984 are not available yet.

TABLE 5.3

Performance Of Selected Studies
In Predicting Seeded Acreages Of Crops In The Prairies
(million acres)

Year		Wheat	Oats	Barley	Rapeseed	Flaxseed
1982	Actual	30.55	3.15	11.65	4.10	1.55
	Predicted (1)	29.86	2.68	11.85	3.99	1.39
	% error	(-2.26)	(-14.92)	(1.80)	(-2.68)	(-10.32)
	Predicted (2)	30.4	-	10.4	5.4	1.2
	% error	(-.49)	-	(-10.73)	(31.37)	(-22.60)
	Predicted (3)	29.6	3.0	12.5	4.4	1.5
	% error	(-3.11)	(-4.76)	(7.30)	(7.32)	(-3.23)
1983	Actual	32.90	2.55	9.85	5.55	1.11
	Predicted (1)	31.59	2.39	10.75	5.33	1.23
	% error	(-3.98)	(-6.27)	(9.13)	(-3.96)	(10.81)
	Predicted (2)	30.55	3.15	11.65	4.10	1.31
	% error	(-7.14)	(23.53)	(18.27)	(-26.13)	(18.02)
	Predicted (3)	31.8	2.9	12.2	4.7	1.0
	% error	(-3.34)	(13.73)	(23.86)	(-15.32)	(-9.91)
1984	Actual	-	-	-	-	-
	Predicted (1)	30.39	2.21	12.20	5.31	1.65
	% change	(-7.63)	(-13.33)	(23.86)	(-4.32)	(48.65)
	Predicted (2)	28.55	3.28	12.94	6.10	1.43
	% change	(-13.22)	(28.63)	(31.37)	(9.91)	(28.83)
	Predicted (3)	-	-	-	-	-
	% change	-	-	-	-	-

(1) : Predicted by the present study
(2) : Predicted by Agriculture Canada
(3) : Predicted by the Canada Grains Council
Predictions from all three studies are incremental acreage forecasts.
Predictions by Agricultural Canada and the Canada Grains Council were obtained by personal correspondings with the respective institutes.

underestimated the actual oats acreage by .47 million acres (14.92%). Better performance was achieved by this study in forecasting oats acreage in 1983. The predicted value of 2.39 million acres was only .16 million acres (6.27%) lower than the actual oats acreage. The Canada Grains Council obtained a fairly accurate forecast of oats acreage in 1982. Its predicted acreage of 3 million acres differed by 4.76 percent from the actual value of 3.15 million acres. However, it did not perform as well in predicting oats acreage in 1983. The predicted 2.9 million acres was 13.73 percent higher than the actual oats acreage of 2.55 million acres in 1983. In view of the relatively small size of oats acreage and the large percentage change from year to year which make forecasting difficult, both this study and the Canada Grains Council are considered to show reasonable performance in the prediction of oats acreage. Agriculture Canada failed to predict the reduction of oats acreage in 1983 with a resultant forecasting error of 23.53 perecnt.

All three studies predicted barley acreage well in 1982. However, only this study had reasonable performance in predicting barley acreage in 1983. This study predicted barley acreage with great accuracy in 1982 - the predicted 11.85 million acres was only .2 million acres (1.8%) higher than the actual barley acreage. Both the Canada Grains Council and Agriculture Canada had reasonable forecasts of barley acreage in 1982 with forecasting errors of 7.30 and -10.73 percent respectively. The seeded acreage of barley in the Prairies fell to 9.85 million acres in 1983. The multinomial logit model in this study successfully captured this downturn and produced a forecasting error of 9.13 percent. Both the Canada Grains Council and Agriculture Canada missed the downturn of barley acreage in 1983, thus incurring forecasting errors of 23.86 and 18.27 percent respectively.

In 1982 4.10 million acres of cropland was seeded to rapeseed in the Prairies. It increased by over 35 percent to 5.55 million acres in 1983. Considering the size of fluctuation, the multinomial logit model employed in this study performed surprisingly well in predicting rapeseed acreage in the Prairies. The predicted values of 3.99 million acres in 1982 and 5.33 million acres in 1983 were only 2.68 and 3.96 percent lower than the respective actual values. The Canada Grains Council also predicted rapeseed acreage well in 1982 with a forecasting error of -7.32 percent. However, its prediction for 1983 was less successful with a forecasting error of 15.32 percent. Agriculture Canada overestimated rapeseed acreage by 1.3 million acres in 1982 and failed to pick up the 1.45 million acres increase of rapeseed acreage in 1983 resulting in forecasting errors of 31.71 and 26.13 percent respectively.

Area seeded to flaxseed is very small with wide fluctuation relative to other major crops grown on the Prairies. After 1.55 million acres of cropland was seeded to flaxseed in 1982, this declined by 28 percent to 1.11 million acres in 1983. This study predicted 1.39 million acres of flaxseed seeded on the Prairies in 1982, and 1.23 million acres of flaxseed in 1983. Both forecasts generated absolute errors just over 10 percent. The Canada Grains Council's forecasts of 1.5 million acres for 1982 and one million acres for 1983 produced absolute forecasting errors of 3.23 and 9.91 percent for 1982 and 1983 respectively. Considering the small size of flaxseed acreage and its wide fluctuation over the years, both the Canada Grains Council and this study provided reasonable predictions of flaxseed acreage. This however, was not the case for the Agriculture Canada which made forecasting errors of 22.6 percent in 1982 and 18.02 percent in 1983.

Only this study and Agriculture Canada provided acreage forecasts for 1984. Since actual areas seeded to various crops are not available yet, corresponding percentage change in forecast acreage from 1983 is presented for each crop.

This study forecasts area seeded to wheat to be reduced by 7.63 percent to 30.39 million acres in 1984, which is 1.84 million acres higher than Agriculture Canada's forecast of a 13.22 percent drop to 28.55 million acres. With regard to oats acreage, this study predicts a decline of .34 million acres (down 13.33% from 1983) to 2.21 million acres while Agriculture Canada predicts an increase of .73 million acres (up 28.63% from 1983) to 3.28 million acres thus resulting in a difference of 1.07 million acres between the two forecasts. This study forecasts a significant 2.35 million acres (or 23.86%) increase in barley acreage to 12.2 million acres. Agriculture Canada predicts a even bigger increase in barley acreage by 3.09 million acres (or 31.37%) to 12.94 million acres. This study forecast a mild drop in rapeseed acreage (.24 million acres or 4.32%) to 5.31 million acres. In contrast, Agriculture Canada forecasts rapeseed acreage to increase by .55 million acres (or 9.91%) to 6.1 million acres. A 48.65 percent (or .54 million acres) increase in flaxseed acreage to 1.65 million acres is predicted by this study. Agriculture Canada predicts a smaller increase of flaxseed acreage (.32 million acres or 28.83%) to 1.43 million acres.

Chapter VI

SUMMARY AND CONCLUSIONS

6.1 SUMMARY

Western Canadian crop supply response has been investigated for decades. The results of these investigations provided information regarding how producers adjusted their cropping patterns in response to economic and other factors, and facilitated policy formulation in guiding crop production and achieving overall economic goals. Conventionally, acreage supply response has been analyzed at a highly aggregated level, usually based on a single-equation approach. Whether this methodology is appropriate for the analysis of acreage response relationships, however, is questionable.

The practice of summerfallowing has been an important feature of Western crop production. Prairie farmers traditionally have set a certain portion of their cropland fallow each year for economic and technical reasons. Therefore, each year there are two categories of cropland available for cropping, i.e., stubbled and fallowed land. It has been well recognized that fallowed land generally contains higher levels of soil moisture and fertility than stubbled land, and thus is more favourable for the production of less drought resistant or more nutrient demanding crops. Higher average yields for crops grown on fallowed land than for those grown on stubbled land have also been well recorded. Due to these factors, summerfallowing should have a significant influence on farmers' cropping patterns. However, this influence has been neglected in most supply response analyses, and only very recently have studies such as those by Lowe-Petrie, and Colman examined this influence. However, as discussed in Chapter II, the approach adopted by Lowe-Petrie and Colman was considered inappropriate and inadequate because it failed to account for the influence of summerfallowing on the overall allocation of stubble and fallow acreage. The primary purpose of this study was therefore to differentiate producers' allocation between stubble and fallow land by disaggregating acreage of crops seeded on stubble and fallow. This analysis was further disaggregated provincially to allow for regional variations in cropping patterns. These disaggregations were performed to reduce aggregation bias which may impair parameter estimates in order to improve the forecasting ability of the supply response model. This analysis covered the acreages of wheat, oats, barley, rapeseed, flaxseed, and sunflowers, which constitute well over 90 percent of the total acreage of all crops grown in the Prairies.

The single-equation approach adopted in conventional acreage supply response analysis was another issue of concern. In each cropping year, after having decided the portion of the land which had been cropped in the previous year that was to be fallowed, there was a fixed amount of land available to producers for cropping. Any substantial increase in the acreage of one crop was necessarily accompanied by a corresponding reduction in the acreage of other crops. The allocation of cropland to alternative crops essentially involved intergrated planning. The single-equation approach is inappropriate for analyzing acreage supply response because it does not take into consideration this interrelationship in acreage allocation. In light of this problem with the single-equation approach, Colman applied the multinomial logit approach which specified a system of seemingly unrelated equations as proxies for the acreage allocation relationships, and employed the simultaneous estimation method to account for the interdependency of acreage allocation among alternative crops. This approach also has the advantage of constraining the sum of the individual crops and guaranteeing positive acreage projections for each crop. It was therefore decided to take Colman's multinomial logit specification of acreage response as the basis for the model specification in this study. The multinomial logit specification explains the allocation of the total acreage of cropland in terms of a set of percentage shares for alternative crops, with values for each crop being between zero and one, and with the sum for all crops being equal to one.

A set of exponential acreage functions, one for each crop in this study, was specified to approximate producers' acreage response relationships. The most important factors incorporated in the system of acreage functions were a set of relative return variables which reflected the complete direct and cross-return relationships among alternative crops based on the hypothesis that all crops grown in the same area were competing for available cropland. The variables common to all the acreage response equations included the inventory of wheat on farms, the total acreage of the major crops seeded on stubble and on fallow for analyzing the allocation of stubble acreage and fallow acreage respectively. In addition, a dummy variable, LIFT, was specified in the acreage function for wheat, and a rapeseed adoption variable was specified in the acreage function for rapeseed. The farm inventories of oats, barley, rapeseed, and flaxseed were specified in the acreage functions of oats, barley, rapeseed, and flaxseed respectively.

Incorporating the set of acreage functions with the multinomial logit model, the percentage share of acreage of any crop i can be derived by estimating a set of n - 1 ratios of the acreage of crop i to the acreage of a common crop m $(m \neq i)$. The flaxseed acreage was selected to be the common acreage because it showed no trend over the period of analysis and was small relative to that of other crops to allow for maximum variations in the acreage ratios. To facilitate empirical estimation, the exponential form of the acreage ratios was transformed into a system of linear equations in which the dependent variables were the logarithm of the acreage ratios of wheat, oats, barley, rapeseed, and sunflowers to flaxseed. The exogenous variables contained in each equation were related to the explanatory variables specified in the denominator (flaxseed) and numerator acreage in the dependent variable of the equation under consideration.

Zellner's Seemingly Unrelated Regression method was employed for estimating the system of equations because it is an efficient estimation method which takes into account the cross-equation disturbance correlations. Time series data for the period 1961 to 1981 were used for the regression. The hypothesis of a distributed lag model, which had been supported by most related studies, was tested by incorporating a lagged dependent variable in each equation in the system. Six sets of estimated equations were obtained for Stubble/Manitoba, Stubble/Saskatchewan, Stubble/Alberta, Fallow/Manitoba, Fallow/Saskatchewan, and Fallow/Alberta.

The results of the statistical estimation varied from province to province. The same was true for crops seeded on stubble and on fallow seedbeds. The estimated coefficients and their statistical significance on most of the explanatory variables for crops seeded on stubble were substantially different from those for crops seeded on fallow. The regional difference among provinces was also obvious in terms of the estimated coefficients and statistical properties. The results of the estimation in this study were generally not as satisfactory as expected in terms of the significance of the estimated coefficients due to multicollinearity among the relative return variables.

Based on the results of the statistical estimation, the percentage share of the acreage of each crop was simulated. Given the total acreage of the six crops grown on stubble (TAs), and the total acreage of the five crops grown on fallow (TAf), historical levels of acreage for each crop can be derived by multiplying the acreage share of each crop grown on stubble by TAs, and multiplying the acreage share of each crop grown on fallow by TAf.

The estimated values of the area of the six crops grown on stubble (TAs) and the area of the five crops grown on fallow (TAf) were used in the historical simulation to maintain consistency between the historical simulation and the future simulation because in the future simulation, the values of TAs and TAf would have to be estimated. Therefore, the success of the acreage simulation depended critically not only on the simulation of the acreage shares based on the acreage allocation model, but also on the estimation of TAs and TAf. TAs was estimated as a linear function of the total stubble acreage (STUBBLE). TAf was assummed to be equal to the total summerfallow acreage in the preceding year minus the acreage seeded to fall rye in that year. Both estimations of TAs and TAf were considered reasonably accurate except in a few cases where the deviations of the estimated values from the actual values were large. Therefore, based on these estimates, the success of the acreage simulations mainly depended on the simulation of the acreage shares. However, it should be noted that estimating TAs may lead to errors in the acreage simulation. In order to identify the sources of errors in the acreage simulation for crops seeded on stubble, two sets of simulations were performed. The actual values of total stubble acreage were used in Simulation I (SI), while the estimated values of total stubble acreage were used in Simulation II (SII). The errors in SI were mainly attributed to the poor simulation performance of the acreage shares based on the acreage allocation model, while the errors in SII could be attributed to errors in the simulated acreage shares and errors transmitted from estimated total stubble acreage.

The simulation results were examined to evaluate the forecasting ability of the acreage allocation model. The simulation results for crops seeded on stubble showed that SI generally performed well in forecasting the acreage of wheat and barley in all three provinces over the period 1962 to 1981 with reasonably small simulation errors and few turning point errors. SI also performed reasonably in simulating oats acreage in terms of the magnitude of simulation errors. However, it performed badly in reflecting the changes in direction of oats acreage in Manitoba and Saskatchewan, with eight and seven turning point errors respectively out of twenty years. The trends of the simulated acreages of rapeseed, flaxseed, and sunflowers were quite consistent with the corresponding trends of the actual acreages and most of the major turning points in these oilseed acreages were reproduced. However, in all three provinces, the simulation errors were generally large for the acreage of oilseeds, except for flaxseed in Manitoba. This is probably because the small size of the oilseed acreages made the percentage changes due to even small absolute changes appear large over the period of analysis,[41] and also make the actual acreages prediction more difficult.

SII had a much poorer performance than SI in the simulation of wheat acreage and sunflower acreage. The errors in estimated TAs affected the simulation of wheat acreage much more than the acreages of other crops because the simulated acreage of crop i (A_i) was derived by multipling the estimated acreage share of crop i (S_i) to TAs. Therefore, the errors in TAs had a compound effect on the simulation of acreage of each crop, i.e., direct influence, and indirect influence through the estimation of S_i. It happened that the variable TAs had a positive coefficient in the wheat/flaxseed equation in all three provinces, and the

[41] During the period 1962 to 1981, on the average, the percentage share of rapeseed acreage was about 5%, 3%, 6%, and that of flaxseed acreage was about 15%, 3%, 1% in Manitoba, Saskatchewan, and Alberta respectively. Sunflower acreage in Manitoba had about a 2% share. The mean absolute percentage change of oilseeds acreages in all three provinces exceeded 50% (except flaxseed acreage in Manitoba) in the period 1962 to 1981.

coefficient of TAs was generally much larger in the wheat/flaxseed equation than in other equations, especially for Saskatchewan and Alberta. Therefore, any error in TAs would result in a much larger error in the simulated wheat share than the simulated acreage share of other crops. Since the wheat acreage historically had a fairly large percentage share of the total seeded area, this, coupled with a large error in the wheat share and the direct influence of error in the estimated area of the six crops seeded on stubble (TAs), are responsiable for large simulation errors in wheat acreage in SII. Likewise, large simulation errors of sunflower acreage in SII were probably due to the relatively large coefficient on TAs in the sunflowers/flaxseed equation compared to the coefficient in other equations. On the average, the inability of the acreage allocation model to simulate the percentage shares of alternative crops accounted for about 40 to 60 percent of the simulation errors in the wheat and sunflowers acreage in SII. The remaining errors were attributed to inaccurate estimation of total stubble acreage. The results obtained from SI and SII were very close for oats, barley, and flaxseed acreage in all three provinces. The net errors attributed to the estimation of total stubble acreage generally accounted for less than ten percent of the errors in SII for these crops.

The results for crops seeded on fallow showed that the simulation performed excellently in predicting wheat acreage in all three provinces, and successfully picked up most turning points in wheat acreage. The simulation also performed well in simulating oats and barley acreage in Saskatchewan and Alberta with reasonably low errors. In contrast to the results for crops seeded on stubble, the simulated oats acreage seeded on fallow had the best performance in reflecting the turning points in the actual oats acreage. All but one turning point in the oats acreage were captured in Saskatchewan and Alberta. Similar to the results for crops seeded on stubble, the simulation of rapeseed and flaxseed acreage seeded on fallow was generally not satisfactory in terms of the magnitude of simulation errors.

The forecasting ability of the acreage allocation model was further tested through a comparison of the simulation performance of the acreage allocation model and a naive model. On the basis of the mean absolute percentage errors and turning point errors, it was apparent that the results obtained from the acreage allocation model were generally more satisfactory than those obtained from the naive model. Especially for oilseeds acreages, the results were remarkably better than those from the naive model. However, for crops seeded on stubble, the performance of the acreage allocation model was generally hindered by inaccurate estimation of total area seeded on stubble, and in some cases simulation errors larger than those obtained from the naive model were generated for cereal grains acreage.

Finally, the predictive ability of the acreage allocation model was tested by a comparing the results of this study with forecasts done by Agriculture Canada and the Canada Grains Council for the Prairies in 1982 and 1983. All three studies performed very well in predicting wheat acreage with very low forecasting errors. Both the present study and the Canada Grains Council study performed reasonably in the prediction of Prairie oats and flaxseed acreages. This, however, was not the case for the Agriculture Canada study, which produced large forecasting errors. The current study outperformed the other two studies in the prediction of barley and rapeseed acreages on the Prairies.

The present study and the Agriculture Canada study also provided acreage forecasts for 1984. Since actual areas seeded to various crops are not yet available, it is not possible to evaluate the performance of the models at this time. Both studies predicted wheat acreage to decline in 1984, with Agriculture Canada predicting a drop almost twice as large as that forecast by the current study. This study predicted oats and rapeseed acreages to drop moderately, while Agriculture Canada predicted them to increase considerably. Substantial increases in barley and flaxseed acreages were predicted by both studies.

6.2 CONCLUSION AND LIMITATION

The allocation of cropland was estimated separately for fallow and stubble acreages in this study to differentiate the responses from producers with respect to the selection of crops to grow on fallow and stubble land due to the influence of summerfallowing. Different parameter estimates were obtained from separate estimations of the acreage allocation model for crops seeded on fallow and on stubble. Regional differences in acreage allocation among the three provinces were also observed. These disaggregations were likely to reduce aggregation bias and improve the forecasting ability of the acreage allocation model.

The intercorrelation among the system of relative return variables appeared to be more serious than anticipated. Since the same pattern of intercorrelation among these variables is expected to continue into the future, the forecasting ability of this model should not be affected by the intercorrelations. However, the statistical insignificance of many of the relative return variables, which were likely due to multicollinearity among these variables, decreased the potential usefulness of the model in terms of using price elasticities for policy formulation.

In general, the acreage allocation model demonstrated reasonable within-estimation period forecasting ability. However, for acreages of crops grown on stubble seedbed, within-estimation period forecasting performance of the model was hindered by imprecise estimation of total area seeded to stubble seedbed to some extent, with wheat and sunflowers acreages affected most.

The forecasts for 1982 and 1983 were more encouraging. Reasonably accurate forecasts of areas seeded to the five major crops in the Prairies were obtained. The predicted barley and rapeseed acreages in 1982 and 1983 generated from the multinomial logit model employed in this study were much closer to the actual values than those obtained by Agriculture Canada or the Canada Grains Council. This study also proved more satisfactory than Agriculture Cananda's in predicting oats and flaxseed acreages.

The theoretical advantages of disaggregating the acreage allocation between stubble and fallow seedbeds, and the multinomial logit specification of a system of seemingly unrelated equations have been proved empirically in this study. Thus this approach merits further research.

6.3 FUTURE RESEARCH

Since the success of this model in forecasting acreages of alternative crops depends critically on accurate estimation of TAf, TAs, and STUBBLE, some effort should be directed toward improving the estimation of these variables in future research employing this method.

This study formulates farmers' price expectations on wheat, oats, and barley based on combined CWB initial and final payments. However, a substantial portion of oats and barley produced in the Prairies has been sold through the open market or between farms. Open market prices have the advantages that (i) they reflect the marginal values farmers receive for their crops which can not be delivered to the CWB, (ii) they are sensitive to domestic excess supply and thus reflect the impact of farm inventories. Therefore, it would be worthwhile to test open market prices of oats and barley as proxies for farmers' price expectations on these crops in future research.

This study examined the impact of summerfallow on Prairie farmers' selection of crops. Another factor which may have influence on Prairie farmers' cropping decisions is the changing Crow Rate. Recent research on Western transportation has revealed that the Crow Rate - a statutory fixed rate for moving the six major grains produced in the Prairies by rail since 1897 - has caused tremendous losses to the rails for moving Prairie grains and resulted in insufficient transportation capacity for handling the export of Prairie grains. With the Federal Government's recent announcement of reforming the Crow, grain producers will share increases in future transportation costs, thus providing the railway with the incentive to improve its grain handling system. Given that other factors do not change, increases in transportation costs would reduce the crop price farmers received. Relief in transportation constraints would eliminate losses in grain sales due to these constraints and reduce the level of grain inventories. Changing the Crow could also encourage crop diversification and influence the mix of crops grown in the Prairies. Some efforts should be directed in future to simulating the impact of changing the grain transportation system on grain prices, inventories, and cropping patterns on the Prairies.

This study found that the mix of crops grown on stubble land is different from that grown on fallow land. Thus, since farm input requirements, such as the type and quantity of fertilizers, pesticides and herbicides, depend on the mix of crops grown, the mix of chemical inputs needed for stubble cropping is different from that needed for fallow cropping. Also, fallow cropping requires less chemical inputs than stubble cropping because fallowed land is more fertile and generally has better pest and weed control. Therefore, disaggregated forecasts of seeded area for crops grown on stubble and fallow provided by this study would be very useful for forecasting the demand for farm inputs. Since fallow cropping is expected to decrease in the Prairies, forecasts of seeded area for crops grown on stubble and fallow are especially important for the farm supply industry in long-run planning.

Since most of the rapeseed, flaxseed, and sunflower seeds produced in the Prairies are processed locally, forecasts of the production of these oilseeds are important for the processing firms to plan production capacity and product marketing. Since the mix, as well as average yields of crops are different between stubble and fallow cropping, combining this model with a yield model which forecasts average yields of oilseed crops grown on stubble and fallow can provide the processing industry more precise forecasts of the quantity of oilseeds which will be available to them.

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Appendix A

DATA AND SOURCES

TABLE A.1

Average Yields Per Seeded Acre
For Crops Grown In Manitoba On Fallow Seedbed
(bushels)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed
1961	12.5	25.4	17.4	13.5	7.9
1962	27.6	58.4	39.2	18.9	13.3
1963	20.8	47.4	35.6	19.6	13.3
1964	26.7	51.4	37.4	19.5	12.6
1965	26.3	57.3	43.1	19.3	14.0
1966	26.8	52.7	41.1	16.9	12.7
1967	28.7	51.1	41.4	18.5	13.2
1968	29.5	60.9	44.0	23.6	14.5
1969	28.2	57.8	44.5	21.1	11.8
1970	22.8	50.0	38.9	19.9	12.9
1971	30.5	63.7	51.3	22.5	13.3
1972	29.0	57.9	47.6	19.7	15.0
1973	28.0	54.7	45.9	21.4	14.3
1974	23.4	43.6	35.0	19.6	11.9
1975	27.0	51.8	39.9	18.8	13.8
1976	28.8	56.4	49.5	20.8	14.3
1977	35.1	64.1	57.8	28.6	20.9
1978	33.8	59.8	57.8	27.3	19.3
1979	26.6	46.2	43.2	19.2	15.0
1980	27.6	47.1	47.7	20.5	16.0
1981	35.2	59.0	52.0	24.4	16.9

TABLE A.2

Average Yields Per Seeded Acre
For Crops Grown In Manitoba On Stubble Seedbed
(bushels)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed	Sunflowers
1961	7.2	16.2	10.6	8.3	4.8	25.0
1962	22.1	46.9	29.8	16.9	10.9	26.8
1963	14.9	36.2	22.3	13.2	10.8	33.9
1964	20.5	43.2	29.4	15.6	9.7	18.8
1965	20.6	47.0	33.7	14.6	11.6	19.6
1966	18.9	40.5	27.4	10.2	9.0	21.2
1967	20.9	40.0	31.8	14.6	8.0	28.6
1968	22.6	50.2	34.6	19.7	12.4	23.2
1969	18.8	43.3	29.8	15.5	8.8	25.3
1970	17.4	40.2	29.4	14.9	9.3	28.6
1971	24.7	52.2	40.9	17.3	9.5	26.8
1972	22.6	47.0	38.0	16.5	11.0	28.6
1973	22.2	47.7	37.6	17.6	12.3	25.0
1974	18.4	34.6	27.7	14.9	8.8	31.0
1975	22.9	44.5	32.4	15.5	10.6	38.0
1976	25.5	47.5	40.3	15.4	11.5	37.9
1977	28.8	53.8	47.7	23.6	16.6	37.9
1978	28.5	53.7	47.1	22.8	16.2	42.3
1979	24.2	44.1	39.5	18.2	13.9	43.3
1980	17.7	38.4	34.3	13.7	9.9	39.1
1981	29.7	49.2	45.8	22.5	15.0	46.5

TABLE A.3

Average Yields Per Seeded Acre
For Crops Grown In Saskatchewan On Fallow Seedbed
(bushels)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed
1961	9.4	17.0	13.7	15.8	7.0
1962	21.5	48.4	34.3	17.2	11.5
1963	29.0	63.7	46.6	21.1	16.1
1964	19.4	43.0	28.9	19.1	10.0
1965	22.6	56.7	42.2	21.3	14.6
1966	29.5	58.7	47.7	19.9	16.3
1967	18.9	39.2	33.4	19.8	10.3
1968	21.3	49.2	37.8	21.4	13.5
1969	28.5	61.6	47.3	19.9	16.2
1970	26.6	60.5	46.3	18.5	17.0
1971	26.8	63.6	47.6	18.8	14.3
1972	24.9	54.8	44.7	17.1	14.7
1973	24.7	57.5	45.0	17.1	14.4
1974	21.9	45.9	36.2	16.5	9.2
1975	26.5	55.2	43.1	19.0	13.9
1976	32.4	67.5	53.3	23.1	17.6
1977	30.6	61.4	51.1	26.6	20.0
1978	30.8	59.6	50.2	23.8	19.6
1979	23.6	49.3	41.1	18.0	14.5
1980	24.7	50.7	44.9	22.5	15.4
1981	28.9	56.4	48.2	24.0	19.9

TABLE A.4

Average Yields Per Seeded Acre
For Crops Grown In Saskatchewan On Stubble Seedbed
(bushels)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed
1961	4.1	9.3	7.3	10.2	3.1
1962	14.1	34.1	24.1	11.0	8.8
1963	20.6	46.8	34.6	14.4	12.1
1964	13.1	33.6	20.8	13.8	7.2
1965	17.8	45.1	33.1	15.1	11.4
1966	22.0	45.6	35.8	13.3	11.8
1967	12.9	29.1	23.3	12.2	6.2
1968	14.1	37.4	27.6	15.0	9.2
1969	20.0	44.6	33.4	13.4	11.5
1970	20.3	44.8	33.3	12.3	13.1
1971	19.6	47.4	34.5	12.7	10.3
1972	16.8	41.0	30.9	11.3	10.9
1973	18.0	43.7	32.2	11.6	11.3
1974	15.6	34.8	26.6	10.7	6.0
1975	18.8	40.6	30.9	11.9	10.2
1976	23.7	48.9	39.5	17.1	15.4
1977	22.0	45.6	38.7	18.5	13.4
1978	23.5	46.0	38.5	18.0	15.1
1979	18.0	36.7	30.7	12.6	10.2
1980	17.5	40.2	35.7	16.7	12.9
1981	22.3	41.9	37.7	18.7	14.2

TABLE A.5

Average Yields Per Seeded Acre
For Crops Grown In Alberta On Fallow Seedbed
(bushels)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed
1961	16.9	41.5	31.2	19.1	11.4
1962	20.3	53.7	36.3	18.9	10.3
1963	27.1	62.1	43.5	19.0	13.2
1964	24.4	53.5	41.5	18.7	12.6
1965	27.2	58.0	43.8	16.2	15.0
1966	32.3	63.2	53.0	21.0	18.9
1967	25.2	51.0	42.0	17.4	12.5
1968	28.8	62.8	50.0	19.4	16.0
1969	28.4	62.6	50.2	16.4	15.2
1970	28.3	64.0	48.9	18.7	16.5
1971	27.2	59.3	45.4	17.2	13.0
1972	28.7	65.9	51.5	19.8	16.8
1973	27.8	63.9	47.8	18.3	15.1
1974	25.1	54.4	43.0	17.6	12.9
1975	31.7	66.2	49.9	19.0	16.8
1976	34.9	69.7	54.5	21.4	16.1
1977	25.7	62.0	49.2	24.5	17.2
1978	31.2	60.2	50.9	21.9	20.6
1979	28.5	61.9	48.2	19.2	18.0
1980	33.7	67.4	57.2	24.1	21.6
1981	36.9	67.1	56.3	23.2	24.1

TABLE A.6

Average Yields Per Seeded Acre
For Crops Grown In Alberta On Stubble Seedbed
(bushels)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed
1961	11.0	33.7	23.2	10.9	9.2
1962	14.6	42.0	27.4	10.1	9.0
1963	17.6	44.6	28.8	10.1	9.3
1964	15.7	35.0	27.2	12.5	9.4
1965	19.9	43.2	29.0	9.4	11.6
1966	22.5	43.4	35.7	12.8	11.6
1967	16.8	37.9	29.0	9.7	10.2
1968	19.1	43.0	33.9	13.1	13.2
1969	20.1	47.2	35.2	11.1	10.7
1970	21.3	51.0	35.5	12.3	13.5
1971	20.9	46.0	32.3	10.6	11.8
1972	23.0	52.6	39.8	15.0	11.1
1973	20.9	51.1	34.5	11.7	10.7
1974	20.8	43.1	33.8	13.2	10.8
1975	24.1	50.0	38.4	14.9	12.8
1976	25.8	54.0	41.8	15.4	15.4
1977	22.4	56.3	44.6	20.3	12.1
1978	26.8	49.0	43.4	19.6	18.8
1979	28.3	57.0	45.4	17.0	17.0
1980	32.5	61.4	49.2	20.2	16.4
1981	30.7	58.3	47.1	18.9	19.0

TABLE A.7

Crop Land Acreages
Seeded To Fallow Seedbed In Manitoba
('000 acres)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed
1961	2467	522	305	23	229
1962	2306	425	240	19	210
1963	2393	302	225	26	189
1964	2508	288	171	41	222
1965	2139	220	188	60	243
1966	2208	165	292	55	150
1967	2115	174	227	47	76
1968	2039	156	273	28	124
1969	1803	185	422	83	187
1970	1130	244	730	246	350
1971	2030	281	971	375	143
1972	1606	126	538	230	100
1973	1934	148	482	174	112
1974	1494	163	434	225	134
1975	1721	139	323	272	145
1976	1822	179	281	120	98
1977	1398	145	329	199	129
1978	1336	117	237	341	119
1979	1004	80	206	443	167
1980	1168	85	256	297	94
1981	1306	105	279	201	59

TABLE A.8

Crop Land Acreages
Seeded To Stubble Seedbed In Manitoba
('000 acres)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed	Sunflowers
1961	447	1251	350	6	519	21
1962	736	1369	389	13	457	21
1963	760	1318	359	19	631	33
1964	877	1347	326	43	803	48
1965	1101	1305	413	85	1107	48
1966	1047	1365	583	115	957	43
1967	1405	1426	743	98	584	44
1968	1361	1424	897	63	696	37
1969	697	1345	778	113	913	48
1970	270	1016	770	154	750	65
1971	489	1114	1081	206	423	140
1972	994	1014	1562	240	400	190
1973	1166	1152	1618	226	488	125
1974	1306	1037	1366	275	566	21
1975	1379	961	1177	478	605	62
1976	1978	1071	1319	130	427	50
1977	1802	905	1571	301	621	165
1978	2064	633	1513	709	631	203
1979	1996	370	1244	907	1083	380
1980	2132	365	1744	503	706	320
1981	2594	545	2021	449	641	289

TABLE A.9

Crop Land Acreages
Seeded To Fallow Seedbed In Saskatchewan
('000 acres)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed
1961	13378	1192	1029	319	685
1962	14687	1226	857	127	253
1963	14820	846	937	149	299
1964	15291	488	605	213	271
1965	14704	640	782	372	287
1966	14760	494	857	450	209
1967	14121	441	824	377	97
1968	14410	567	1051	363	223
1969	13610	693	1351	743	517
1970	7566	1249	2479	2016	1390
1971	12785	1118	4573	2678	847
1972	11396	706	2536	1359	503
1973	13558	838	2253	1302	499
1974	12270	801	2326	1319	434
1975	13173	744	1791	1640	352
1976	15098	633	1412	709	148
1977	13421	590	1928	1255	406
1978	13396	426	1256	2351	271
1979	12217	343	979	2784	477
1980	13065	363	1311	1832	279
1981	14228	468	1298	1075	181

TABLE A.10
Crop Land Acreages
Seeded To Stubble Seedbed In Saskatchewan
('000 acres)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed
1961	2704	1486	810	55	256
1962	2701	1486	772	40	136
1963	3090	1370	993	61	207
1964	3909	981	795	90	250
1965	3796	1280	968	183	273
1966	4645	1316	1398	281	220
1967	5549	1089	1526	223	96
1968	4590	1233	1459	148	174
1969	2990	1307	1349	257	253
1970	434	701	821	184	160
1971	131	848	998	59	78
1972	2504	984	2064	141	147
1973	2242	1162	1947	148	151
1974	2230	1099	1874	131	116
1975	2027	1106	1709	160	98
1976	2602	967	1538	41	52
1977	2779	960	1872	195	194
1978	3704	774	1844	449	179
1979	4783	657	1621	516	323
1980	4335	537	1939	168	171
1981	4772	682	2452	225	169

TABLE A.11
Crop Land Acreages
Seeded To Fallow Seedbed In Alberta
('000 acres)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed
1961	4570	1084	1319	233	297
1962	4751	1013	1259	104	273
1963	4708	903	1415	146	228
1964	4943	587	1166	227	253
1965	4453	612	1135	381	234
1966	4549	536	1177	367	201
1967	4500	431	1079	487	96
1968	4386	494	1265	253	194
1969	4012	538	1565	498	329
1970	2379	959	2190	1201	613
1971	3022	838	3063	1665	254
1972	3325	586	1960	936	143
1973	4028	692	1704	954	172
1974	3430	594	1761	802	163
1975	3222	737	2143	1116	270
1976	4099	564	1583	542	62
1977	3453	481	1466	963	87
1978	3485	440	1160	1797	68
1979	3140	360	828	1772	150
1980	3507	371	1021	1404	97
1981	3608	410	957	867	58

TABLE A.12
Crop Land Acreages
Seeded To Stubble Seedbed In Alberta
('000 acres)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed
1961	1063	1558	1548	74	65
1962	1056	1633	1580	68	67
1963	1225	1521	1993	77	75
1964	1552	1363	2154	177	117
1965	1597	1588	2255	354	121
1966	1957	1546	2703	257	146
1967	1880	1521	3201	388	49
1968	2074	1466	3385	197	91
1969	1288	1362	3335	318	121
1970	221	1091	2310	249	37
1971	421	1116	2626	323	17
1972	975	1244	3240	364	27
1973	872	1308	3346	346	28
1974	770	1106	3439	348	37
1975	626	1170	2985	322	29
1976	1501	1236	3967	208	13
1977	1347	1069	3984	587	33
1978	1615	1010	3890	1053	32
1979	2060	890	3722	1728	100
1980	2393	929	4379	796	73
1981	2892	1090	5293	683	42

TABLE A.13

Stocks On-Farm At March 31 In Manitoba
('000 bushels)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed
1961	49	32	21	-	1.4
1962	23	18	8	-	1.4
1963	37	42	12	-	1.4
1964	28	35	10	-	2.2
1965	39	35	9	-	1.8
1966	39	38	10	-	2.3
1967	42	33	14	-	3.5
1968	48	30	20	-	1.7
1969	79	39	36	-	2.2
1970	79	65	38	0.6	3.0
1971	46	40	25	1.8	6.0
1972	50	35	45	6.5	3.2
1973	30	26	42	3.7	2.6
1974	35	28	45	1.9	2.4
1975	30	21	32	3.0	2.8
1976	30	25	25	5.5	4.0
1977	55	30	30	2.0	2.8
1978	70	30	60	3.5	5.7
1979	82	23	65	10.5	7.0
1980	67	9	34	15.5	11.3
1981	33	7	37	11.0	4.5

TABLE A.14

Stocks On-Farm At March 31 In Saskatchewan
('000 bushers)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed
1961	295	61	58	-	3.2
1962	155	27	23	-	2.5
1963	190	69	30	-	2.1
1964	320	89	55	-	3.1
1965	263	55	37	-	2.4
1966	307	62	33	-	4.2
1967	377	60	63	-	4.6
1968	304	36	56	-	1.2
1969	392	38	75	-	1.6
1970	556	95	108	4.6	4.0
1971	453	90	75	12.2	15.0
1972	400	75	145	24.5	10.7
1973	300	52	110	12.7	3.9
1974	265	55	115	7.1	3.6
1975	210	43	90	9.0	3.3
1976	205	48	70	17.0	4.0
1977	360	50	60	8.0	2.5
1978	370	50	120	10.0	4.5
1979	395	37	115	26.5	5.6
1980	352	25	56	28.5	8.4
1981	249	23	72	31.0	5.4

TABLE A.15

Stocks On-Farm At March 31 In Alberta
('000 bushels)

Year	Wheat	Oats	Barley	Rapeseed	Flaxseed
1961	73	54	52	-	1.4
1962	51	36	34	-	1.1
1963	48	60	49	-	0.8
1964	78	76	68	-	1.1
1965	74	53	68	-	1.0
1966	99	60	74	-	2.2
1967	108	59	93	-	2.7
1968	93	40	84	-	0.8
1969	142	50	120	-	1.4
1970	165	80	185	4.5	3.4
1971	121	90	105	5.0	6.0
1972	85	45	110	14.0	3.1
1973	60	58	120	5.6	1.0
1974	70	57	105	6.0	1.0
1975	55	46	108	6.0	1.1
1976	55	47	105	14.0	2.0
1977	105	50	120	8.0	0.8
1978	80	50	145	6.0	0.7
1979	98	45	155	21.0	0.9
1980	107	39	105	29.0	2.2
1981	100	33	122	31.0	1.8

TABLE A.16

Price Of Rapeseed And Flaxseed
Received In The Prairie Provinces
(six month average prior to seeding, Oct.1 - Mar.31)
($ bushel)

Year	Rapeseed	Flaxseed
1961	2.088	2.958
1962	1.888	3.594
1963	1.838	3.277
1964	2.772	3.197
1965	3.003	3.183
1966	2.707	2.988
1967	2.803	2.940
1968	2.312	3.437
1969	2.271	3.254
1970	2.904	2.910
1971	2.766	2.513
1972	2.420	2.504
1973	3.125	4.220
1974	5.970	10.608
1975	4.761	9.825
1976	4.757	6.599
1977	5.893	6.984
1978	6.504	5.460
1979	6.946	7.588
1980	6.798	8.201
1981	7.630	9.720

TABLE A.17

Average Initial And Final Payments
On Canadian Wheat Board Grains In The Prairie Provinces
($ bushel)

Year	Wheat		Oats		Barley	
	Initial Price	Final Price	Initial Price	Final Price	Initial Price	Final Price
1961	1.50	0.410	0.55	0.179	0.87	0.292
1962	1.50	0.374	0.55	0.130	0.87	0.182
1963	1.50	0.474	0.55	0.101	0.87	0.228
1964	1.50	0.387	0.55	0.181	0.87	0.315
1965	1.50	0.497	0.55	0.252	0.87	0.329
1966	1.50	0.487	0.55	0.245	0.87	0.338
1967	1.70	0.114	0.60	0.178	0.97	0.038
1968	1.70	0.000	0.60	0.000	0.97	0.000
1969	1.50	0.073	0.55	0.097	0.81	0.022
1970	1.50	0.171	0.55	0.089	0.81	0.000
1971	1.46	0.136	0.55	0.083	0.81	0.000
1972	1.76	0.394	0.65	0.408	0.95	0.515
1973	3.75	0.828	1.05	0.669	2.15	0.442
1974	3.75	0.724	1.15	0.505	2.15	0.181
1975	3.75	0.231	1.15	0.476	1.09	0.366
1976	3.00	0.188	1.16	0.164	1.75	0.242
1977	3.00	0.274	1.15	0.000	1.75	0.377
1978	3.50	0.869	1.14	0.176	1.73	0.249
1979	4.25	1.096	1.14	0.176	1.95	0.390
1980	5.35	0.700	1.36	0.580	2.85	0.340
1981	4.35	0.700	1.70	0.000	2.70	0.000

TABLE A.18

Average Initial And Final Payments On Sunflower Seeds
In The Prairie Provinces
($ bushel)

Year	Initial Price	Final Price
1961	0.98	0.30
1962	1.12	0.38
1963	1.12	0.14
1964	1.12	0.36
1965	1.12	0.66
1966	1.20	0.54
1967	1.20	0.00
1968	0.90	0.42
1969	1.05	0.63
1970	1.05	0.87
1971	1.05	0.67
1972	1.05	1.05
1973	1.20	1.81
1974	1.80	4.20
1975	2.28	0.61
1976	2.96	0.68
1977	2.77	0.84
1978	3.04	0.61
1979	2.52	0.64
1980	2.88	0.34
1981	3.00	0.00

Data Sources:

Crop Yields:

Yields of wheat, oats, barley, rapeseed, and flaxseed seeded on stubble and fallow for the three Prairie provinces (presented in Table A.1 to A.6) were obtained from Statistics Canada: Field Crop Reporting Series (no.1.cat.no.22-002). Average yield of sunflower seeds was taken from Manitoba Agriculture Yearbooks.

Crop Acreages:

Annual acreages seeded to wheat, oats, barley, rapeseed, and flaxseed on stubble and fallow for the three Prairie provinces (presented in Table A.7 to A.12) were obtained from Statistics Canada: Field Crop Reporting Series (cat.no.22-002). Annual acreage of sunflower was taken from Manitoba Agriculture Yearbooks.

Grain Inventories:

Inventories of wheat, oats, barley, rapeseed, and flaxseed for the three Prairie provinces (presented in Table A.13 to A.15) were obtained from Statistics Canada: Quarterly Bulletin of Agricultural Statistics (cat.no.21-2003), and Saskatchewan Agriculture Statistics Branch: Statistics Facts.

Rapeseed and Flaxseed Prices:

Prices of rapeseed and flaxseed Prairie farmers received (presented in Table A.16) were obtained from Canadian Grain Commission: Grain Statistics.

Wheat, Oats, and Barley Prices:

Average initial and final payments on wheat, oats, and barley in the Prairie provinces (presented in Table A.17) were obtained from the Canadian Wheat Board Annual Reports.

Sunflower Seeds Price:

Initial payment prior to 1979 and final payment of sunflower seeds were obtained from financial statements of CSP Foods Ltd. and Cargill Grain Company. Initial payment in 1980 was calculated as 80% of Manitoba Pool street price for rapeseed. Manitoba pool sunflower seeds price was used as the initial payment in 1981.

Appendix B

RESULTS OF THE ESTIMATION OF TOTAL ACREAGE OF THE FIVE CROPS SEEDED ON FALLOW (TAF), TOTAL ACREAGE OF THE SIX CROPS SEEDED ON STUBBLE (TAS), AND TOTAL AREA SEEDED ON STUBBLE (STUBBLE)

TABLE B.1

Actual vs. Estimated Values Of
Total Acreage Of The Five Crops Seeded On Fallow
On The Prairies
('000 acres)

	Manitoba		Saskatchewan		Alberta	
Year	Act.	Est.	Act.	Est.	Act.	Est.
1962	3200	3122	17150	16965	7400	7271
1963	3135	3061	17051	16875	7400	7075
1964	3230	3114	16868	16682	7176	6896
1965	2850	2732	16785	16552	6815	6504
1966	2870	2767	16770	16585	6830	6936
1967	2639	2529	15860	15577	6601	6501
1968	2620	2531	16614	16322	6592	6566
1969	2680	2530	16914	16510	6942	6867
1970	2700	3010	14700	17740	7342	7245
1971	3800	3820	22001	23450	8842	8725
1972	2600	2575	16500	16300	6950	6809
1973	2850	2820	18450	18260	7550	7280
1974	2450	2410	17150	16865	6750	6475
1975	2600	2600	17700	17590	7488	7025
1976	2500	2500	18000	17865	6850	6620
1977	2200	2218	17600	17575	6450	6325
1978	2150	2177	17700	17480	6950	6770
1979	1900	1876	16800	16665	6250	6070
1980	1900	1942	16850	16750	6400	6130
1981	1950	1562	17250	16600	5900	5600

TABLE B.2

Actual vs. Estimated Values Of
Total Acreage Of The Six Crops Seeded On Stubble
On The Prairies
('000 acres)

	MANITOBA			SASKATCHEWAN			ALBERTA		
Year	Act.	Est.1	Est.2	Act.	Est.1	Est.2	Act.	Est.1	Est.2
1962	2985	3076	3129	5135	5133	5678	4404	4135	4159
1963	3120	3205	3366	5721	5708	6143	4891	4868	4412
1964	3444	3565	3605	6025	5959	6659	5363	5352	5429
1965	4059	4137	4073	6500	6537	6789	5915	6000	6121
1966	4110	4179	4410	7860	7817	7621	6609	6375	6750
1967	4300	4396	4637	8483	8278	8060	7039	6948	7656
1968	4478	4583	4586	7604	7754	7077	7213	7127	7225
1969	3894	4087	4481	6156	6347	6878	6424	6304	6318
1970	3025	2898	2772	2300	2116	1928	3908	3826	3770
1971	3453	3585	3639	2114	1945	2482	4503	4335	3912
1972	4400	4542	4751	5840	5940	4993	5850	6205	5352
1973	4775	4910	4757	5650	5803	4912	5900	6233	5896
1974	4571	4626	5350	5450	5666	5659	5700	5785	6800
1975	4662	4652	5048	5100	5053	5682	5132	6284	6635
1976	4975	4915	5323	5200	4990	6054	6925	6675	7680
1977	5365	5335	5576	6000	6020	5774	7020	6801	8088
1978	5753	5756	5855	6950	6852	7002	7700	7556	8093
1979	5980	6005	6062	7900	7636	6518	8500	8369	9218
1980	5770	6028	6378	7150	6861	8299	8570	8461	9764
1981	6539	6696	6564	8300	8105	8347	10000	9978	10154

Est.1 based on actual value of total area seeded on stubble, and Est.2 based on projected value of total area seeded on stubble.

TABLE B.3

Actual vs. Estimated Values Of
Total Area Seeded On Stubble On The Prairies
('000 acres)

	MANITOBA		SASKATCHEWAN		ALBERTA	
Year	Actual	Estimated	Actual	Estimated	Actual	Estimated
1962	3343	3401	5579	6172	4986	5009
1963	3484	3659	6204	6677	5688	5251
1964	3875	3918	6477	7238	6152	6226
1965	4497	4427	7105	7380	6773	6889
1966	4542	4794	8497	8284	7133	7492
1967	4778	5040	8998	8761	7682	8361
1968	4982	4876	8428	7693	7854	7948
1969	4442	4871	6899	7476	7065	7078
1970	3150	3013	2300	2096	4689	4635
1971	3897	3955	2114	2698	5177	4772
1972	4937	5164	6456	5427	6970	6152
1973	5337	5170	6308	5339	6997	6674
1974	5028	5815	6159	6151	6567	7541
1975	5056	5487	5492	6176	7046	7382
1976	5342	5785	5425	6580	7421	8384
1977	5799	6060	6544	6276	7541	8775
1978	6257	6364	7448	7610	8265	8780
1979	6527	6589	8300	7084	9045	9858
1980	6552	6933	7458	9021	9133	10382
1981	7278	7134	8810	9073	10587	10756

TABLE B.4
Regression Results Of
Total Acreage Of The Six Crops Seeded On Stubble

Province	STUBBLE	Intercept	Corrected R Square	Standard Error	Durbin-Watson Statistics
Manitoba	.92037 (48.01)	-86.933 (-.90)	.9914	100.24	1.54
Saskatchewan	.91860 (39.30)	32.203 (.20)	.9872	188.50	1.15
Alberta	1.0431 (21.65)	-1065.4 (-3.08)	.9590	319.12	1.91

Note: Intercept in Manaitoba and Saskatchewan were excluded from estimating TAs because of statistical insignificance.

Appendix C

RESULTS OF HISTORICAL SIMULATIONS

TABLE C.1

Actual vs. Estimated Values of Crop Land Acreages
Seeded to Stubble Seedbed in Manitoba
-Based on Simulation I
('000 acres)

	Wheat		Oats		Barley		Rapeseed		Sunflower		Flaxseed	
Year	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.
1962	736	882	1369	1194	389	400	13	15	20	28	457	555
1963	760	745	1318	1353	359	430	19	20	33	25	631	631
1964	877	1012	1347	1201	326	442	43	40	48	75	803	794
1965	1101	1138	1305	1394	413	527	85	73	48	50	1107	954
1966	1047	1295	1365	1264	583	492	115	115	43	50	957	962
1967	1405	1444	1426	1290	743	819	98	95	44	53	584	695
1968	1361	1632	1424	1200	897	961	63	74	37	52	696	666
1969	697	771	1345	1342	778	828	113	120	48	53	913	973
1970	270	298	1016	814	770	616	154	169	65	61	750	940
1971	489	531	1114	986	1081	1171	206	296	140	138	423	463
1972	994	1128	1014	937	1562	1586	240	248	190	200	400	443
1973	1166	1370	1152	919	1618	1614	226	290	125	158	488	559
1974	1306	1358	1037	912	1366	1422	275	328	21	23	566	582
1975	1379	1429	961	959	1177	1135	478	396	62	54	605	678
1976	1978	2246	1071	790	1319	1210	130	140	50	52	427	477
1977	1802	1748	905	739	1571	1631	301	410	165	143	621	664
1978	2064	1939	633	495	1513	1909	709	593	203	259	631	561
1979	1996	2091	370	292	1244	1274	907	858	380	398	1083	1092
1980	2132	2369	365	281	1744	1769	503	545	320	394	706	670
1981	2594	2662	545	403	2021	2021	449	595	289	301	641	714

TABLE C.2

Actual vs. Estimated Values of Crop Land Acreages
Seeded to Stubble Seedbed in Saskatchewan
-Based on Simulation I
('000 acres)

	Wheat		Oats		Barley		Rapeseed		Flaxseed	
Year	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.
1962	2701	2713	1486	1403	772	804	40	41	136	172
1963	3090	2758	1370	1567	993	1170	61	49	207	163
1964	3909	3346	981	1109	795	1139	90	128	250	237
1965	3796	4290	1280	1049	968	867	183	128	273	203
1966	4645	4880	1316	1310	1398	1169	281	241	220	217
1967	5549	5498	1089	1037	1526	1334	223	241	96	169
1968	4590	4645	1233	1085	1459	1724	148	160	174	141
1969	2990	3610	1307	1140	1349	1214	257	186	253	197
1970	434	376	701	676	821	713	184	169	160	183
1971	131	132	848	735	998	956	59	50	78	69
1972	2504	2241	984	1068	2064	2377	141	134	147	119
1973	2242	2879	1162	1006	1947	1602	148	147	151	170
1974	2230	2304	1099	1254	1874	1777	131	176	116	155
1975	2027	2104	1106	1018	1709	1692	160	143	98	94
1976	2602	2450	967	1054	1538	1369	41	48	52	70
1977	2779	2353	960	1099	1872	2117	195	253	194	198
1978	3704	3417	774	938	1844	1688	449	578	179	231
1979	4783	4547	657	611	1621	1898	516	353	323	228
1980	4335	3589	537	703	1939	2148	168	209	171	212
1981	4772	4821	682	659	2452	2236	225	217	169	173

TABLE C.3

Actual vs. Estimated Values of Crop Land Acreages
Seeded to Stubble Seedbed in Alberta
-Based on Simulation I
('000 acres)

	Wheat		Oats		Barley		Rapeseed		Flaxseed	
Year	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.
1962	1056	892	1633	1553	1580	1576	68	58	67	56
1963	1225	1143	1521	1572	1993	1585	77	90	75	78
1964	1552	1368	1363	1562	2154	2165	177	179	117	79
1965	1597	1700	1588	1539	2255	2374	354	301	121	86
1966	1957	1686	1546	1545	2703	2786	257	277	146	81
1967	1880	2029	1521	1471	3201	3034	388	341	49	72
1968	2074	1626	1466	1462	3385	3798	197	173	91	69
1969	1288	1353	1362	1356	3335	3178	318	312	121	104
1970	221	220	1091	1087	2310	2152	249	312	37	55
1971	421	381	1116	1076	2626	2523	323	299	17	16
1972	975	940	1244	1263	3240	3701	364	282	27	18
1973	872	1228	1308	1186	3346	3318	346	468	28	33
1974	770	803	1106	1266	3439	3238	348	425	37	53
1975	626	1684	1170	1060	2985	3110	322	386	29	44
1976	1501	1468	1236	1327	3967	3576	208	283	13	20
1977	1347	1136	1069	1122	3984	3956	587	542	33	45
1978	1615	1632	1010	1011	3890	3462	1153	1402	32	49
1979	2060	1858	890	854	3722	4301	1728	1290	100	67
1980	2393	1982	929	1101	4379	4506	796	819	73	53
1981	2892	3085	1090	1025	5293	5107	683	703	42	57

TABLE C.4

Actual vs. Estimated Values of Crop Land Acreages
Seeded to Stubble Seedbed in Manitoba
-Based on Simulation II
('000 acres)

	Wheat		Oats		Barley		Rapeseed		Sunflower		Flaxseed	
Year	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.
1962	736	911	1369	1203	369	407	13	16	21	30	457	562
1963	760	822	1318	1382	359	452	19	22	33	29	631	658
1964	877	1035	1347	1204	326	447	43	41	48	78	803	800
1965	1101	1100	1305	1391	413	521	85	71	48	47	1107	944
1966	1047	1449	1365	1265	583	512	115	131	43	61	957	992
1967	1405	1615	1426	1284	743	851	98	107	44	65	584	714
1968	1361	1560	1424	1203	897	946	63	70	37	48	696	659
1969	697	948	1345	1363	778	901	113	151	48	76	913	1042
1970	270	274	1016	796	770	589	154	154	65	54	750	904
1971	489	546	1114	989	1081	1185	206	305	140	145	423	468
1972	994	1234	1014	927	1562	1628	240	275	190	237	400	450
1973	1166	1283	1152	927	1618	1584	226	269	125	139	488	553
1974	1306	1834	1037	867	1366	1537	275	461	21	41	566	610
1975	1379	1685	961	932	1177	1184	478	477	62	75	605	695
1976	1978	2611	1071	754	1319	1241	130	166	50	71	427	480
1977	1802	1910	905	719	1571	1655	301	454	165	171	621	666
1978	2064	2002	633	488	1513	1912	709	616	203	278	631	560
1979	1996	2125	370	289	1244	1272	907	875	380	414	1083	1088
1980	2132	2608	365	261	1744	1748	503	612	320	496	706	652
1981	2594	2562	545	413	2021	2025	449	569	289	275	641	721

TABLE C.5

Actual vs. Estimated Values of Crop Land Acreages
Seeded to Stubble Seedbed in Saskatchewan
-Based on Simulation II
('000 acres)

	Wheat		Oats		Barley		Rapeseed		Flaxseed	
Year	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.
1962	2701	3373	1486	1299	772	794	40	45	136	167
1963	3090	3290	1370	1477	993	1162	61	54	207	160
1964	3909	4253	981	966	795	1078	90	142	250	221
1965	3796	4633	1280	988	968	841	183	131	273	196
1966	4645	4595	1316	1371	1398	1196	281	236	220	222
1967	5549	5174	1089	1098	1526	1376	223	236	96	175
1968	4590	3704	1233	1247	1459	1829	148	145	174	152
1969	2990	4311	1307	1021	1349	1159	257	201	253	186
1970	434	319	701	636	821	656	184	149	160	169
1971	131	211	848	882	998	1229	59	72	78	88
1972	2504	1414	984	1125	2064	2237	141	102	147	114
1973	2242	1946	1162	1101	1947	1577	148	118	151	171
1974	2230	2296	1099	1255	1874	1777	131	176	116	155
1975	2027	2765	1106	952	1709	1705	160	167	98	94
1976	2602	3709	967	897	1538	1323	41	59	52	66
1977	2779	2108	960	1125	1872	2105	195	237	194	198
1978	3704	3601	774	912	1844	1670	449	592	179	228
1979	4783	3113	657	765	1621	2083	516	300	323	256
1980	4335	5563	537	501	1939	1815	168	246	171	174
1981	4772	5172	682	620	2452	2166	225	222	169	167

TABLE C.6

Actual vs. Estimated Values of Crop Land Acreages
Seeded to Stubble Seedbed in Alberta
-Based on Simulation II
('000 acres)

	Wheat		Oats		Barley		Rapeseed		Flaxseed	
Year	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.
1962	1056	908	1633	1554	1580	1583	68	59	67	56
1963	1225	833	1521	1563	1993	1866	77	79	75	72
1964	1552	1435	1363	1556	2152	2176	177	182	117	79
1965	1597	1825	1588	1520	2255	2381	354	308	121	87
1966	1957	2090	1546	1482	2703	2799	257	295	146	83
1967	1880	2940	1521	1314	3201	2957	388	371	49	73
1968	2074	1722	1466	1449	3385	3809	197	176	91	69
1969	1288	1365	1362	1355	3335	3181	318	313	121	105
1970	221	211	1091	1080	2310	2121	249	304	37	54
1971	421	274	1116	1033	2626	2336	323	255	17	14
1972	975	524	1244	1262	3240	3328	364	221	27	16
1973	872	992	1308	1205	3346	3235	346	433	28	32
1974	770	1525	1106	1199	3439	3480	348	536	37	60
1975	626	2051	1170	1016	2985	3114	322	408	29	45
1976	1501	2578	1236	1172	3967	3578	208	332	13	21
1977	1347	2374	1069	972	3984	4020	587	674	33	48
1978	1675	2179	1010	935	3890	3421	1153	1508	32	50
1979	2060	2868	890	738	3722	4130	1728	1414	109	67
1980	2393	3781	929	862	4379	4145	796	924	73	52
1981	2892	3358	1090	989	5293	5037	683	713	42	56

TABLE C.7

Actual vs. Estimated Values of Crop Land Acreages
Seeded to Fallow Seedbed in Manitoba
('000 acres)

	Wheat		Oats		Barley		Rapeseed		Flaxseed	
Year	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.
1962	2306	2292	425	361	240	213	19	32	210	225
1963	2393	2347	302	310	225	201	26	20	189	184
1964	2508	2424	288	229	171	258	41	36	222	168
1965	2139	2117	220	227	188	155	60	49	243	184
1966	2208	2150	165	211	292	181	55	66	150	158
1967	2115	1980	174	133	227	275	47	52	76	88
1968	2039	1997	156	137	273	268	28	34	124	96
1969	1803	1652	185	208	422	348	83	109	187	213
1970	1130	1303	244	302	730	687	246	337	350	381
1971	2030	2079	281	315	971	844	375	426	143	156
1972	1606	1602	126	147	538	522	230	197	100	106
1973	1934	1838	148	161	482	482	174	194	112	144
1974	1494	1496	163	148	434	358	225	269	134	137
1975	1721	1735	139	208	323	309	272	205	145	143
1976	1822	1850	179	193	281	249	120	115	98	94
1977	1398	1434	145	109	329	369	199	181	129	124
1978	1336	1341	117	107	237	298	341	312	119	119
1979	1004	1041	80	85	206	248	443	339	167	164
1980	1168	1196	85	81	256	242	297	336	94	86
1981	1306	1014	105	82	279	220	201	186	59	60

TABLE C.8

Actual vs. Estimated Values of Crop Land Acreages
Seeded to Fallow Seedbed in Saskatchewan
('000 acres)

Year	Wheat Act.	Wheat Est.	Oats Act.	Oats Est.	Barley Act.	Barley Est.	Rapeseed Act.	Rapeseed Est.	Flaxseed Act.	Flaxseed Est.
1962	14687	14708	1226	994	857	754	127	192	253	317
1963	14820	14946	846	732	937	884	149	103	299	210
1964	15291	14561	488	627	605	926	213	222	271	347
1965	14704	14857	640	574	782	623	372	283	287	216
1966	14760	14573	494	557	857	829	450	430	209	196
1967	14121	13461	441	439	824	895	377	605	97	177
1968	14410	14346	567	445	1051	1010	363	351	223	170
1969	13610	13189	693	765	1351	1319	743	669	517	567
1970	7566	9026	1249	1116	2479	2892	2016	2922	1390	1786
1971	12785	13714	1118	966	4573	5129	2678	2772	847	868
1972	11396	11313	706	796	2536	2602	1359	1139	503	451
1973	13558	12773	838	898	2253	2246	1302	1703	499	640
1974	12270	12079	801	763	2326	1993	1319	1565	434	466
1975	13173	13145	744	795	1791	1977	1640	1344	352	330
1976	15098	14738	633	719	1412	1363	709	866	148	179
1977	13421	13795	590	590	1928	1591	1255	1244	406	355
1978	13396	13154	426	503	1256	1230	2351	2307	271	286
1979	12217	13071	343	392	979	1378	2784	1485	477	339
1980	13065	13239	363	355	1311	1143	1832	1760	279	253
1981	14228	13257	468	457	1298	1090	1075	1571	181	226

TABLE C.9

Actual vs. Estimated Values of Crop Land Acreages
Seeded to Fallow Seedbed in Alberta
('000 acres)

	Wheat		Oats		Barley		Rapeseed		Flaxseed	
Year	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.
1962	4751	4481	1013	1056	1259	1350	104	195	273	190
1963	4708	4618	903	873	1415	1225	146	178	228	180
1964	4943	4495	587	698	1166	1174	227	371	253	158
1965	4453	4612	612	579	1135	876	381	310	234	126
1966	4549	4565	536	535	1177	1232	367	418	201	186
1967	4500	4228	439	487	1079	1205	487	476	96	105
1968	4386	4311	494	452	1265	1401	253	244	194	159
1969	4012	4103	538	564	1565	1369	498	477	329	354
1970	2379	2044	959	859	2190	2137	1201	1777	613	428
1971	3022	3130	838	840	3063	2884	1665	1596	254	275
1972	3325	3515	586	550	1960	1923	936	742	143	79
1973	4028	3788	692	659	1704	1709	954	1047	172	177
1974	3430	3265	594	588	1761	1494	802	979	163	150
1975	3222	3272	737	742	2143	1956	1116	932	270	123
1976	4099	3664	564	548	1583	1444	542	894	62	71
1977	3453	3552	481	465	1466	1281	963	938	87	89
1978	3485	3327	440	395	1160	1115	1797	1834	68	98
1979	3140	3084	360	346	828	903	1772	1647	150	91
1980	3507	3638	371	366	1021	895	1404	1152	97	79
1981	3608	3274	410	397	957	835	867	1043	58	51

Appendix D

REGRESSION RESULTS OF THE NAIVE MODEL

TABLE D.1

Regression Results For Crops Seeded On Stubble Seedbed
In Prairie Provinces
- Based on the Naive Model

	Crop	Lagged Dependent Variable	LIFT	Intercept	Corrected R Square	D-W
Manitoba	Wheat	.93084	-586.58	207.78	.80	2.10
		(8.29)	(-1.99)	(1.41)		
	Oats	1.0080	-314.50	-25.275	.85	1.56
		(10.74)	(-2.33)	(-0.24)		
	Barley	.98300	-85.018	90.242	.81	1.51
		(9.23)	(-0.36)	(0.78)		
	Rapeseed	.75307	-7.5558	76.458	.52	1.88
		(4.85)	(-1.04)	(1.49)		
	Sunflowers	.88561	-1.7961	24.287	.66	1.80
		(6.38)	(-0.03)	(1.22)		
	Flaxseed	.45580	-33.596	367.45	.12	1.80
Saskatchewan	Wheat	.73587	-2789.5	1023.3	.67	2.05
		(5.56)	(-3.42)	(2.29)		
	Oats	.78661	-544.31	217.21	.68	1.98
		(6.30)	(-3.34)	(1.56)		
	Barley	.80003	-629.24	371.00	.56	1.58
		(4.80)	(-1.87)	(1.51)		
	Rapeseed	.50218	-37.813	92.753	.16	1.71
		(2.42)	(-0.32)	(2.13)		
	Flaxseed	.29524	-37.256	122.56	.04	1.97
		(1.66)	(-0.53)	(3.29)		

TABLE D.1 (cont'd)

Regression Results For Crops Seeded On Stubble Seedbed
In Prairie Provinces
- Based on the Naive Model

	Crop	Lagged Dependent Variable	LIFT	Intercept	Corrected R Square	D-W
Alberta	Wheat	.88531 (6.47)	-1216.5 (-3.38)	297.25 (1.52)	.72	2.12
	Oats	.85870 (7.10)	-260.30 (-2.01)	181.75 (1.15)	.72	1.75
	Barley	1.0143 (9.83)	-1256.6 (-3.14)	183.82 (0.58)	.83	1.89
	Rapeseed	.70232 (4.31)	-129.49 (-0.43)	155.16 (1.68)	.46	1.77
	Flaxseed	.60724 (3.16)	-62.188 (-1.75)	25.712 (1.81)	.30	2.15

TABLE D.2

Regression Results For Crops Seeded On Fallow Seedbed
In Prairie Provinces
- Based on the Naive Model

	Crop	Lagged Dependent Variable	LIFT	Intercept	Corrected R Square	D-W
Manitoba	Wheat	.71778	-672.35	508.19	.58	2.37
		(4.89)	(-2.17)	(1.81)		
	Oats	.76686	64.954	37.176	.54	1.57
		(5.03)	(0.84)	(1.02)		
	Barley	.69170	349.05	89.053	.63	2.67
		(5.06)	(2.87)	(1.62)		
	Rapeseed	.77371	144.33	37.455	.60	1.90
		(5.56)	(1.69)	(1.29)		
	Flaxseed	.35342	194.51	89.405	.49	1.14
		(2.10)	(3.90)	(3.05)		
Saskatchewan	Wheat	.27027	-6228.0	10116	.67	2.04
		(2.10)	(-6.25)	(5.85)		
	Oats	.71420	597.40	156.66	.67	1.69
		(5.54)	(3.57)	(1.54)		
	Barley	.66568	1115.3	464.33	.44	2.60
		(3.98)	(1.59)	(1.54)		
	Rapeseed	.73565	1208.5	260.86	.57	1.90
		(5.09)	(2.12)	(1.29)		
	Flaxseed	.44385	992.19	168.34	.79	2.46

TABLE D.2 (cont'd)

Regression Results For Crops Seeded On Fallow Seedbed
In Prairie Provinces
- Based on the Naive Model

	Crop	Lagged Dependent Variable	LIFT	Intercept	Corrected R Square	D-W
Alberta	Wheat	.69833 (5.81)	-1650.8 (-4.31)	1228.1 (2.57)	.71	2.31
	Oats	.78176 (6.80)	442.34 (3.82)	96.071 (1.20)	.73	2.11
	Barley	.69051 (4.23)	700.41 (1.85)	408.94 (1.57)	.50	2.46
	Rapeseed	.74245 (5.21)	630.22 (1.72)	201.04 (1.48)	.57	2.05
	Flaxseed	.32412 (2.52)	394.78 (5.07)	111.59 (3.45)	.64	1.68