RURAL ECONOMY

An Annotated Bibliography of Crop Rotation and Tillage Literature With Special Emphasis on the Canadian Prairies

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Staff Paper 95-08

STAFF PAPER

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The purpose of the Rural Economy 'Staff Paper' series is to provide a forum to accelerate the presentation of issues, concepts, ideas and research results within the academic and professional community. Staff Papers are published without peer review.

Foreword

This annotated bibliography was complied during research project 94-0492 funded by Farming for the Future. Some of these references were cited in the research and others simply provided background information. The references shown here are not meant to be a comprehensive listing of literature about tillage and risk, but merely to be a useful compilation for researchers in future studies.

Citations

Alberta Agriculture (1994). Agricultural Prices and Indexes. Edmonton: Alberta Agriculture, Statistics Branch.

Alberta Agriculture (1994). Agriculture Fact Sheet 1993 (AGDEX 853). Edmonton: Alberta Agriculture, Market Analysis and Statistics Branch.

Alberta Agriculture (1989). Alberta Fertillizer Guide (AGDEX 541-1). Edmonton: Alberta Agriculture.

Alberta Agriculture (1989, April). A Concencus of Costs and Returns for Barley, Canola and Wheat Production on a 1920 Acre Farm in the High River District, April, 1989 (CRD No. 274). Edmonton: Alberta Agriculture.

Alberta Agriculture (1985). Farm Machinery Costs (AGDEX 825-12). Edmonton: Alberta Agriculture, Production and Resource Economics Branch.

Alberta Agriculture (1986). Wheat Production in Alberta (Agdex 000-6). Edmonton: Alberta Agriculture.

American Society of Agricultural Engineers (1992). ASAE Standards 1992, 39th Edition: Standards, Engineering Practices, and Data. St. Joseph, MI: American Society of Agricultural Engineers.

Antle, J. M. (1983). Incorporating Risk in Production Analysis. American Journal of Agricultural Economics, 65, 1099- 1106.

"Incorporating risk in production analysis means incorporating probability distribution parameters in decision models. Static models have serious limitations; they imply risk matters only if decision makers are risk averse, and they cannot be used to model cost uncertainty. Dynamic models, in contrast, support the risk-efficiency hypothesis, and show that input and output price risk and production risk generally affect productivity and optimal resource allocation, whether or not the decision maker is risk averse. An important implication for both research and extension is that all farmers, whether risk neutral or risk averse, can gain from information about price and production risk." (pg 1105).

Appleby, T. (1993). The Economics of Conservation Tillage in Alberta (AGDEX 821-67). Edmonton: Alberta Agriculture, Food and Rural Development, Production Economics Branch.

"This publication reviews the management and economic aspects associated with changes occurring in conservation farming. It also provides information about the attitudes and flexibility required by farm managers. And it provides an economic and agronomic overview of the producers or cooperators involved in conservation farming activities in Alberta in 1992." (pg 1).

Bauer, L., Jeffrey, S., & Orlick, C. (1995).A Comparison of Risk Between Continuous and Fallow Cropping Regimes. (Project Report 95-08, Farming for the Future Project 94-0492). Edmonton: University of Alberta, Department of Rural Economy.

The focus of this study is to examine the risk and return trade-offs for various crop rotations and tillage systems. The geographic area represented in this study is contained within four soil, and five climatic zones within the province of Alberta. The predominant crops grown in these areas (i.e. spring wheat, barley, and canola) were used to derive cost estimates that reflect agronomic processes.

The results obtained from each of the areas indicate that several generalizations can be made about the interaction of crop rotations, tillage systems, and farm size. Firstly, the size of predicted net revenue increases and the probability of generating a negative net revenue decreases as one moves north from the Brown soil zone into the Dark Brown and Black soils. Secondly, as one moves from the Brown soil zone through to the Black soil zone, less significance can be placed on fallow crop rotations. Lastly, at the current price of fallow herbicides, conventional tillage systems have a cost advantage over the alternatives tested here. See also Orlick (1995).

Bauer, L., & McEvoy, M. J. (1990). An Economic Evaluation of Tillage Systems on Dark Brown Soils in Alberta (Farming for the Future Report No. 84-0360 and 87-0093, Project Report No. 90-05). Edmonton: University of Alberta, Department of Rural Economy.

Field trials, under commercial farm conditions were conducted on 14 farms located on dark brown soils in Alberta, during the three year period 1985 through 1987. Because of farm variability in tillage methods used, and because of the wide geographic dispersion of participating farm operations, general statistical inferences about agronomic matters are not warranted. In some cases the reduced tillage practice resulted in higher yields, while in other cases reduced tillage resulted in yield reductions. The results presented, although of limited scope and generality, are not dissimilar to previous research. Some researchers have reported a yield disadvantage for conservation tillage practices; other researchers have suggested the opposite may be true. The lack of statistical significance in yield differences in this study, and the inconclusiveness in other research suggests that differences between tillage methods may be economic rather than agronomic.

Because agronomic results about the relative merits of tillage methods evaluated in field trials, in this study and elsewhere were inconclusive, further and more long term experimentation to establish yield differences for alternative tillage systems is important.

Considerable effort in this study was directed toward refinement of analytical techniques for economic comparison of the alternatives available. Asset costing and

replacement theory was applied to farm machinery compliments used in three tillage systems- conventional, reduce and minimum tillage- under two cropping systems - continuous cropping and a crop fallow program. Comparisons were made across three farm sizes- 960 acres, 1280 acres and 1600 acres.

Under continuous cropping, costs for the conventional and the minimum tillage systems were virtually identical. Both were lower than reduced tillage systems. This suggests that there are no economic cost penalties for adopting minimum tillage in preference to the conventional system. Under the crop fallow program, however, conventional tillage had a distinct cost advantage over reduced tillage, and even more pronounced over minimum tillage. A word of caution must be given. This study was confined, due to data limitations, to expected values and does not investigate stability of income issues for the various options evaluated. If there are sizeable differences between the variability of yields under minimum and conventional tillage, preferences would go towards the more stable system.

Additional studies of an empirical nature are warranted with regard to the relative risks involved. In the first place, the empirical question about the relative variability of crop yields under alternative tillage and cropping systems needs to be answered. This answer must be obtained, at least in part, from long term field experimentation. Secondly, sound data about forecasting errors in machinery repair rates, in downtimes and in salvage values are currently not available. For this reason the present study relied on an arbitrary discount rate, rather than one incorporating a market determined risk premium, for evaluating the costs of machinery complements.

It is crucial that these empirical questions of crop yield variability under alternative tillage and cropping programs be addressed. It is equally important that research be carried on to provide a better understanding of machinery asset management.

Finally, the economic analysis was conducted in a static framework. Useful additional information, of a dynamic nature, would investigate relative cost advantages under a flexible cropping system in which the cropping program responds to economic and technical variables from year to year. Data requirements for dynamic economic analysis include inter-relationships among agronomic variables such as crop yields, soil moisture, growing season precipitation, nutrient carryover, and weed and pest problems. Further research to accumulate data in these areas should be encouraged.

Bauer, L., Novak, F., Armstrong, G., & Staples, B. (1992). An Economic Analysis of Alternative Cropping Decisions Under Uncertainty (Project Report 92- 07, Farming for the Fututre Project 55-57238). Edmonton: University of Alberta, Department of Rural Economy.

This project has examined after tax gross margin net present values accruing to Alberta wheat farmers under three fertilizer and crop rotation systems; a fixed rotation traditional fertilizer system, a static economic fertilizer decision system within

a fixed rotation, and a static economic fertilizer decision system within a dynamic flex-cropping framework. Decision rules appropriate to each system were developed for case farms in three Alberta agro-climatic regions; Medicine Hat, Lethbridge, and Olds.

Bentley, C. F., & Leskiw, L. A. (1985). Sustainability of Farmed Lands: Current Trends and Thinking. Ottawa: Canadian Enviromental Advisory Council.

"The authors of this review are of the opinion that massive, sustained, long-term soil conservation programs and policies by Canadian governments are urgently needed to ensure the sustainability of productivity of Canada's farmed lands. To achieve that, society must be convinced that the need for the advocated program exists-and that the benefits will be real!".

Binswanger, H. P. (1980). Attitudes toward Risk: Experimental Measurment in Rural India. American Journal of Agricultural Economics, 62, 395- 407.

Attitudes towards risk were measured in 240 households using two methods: an interview method eliciting certainty equivalents and an experimental gambling approach with real payoffs which, at their maximum, exceeded monthly incomes of unskilled laborers. The interview method is subject to interviewer bias and its results were totally inconsistent with the experimental measures of risk aversion. Experimental measures indicate that, at high payoff levels, virtually all individuals are moderately risk-averse with little variation according to personal characteristics. Wealth tends to reduce risk aversion slightly, but its effect is not statistically significant.

Brorsen, B. W., Chavas, J., & Grant, W. R. (1987). A Market Equilibrium Analysis of the Impact of Risk on The U.S. Rice Industry. American Journal of Agricultural Economics, 69, 733-739.

An economic model of supply/demand for U.S. rice suggests that increases in risk result in decreased acreage and marketing margins. In a market equilibrium context, the empirical results also suggest rice production and rice prices are more responsive to changes in risk faced by marketing firms than changes in risk faced by producing firms.

Boyda, A. C. (1988). Risk and Returns on Alberta Grain Farms. Edmonton: University of Alberta (MSc Thesis).

Mean-variance models following in the Markowitz tradition have seen application in business and agriculture. These models are generalizations to a world of uncertainty of the work of Irving Fisher. This thesis used the Fisher framework of the single-period investment model to examine risk- related farmer choice of multiple crop rather than single crop. The causal influence of risk reduction is analyzed. Choice is based on the present cost commitment at the time of decision and future

anticipated revenue resulting from harvest. Value conversion between present and future is accomplished by a risk-sensitive discount rate. Risk is ascribed to anticipated crop receipts. Measurement of risk is based on dispersion of actual revenue around the predicted values, a mean square error estimate. The relative measurement is the coefficient of variation.

Revenue is derived from three components; yield, price and grade factor. Actual yield estimates for wheat, barley and canola were obtained from Alberta Wheat Pool by grain elevator point for the period 1974 through 1986. Variability in yield may be attributed to agronomic relationships and statistical relationships. This thesis concentrates on statistical characteristics. Predicted yield is based on local historical experience and the province-wide deviation attributed to fertilizer use. Predicted and actual prices are based on Canadian Wheat Board payments and futures contracts for each crop. Grade factors were determined from discount associated with quality. Predicted revenue is composed of predicted yield times predicted price times mean grade factor. Differences between actual revenue and predicted revenue estimates provide the relevant variability for analysis.

In the market, there is a trade- off between risk and return. Managers select portfolios which have the least risk for a given expected revenue or maximum revenue for a given risk class. Markowitz diversification is used to reduce risk by combining less than perfectly correlated investments. Covariance and correlation matrices provide the interdependence relationships between the investments. This thesis examined the risk reduction effects of diversification on crop combinations, as well as other risk responses. The other risk responses considered were crop insurance and a hypothetical price insurance.

Tests of the hypothesis that risk reduction through crop diversification provides significant economic benefit were not rejected, however the additional risk reduction associated with diversifying from two crops to three was minor. Alternative risk responses such as the use of price and crop insurance provided more economic benefit than diversification of uninsured crops.

Bradford, G., & Reid, D. (1982). Theoretical and Empirical Problems in Modeling Optimal Replacement of Farm Machines. Southern Journal of Agricultural Economics, 14(1), 109- 116.

"Research on the optimal replacement problem has emphasized specification of the theoretically appropriate criterion. Today, the most commonly applied replacement decision theory for machinery assumes that the owner will replace each older machine, 'defender,' with an identical new machine, 'challenger,' in accordance with long- run cost minimizing or profit maximizing criteria (ie., wealth maximization). ... Recently, the net present value (PV) criterion has been more common in the replacement literature than the marginal criterion (references omitted). Other than demonstrating the PV criterion with attendant modifications for taxes and inflation, little research has been directed toward applying it to machinery replacement, two general problems are encountered. First, there is a problem of what

is the correct theoretical specification for a replacement model. Second, there are empirical problems in generating reliable estimates for parameters in the replacement model. This paper explicitly addresses these two problems. In addition, the need for more powerful analytical method- one which can handle inflation or technical change- is pointed out, along with the outline of potential solutions. Because of misconceptions (past and present) in using theoretically correct criteria, the basic identical- challenger PV criterion will first be reviewed and related to the standard investment formulation.

Brandt, S. A. (1992). Zero vs. Conventional Tillage and Their Effects on Crop Yield and Soil Moisture. Canadian Journal of Plant Science, 72, 679- 688.

A study comparing zero tillage (ZT) with conventional tillage (CT) crop production in two rotations; fallow-oilseed-wheat, and oilseed-wheat-wheat, was conducted during 1979- 1990. In 36 comparisons of ZT with CT over three rotation phases and 12 yr, ZT increased spring soil moisture in nine cases and resulted in no decreases; increased yield in nine cases while decreasing yield in three; and increased moisture use efficiency in six cases with two decreases. Increases in spring soil moisture were not related to precipitation during the non-growing season but may have been influenced by weeds. Increased spring soil moisture with ZT occurred more frequently on fallow than on stubble, presumably because precipitation was greater. Yield increases with ZT generally occurred where spring soil moisture was increased and weeds were adequately controlled. Yield decreases with ZT were normally associated with poor weed control, but in one case poor seed placement with ZT reduced yield. Throughout the study, inadequate weed control with ZT was a major factor limiting responses. Implications of these results on future research required to improve adoption of this important soil- conserving practice are discussed.

Brown, W. J. (1987). A Risk Efficient Analysis of Crop Rotations in Saskatchewan. Canadian Journal of Agricultural Economics, 35, 333- 355.

Spring wheat and fallow have dominated land use practices in Saskatchewan for the 1971- 85 period, despite the urgings of soil scientists, crop scientists and agricultural economists to reduce fallow area and to diversify into other crops. This paper demonstrates that if production and marketing risks associated with various rotations are considered, there is close correspondence between rotations that are selected via stochastic dominance and actual producer behavior with respect to fallow use in crop rotations. Gross margins for a number of hypothetical rotations are calculated for the 1971- 85 period and are analyzed using stochastic dominance and mean variance trade off criteria. Resulting risk efficient sets are found to be a reasonable explanation of actual producer behavior over the time period examined.

Brown, W. J., & Schoney, R. A. (1985). Calculating Least- Cost Machinery Size for Grain Farms Using Electronic Spreadsheets and Microcomputers. Canadian Journal of Agricultural Economics, 33, 47- 65.

Proper machinery sizing for a given farm has the potential of reducing costs and thereby increasing profits substantially. The microcomputer and the electronic spreadsheets now available are the latest tools farm business managers can use to solve this recurrent, complex and important problem. This paper finds the least- cost combination of machinery taking into account fixed, variable and timeliness costs. The model is solved using a microcomputer spreadsheet.

Burt, O. R. (1981). Farm Level Economics of Soil Conservation in the Palouse Area of the Northwest. American Journal of Agricultural Economics, 63, 83- 92.

Control theory is applied to the farm level economics of soil conservation in a model which uses depth of top soil and percentage of organic matter therein as the two state variables. An approximately optimal decision rule was tested against the optimal rule and found to be excellent; errors in the decision rule were less than one percent within the region in state space of practical consideration. Results suggest that intensive wheat production under modern farming practices and heavy fertilization is the most economic cropping system in both the short and long run in the Palouse Area except under low wheat prices.

Buschena, D. E., & Zilberman, D. (1994). What Do We Know About Decision Making Under Risk and Where do We Go from Here? Journal of Agricultural and Resource Economics, 19, pg 425- 445.

This article reviews two major approaches used in the past for risk analysis-the expected utility approach and the use of safety rules-and endeavors to reconcile their applicability and use in light of recent nonexpected utility risk literature and work using the mean-Gini coefficient for risk analysis. This leads to the identification of several "reduced form" hypotheses that hold under a variety of theoretical structures and to a discussion of some empirical evidence regarding these hypotheses. The major lesson of recent research of individual behavior under risk is that it is not always consistent with the expected utility approach; in short, there is no generic model for evaluating behavior under risk.

Collins, R. A., & Barry, P. J. (1986). Risk Analysis with Single-Index Portfolio Models: An Application to Farm Planning. American Journal of Agricultural Economics, 68, 152- 161.

Sharpe's 1963 single index portfolio model, the separation theorem, and a solution method suggested by Elton, Gruber, and Padberg are adapted in this paper to the farm diversification problem. The objectives are to develop risk measures, based on single index parameters and computationally simple methods for farm risk planning, that are suitable for microcomputers and modern hand held calculators. The intent is to produce a normative model with possible extension applications.

Crosson, P. R., & Rosenberg, N. J. (1989). Strategies for Agriculture. Scientific American, 261(3 (September)), 128- 135.

Agricultural research will probably yield many new technologies for expanding food production while preserving land, water and genetic diversity. The real trick will be getting farmers to use them.

Culver, D., & Seecharan, R. (1985). Factors That Influence the Adoption of Soil Conservation Technologies. Canadian Farm Economics, 20(2), 9- 13.

"The reduction of on-farm costs associated with soil erosion depends largely on the increased adoption of soil conservation practices. This article provides an overview of the factors that influence this adoption. The major factors and relationship between them are outlined in the model." (pg 9).

D'Itri (Editor), F. M. (1985). A Systems Approach to Conservation Tillage. Chelsa, Mich.: Lewis Publishers,Inc.

Dobbs, T. L. (1994). Organic, Conventional and Reduced Till Farming Systems: Profitability in the Great Plains. Choices, 9(2 (Second Quarter)), 31- 32.

"The analysis shows that organic farming systems were economically competitive with conventional and reduced tillage farming systems during the late 1980's and early 1990's in portions of South Dakota." (pg 32).

dos Santos, H. P., Zentner, R. P., Selles, F., & Ambrosi, I. (1993). Effects of Crop Rotation on Yeilds, Soil Chemical Characteristics, and Economic Returns of Zero-till Barley in Southern Brazil. Soil & Tillage Research, 28, 141- 158.

Driver, H. C., & Josephson, R. M. (1991). A Pilot Study Into An Economic Analysis of Zero Tillage vs. Conventional Tillage Practices. Winnipeg: Solomon Sinclair Farm Management Institute, The University of Manitoba and North American Wildlife Foundation.

This is the research pilot project report. The objectives of this project are as follows:

"a.) determining the economic cost competitiveness of the zero tillage system as compared to conventional or minimum tillage practices for selected crop enterprises over a time period which is long enough to satisfy rotational restrictions, and allow advantages or disadvantages of the two systems to be manifested in the data.

b.) identifying and evaluating factors affecting adoption of zero- till technology as well as types of incentives which might be required to provide motivation for zero-till adoption on farms."

Driver, H. C., & Josephson, R. M. (1993). Report of Economic Analysis of Zero Tillage vs. Conventional Tillage Practices Study - 1992. Winnepeg: Solomon Sinclair Farm Management Institute, The University of Manaitoba and North American Wildlife Foundation.

"1992 was the third year of this research project to provide an economic comparison of conventional and zero tillage farming. Data collected in 1990 indicated yield and economic advantages were in favor of zero tillage while the 1991 results were essentially reversed. The 1992 results showed a significant economic advantage in favor of zero till for wheat and for flax. There was very litle advantage for barley, but canola results showed a significant advantage for conventional tillage. These inconclusive overall results further sugest that additional time, observations and multidisciplinary expertise is required to fully analyse cause and effectof production factors on yields and costs and their implications for optional management of competing tillage systems.".

Driver, H. C., & Josephson, R. M. (1994). Report of Economic Analysis of Zero tillage vs. Conventional Tillage Practices Study - 1993. Winnipeg: Solomon Sinclair Farm Management Institute. The University of Manitoba and North American Wildlife Foundation.

"1993 was the fourth year of this research project to provide an economic comparison of conventional and zero tillage farming. Data collected in 1990 indicated yield and economic advantages were in favor of zero tillage while the 1992 results were essentially reversed. The 1992 results showed a significant economic advantage in favor of zero till for wheat and for flax. There was very little difference for barley, but canola results showed a significant advantage for conventional tillage. 1993 again showed economic advantage in favor of zero till for CWRS wheat and barley. CPS wheat and canola showed very little difference between systems. Flax showed an economic advantage for conventional tillage which was the reverse of previous flax observations in 1990 and 1992."

Duckworth, B. (1994, June 23). Farmers See Room For Improvement in Zero-Till Units. The Western Producer, 71(46), 53.

"The move to soil conservation is no longer a fad, but a serious commitment by many farmers who name soil erosion as public enemy number one." The article goes on to describe some field trials conducted at Strathmore, Alberta, and of new innovations in conservation tillage equipment. The article contains some insightful comments by farmers currently using this type of tillage system.

Dumanski, J., Coote, D. R., Luciuk, G., & Lok, C. (1986). Soil Conservation in Canada. Journal of Soil and Water Conservation, 41, 204- 210.

Given the nation's small reserve of cropland, Canada is beginning to take a hard look at how to protect the land and water resources that underpin its agricultural industry.

Dzikowski, P., & Heywood, R. T. (1990). Agroclimatic Atlas of Alberta (AGDEX 071-1). Edmonton, Alta.: Alberta Agriculture.

This Agroclimatic Atlas brings together a variety of climatic information that is particularly relevant to agriculture. Although climatic information is available, it is not always readily accessible in a form that is suited to the needs of agriculture. The purpose of this publication is to present climatic information of importance to agriculture and to get the information into the hands of the agricultural community.

Eleveld, B., Johnson, G. V., & Dumsday, R. G. (1983). SOILEC: Simulating the economics of soil conservation. Journal of Soil and Water Conservation, 38, 387- 389.

SOILEC is a computerized, long-run, physical and economic simulation model.

Ervin, C. A., & Ervin, D. E. (1982). Factors Affecting the Use of Soil Conservation: Hypotheses, Evidence, and Policy Implications. Land Economics, 58, 277-292.

"The major purposes of this paper are to purpose and test a conceptual model of the farmer's decision to use conservation practices. The results should prove useful in designing conservation policy and programs." (pg 278).

Farzin, Y. H. (1984). The Effects of the Discount Rate on Depletion of Exhaustible Resources. Journal of Political Economy, 92, 841- 851.

This paper argues that, despite its widespread acceptance in the literature, the basic proposition that a reduction (an increase) in the discount rate leads to greater conservation (faster depletion) of an exhaustible resource is not generally valid. It shows that the effect of the discount rate on the rate of resource depletion depends on capital requirements for production of the substitute and extraction of the resource and on the size of the resource stock. In fact, it shows that there always exists at least two ranges of the resource stock size for which the effect is opposite to that conventionally believed.

Fenster, C. R. (1977). Conservation Tillage in the Northern Plains. Journal of Soil and Water Conservation, 32, 37- 42.

Fox, G., & Dickson, E. J. (1988). What's Economic About the Economic Costs of Soil Erosion to Canadian Farmers? (Discussion Paper No. DP88/3). Guelph, On.: University of Guelph, Department of Agricultural Economics and Business.

Gibbons, B. (1984, September). Do We Treat Our Soil Like Dirt? National Geographic, 350-389.

"How readily we manipulate our soil. We rearrange and restructure it. We pump it full of chemicals, we flood it, we drain it. On its health the fate of empires has rested. Yet we avoid it. In our cities, rivers of concrete keep us from its touch. Naked, it tends to offend the eye. But a close look reveals that the soil is an essential bridge between the rock below and the life above. It is dynamic and vital, and far too easily- and frequently- abused."

Govindasamy, N. (1983). An Economic Analysis of Continuous Cropping in the Dark Brown Soil Zone of Alberta. Edmonton: University of Alberta, Department of Rural Economy (MSc Thesis).

"This study identifies the relative profitability and risk, at the farm level, of different cropping programs in the Dark Brown soil zone of Alberta. The problem was to determine whether it is technologically and economically feasible to reduce summerfallow acreages and thereby increase net farm incomes and Alberta's agricultural production. The general objectives of the study were to examine the economic consequences at the farm level of increasing or decreasing summerfallow acreages and to identify the main factors affecting the farm operator's decisions on cropping program selection.

Govindasamy, R., & Duffy, M. (1993). Alternative Methods for Soil Conservation to Comply with the Conservation Compliance Program. Journal of the American Society of Farm Managers and Rural Appraisers, 57, 122- 127.

The Conservation Compliance Provision of the 1985 Food Security Act stated that a producer who does not reduce soil erosion to T t/a/y (tons /acre/year) or less will not be eligible for any federal farm program benefits. Amendments to the Act allowed slightly more erosion in certain cases but T can still be required. Therefore, most of the producers will be forced to reduce soil erosion to T t/a/y by 1995 in spite of the high cost of soil erosion control measures. This paper analyzes alternative methods to maximize the net returns per acre given that the soil erosion is no more than 7 t/a/y (equals T in selected soils) on twelve major soils.

Haigh, R. J., & Haigh, C. (1992). The Alberta Conservation Tillage Surveys: A Comparative Analysis of Selected Issues. Edmonton: The Alberta Conservation Tillage Society and The University of Alberta, Department of Rural Economy.

Halverson, A. D., Anderson, R. L., Toman, N. E., & Welsh, J. R. (1994). Economic Comparison of Three winter Wheat- Fallow Tillage Systems. Journal of Production Agriculture, 7, 381- 385.

Economic Information is needed to evaluate the sustainability of tillage systems used for winter wheat (Triticum aestivum L.) production in the Central Great Plains. This study compared the potential economic returns of conventional stubble-mulch tillage (CT), reduced-till (RT), and no-till (NT) winter wheat production systems using estimated farmer costs or custom costs. Grain yields were not significantly different between tillage systems from 1987 through 1992 with 6-yr average grain yields of 40, 40, and 42 bu/acre for the CT, RT, and NT systems, respectively. Preharvest costs were highest for the NT while RT and CT costs were virtually the same when using farmer based costs. Using custom rates, preharvest costs were in the order CT > NT > RT. Returns above production costs were in the order RT > CT >NT when using farmer based costs and an average yield of 40.4 bu/acre for all tillage systems. Returns above production costs were in the order RT

> NT > CT when using custom rates. Using farmer estimated costs of production, estimated net returns to land, labor, capital, management, and risk were 107 and 95% of the CT system for RT and NT systems, respectively. When labor costs were included, net returns to land, capital, management, and risk were 111 and 100% of CT for RT and NT systems, respectively. When custom rates were used for the tillage practices, net returns to land, labor, and capital were 123 and 110% of CT for the RT and NT systems, respectively. If costs or application rates for herbicides could be reduced, the NT system would become even more economically competitive with other tillage systems. Because the cost variations between tillage systems are minimal, the added benefits of increased precipitation storage efficiency and decreased soil erosion potential with RT and NT must be considered when selecting a tillage system.

Hart, L. (1994, April). Direct- Seeding Opens new farm Business Options. Country Guide, 113(4), 29- 30.

This is a case study presentation illustrating how one family in central Alberta has used conservation tillage to diversify their operation.

Hedlin, R. A. (1985). An Additional Perspective. Canadian Journal of Agricultural Economics, 33(Proceedings Issue), 30-40.

In recent years it has become popular to make pessimistic statements regarding the future of agriculture in Canada. These appear to me to have been arrived at by emphasizing (or perhaps overemphasizing) aspects which are cause for concern and ignoring developments of a positive nature. Certainly we are faced with proper concerns with respect to soil deterioration. At the same time we have steadily increased production and there is every reason to expect this to continue. Four points made in the paper: Realistic assessment of the soil degradation problems with a view towards solutions; Why have crop yields changed over time?; Impact upon the economic viability of farm operations; Suggestions for a realistic approach to reducing land degradation.

Helms, G. L., Bailey, D., & Glover, T. F. (1987). Government Programs and Adoption of Conservation Tillage Practices on Nonirrigated Wheat Farms. American Journal of Agricultural Economics, 69, 786- 795.

A whole farm simulation analysis is used to investigate producer preferences for adoption of separate tillage practices (minimum-till, combination till, or no-till) under provisions of both the 1981 and 1985 farm bills. An analysis of preferences for participation or nonparticipation in government programs under both farm bills is also considered. For risk averse producers, a combination-tillage practice with program participation is found to dominate (as measured by stochastic dominance) the other strategies considered under both the 1981 and 1985 provisions.

Heywood, R. T. (1987). Soil Moisture Management (AGDEX 510-1). Edmonton: Alberta Agriculture, Conservation and Development Branch.

Hildebrand, P. E., Singh, B. K., Bellows, B. C., Campbell, E. P., & Jamma, B. A. (1993). Farming Systems Research for Agroforestry Extension. Agroforestry Systems, 23(pg 219- 237),

Farming systems research and extension (FSRE), as used by the global Association for Farming Systems and Research, applies to a family of methodologies used to generate, evaluate and disseminate agricultural technologies in association with farmer participation. FSRE shares many attributes with Diagnosis and Design as practiced in agroforestry. The history of FSRE is traced from 1965 to the present, showing the formalization of the methodology and its critical use in sustainable agricultural technology development. In on-farm research, a primary basis for FSRE, research and extension merge in practice. The definition of recommendation domains (a fundamental concept of FSRE) is based on analysis and interpretation of multi-environmental research as evaluated by varied criteria.

In this paper, we present the results of three research projects to demonstrate the nature of farmer criteria for evaluation. Modified Stability Analysis (MSA) is used to demonstrate the relationship of on-farm research to specific extension massages. Design of on-farm research to make it amenable to analysis by MSA is discussed.

Hildebrand, P. E. (1984). Modified Stability Analysis of Farmer Managed, On-Farm Trials. Agronomy Journal, 76(March-April), pg 271- 274.

The Farming Systems Research and Extension (FSR\E) approach to technology generation and promotion is creating interest in on-farm research. Described is a form of research design and analysis that explicitly incorporates variation in farmer management as well as in soils and climate, to help agronomists evaluate responses to treatments and partition farmers into recommendation domains. Mean treatment yields at each location are used as an "environmental index." Individual treatment results are regressed on environmental index. A graphic distribution of confidence intervals within partitioned groups helps in selecting superior treatments. Data from unreplicated trials on 14 farms in two villages in Malawi were analyzed. The design was a 2X2 factorial with two maize (Zea mays L.) cultivars and two fertilizer treatments (0 and 30 kg N/ha). Results show that in poorer maize environments, local flint cultivars were superior to an improved semi-flint composite, with or without fertilizer. The composite yielded more than local material with or without fertilizer in better environments. In all cases there was a marked and significant response to fertilizer.

Innes, R., & Ardila, S. (1994). Agricultural Insurance and Soil Depletion in a simple Dynamic Model. American Journal of Agricultural Economics, 76, 371- 384.

We study the effects of agricultural insurance on farm production choices, soil depletion and enviroment when there are two related risks, one in short- to- medium run production revenues and the other in land value. The analysis considers "pure" and "truncating" insurance programs that stabilize linear combinations of short- run revenue risk and land price risk. Production- revenue- stabilizing insurance is often found to elicit increased farmer output, thus exacerbating enviromental externalities and causing further soil depletion. Land- value- stabilizing insurance typically elicits lower output thus mitigating enviromental externalities and pushing farmers closer to their complete- insurance output levels.

Jensen, T. (Editor). (1993). Conservation Tillage (Soil and Water Conservation Manual Series). Edmonton: Alberta Agriculture, Food and Rural Development, Conservation and Development Branch.

This manual provides an overview of tillage systems which conserve soil and water, called conservation tillage systems. It discusses the effects of these systems, outlines current practices and provides ways of evaluating the costs and benefits of conservation tillage.

Jensen, T., & Timmermans, J. (1991). Conservation Tillage (AGDEX 516-3). Edmonton: Alberta Agriculture, Conservation and Development Branch.

Johnson, J. B., Baquet, A., Clarke, A., Miller, C., & Watts, M. (1986). The Economics of Alternative Tillage Methods and Cropping Systems: Major Land Resource Area 53A, Northeast Montana. Bozeman: Montana State University, Cooperative Extension Service.

This study was conducted to develop estimates of net returns to land, overhead, risk and management through the use of illustrative enterprise budgets for spring wheat, barley and fallow under conventional, minimum and no- till tillage methods and crop fallow, flexible and continuous cropping systems. Enterprise budgets provide the basis for comparisons of net returns of illustrative whole farm situations employing alternative tillage method- cropping system combinations.

Jolly, R. W. (1983). Risk Management in Agricultural Production. American Journal of Agricultural Economics, 1107- 1113.

"Agriculture will continue to be a high risk industry. Its efficiency, structure, and performance will be influenced by agricultural decision makers' response to risk. Risk management, in its most unadorned sense, involves increasing the information base upon which decisions are made. Economists can play an important role in developing managerial and analytical techniques as well as teaching the decision makers. We have made important advances in risk theory and extremely modest advances in application. In my judgement, the most important challenge in risk management today involves assisting farmers and farm advisors to understand and measure the impact of their decisions in a probabalistic sense. Ultimately, this is a problem in estimation rather than choice; however the most elegant choice process cannot be effective if it is based on incomplete or unreliable estimates of the underlying problem."

Ker, A. (1991). An Analysis of Yield and Net Return Distributions for Conventional and Conservation Tillage Practices in Southwestern Ontario (Working Paper WP/05). Guelph, On: University of Guelph, Department of Agricultural Economics and Business.

The effects of three alternative tillage systems on yields and net returns in southwestern Ontario are compared for corn, soybeans, spring grains, and wheat production. The contribution this paper offers is two fold. First, it estimates the differences in magnitude of the two moments between alternative distributions. Although normality in variables is often assumed in this type of analysis, it is generally considered that yields and net returns in agriculture are not distributed normally. Therefore, the analysis undertaken must be, and is, robust to nonnormality. Second, it provides a simple ranking procedure that incorporates sample errors. That is, rankings are not plagued, as they tend to be in empirical applications of stochastic dominance techniques, by the assumption that the sample set is the population.

Kiker, C., & Lynne, G. (1986). An Economic Model of Soil Conservation: Comment. American Journal of Agricultural Economics, 68, 739-742.

Kramer, R. A., McSweeney, W. T., & Stavros, R. W. (1983). Soil Conservation with Uncertain Revenues and Input supplies. American Journal of Agricultural Economics, 65, 694-702.

The influence of risk on farm level soil conservation decisions is examined. A symmetric quadratic risk- programming model is used which allows simultaneous consideration of uncertainty in revenues and input supplies. It demonstrates that risk aversion can influence the selection of soil- conserving activities.

Lafond, G. P., Zentner, R. P., Geremia, R., & Derksen, D. A. (1993). The Effects of Tillage Systems on the Economic Performance of Spring Wheat, Flax and Field Pea Production in East-central Saskatchewan. Canadian Journal of Plant Science, 73, 47-54.

The long term viability of Canadian prairie agriculture depends on the ability to arrest soil degradation caused by wind and water erosion and excessive tillage. The challenge is to develop crop- production systems that are economically viable and environmentally sustainable. The objective of this study was to quantify the short-term economic performance of field pea (Pisum sativium L.), flax (Linum usitatissimum L.) and spring and winter wheat (Triticum aestivum L.) grown under three tillage-management systems. The economic analysis was based on a tillage X crop rotation experiment started in 1986 and involving zero tillage (ZT), minimum tillage (MT) and conventional tillage (CT) and three 4-yr crop rotations. The economic analysis considered only costs associated with purchased inputs and machinery. The effects of method of tillage management on herbicide and fuel use were also determined for each crop. Costs of production were similar for all tillage systems and crop types. Net returns were higher for field peas, flax and spring wheat grown on stubble using ZT and MT than when CT was used, because of higher grain yields. Net returns were similar for winter wheat grown on stubble and for spring wheat grown on fallow for all tillage- management systems. Fuel consumption was highest for CT, intermediate for MT and lowest for ZT for all crops except winter wheat. In contrast, herbicide use was greater for ZT and MT than for CT for all crops except winter wheat; no differences were observed among tillage systems for this crop because it was always seeded directly into standing stubble. The shift from CT to ZT or MT systems did not increase costs of production or reduce short- term economic returns. ZT and MT had higher production potential than CT because increased soil- moisture conservation generally provided higher net returns. ZT used less fuel but more herbicides than MT and CT.

Lee, J., Brown, D. J., & Lovejoy, S. (1985). Stochastic Efficiency versus Mean-Variance Criteria of Adoption of Reduced Tillage. American Journal of Agricultural Economics, 67, 839- 845.

Costs and benefits of conservation programs depend on the fraction of participants adopting the practice. Under risk, it is not clear whether predictions of adoption should be based on adoption's effect on the farmer's entire income distribution or only on its mean and variance. It is also unclear whether one must elicit the farmer's subjective beliefs about the effect on his income distribution or whether some "objective" distribution can be used. This paper describes how well mean- variance and stochastic efficiency criteria predict adoption of a reduced tillage practice in a watershed in central Indiana when applied to "objective" and "subjective" income distributions.

Lerohl, M. L., Anderson, M. S., & Robertson, J. A. (1990). Soil Erosion Implications of Selected Agricultural Programs (Project Report No. 90-09). Edmonton: University of Alberta, Department of Rural Economy.

The general objective of this study is to assess producer attitudes and provide a quantitative assessment of the extent to which selected policies and programs influence the adoption of soil conservation practices in Alberta.

Malhi, S. S., Mumey, G., O'Sullivan, P. A., & Harker, K. N. (1988). An Economic Comparison of Barley Production Under Zero and Conventional Tillage. Soil & Tillage Research, 11, 159- 166.

Zero tillage consistently resulted in reduced costs associated with equipment operations, in reduced barley yields, and in higher herbicide costs at all 4 locations. Summation of these major effects indicate that zero tillage on the average was $48.77/ha (range $18.43- 68.79) less economical than conventional tillage. Long-term effects, such as erosion control, changes in soil structure and nutrients, or the indirect consequences of increased herbicide use were not considered in the economic analysis.

Mannering, J. V., & Fenster, C. R. (1983). What is Conservation Tillage? Journal of Soil and Water Conservation, 38, 141-143.

Marothia, D. K. (1981). An Economic and Institutional Analysis of Soil Erosion on Agricultural Land. Unpublished Doctoral Dissertation, University of Alberta, Department of Rural Economy, Edmonton.

This study is concerned with the socioeconomic consequences and policy implications of the soil erosion problem within several categories of interdependencies and human interactions with respect to soil resource use. The development and selection of potential alternative farm level soil erosion control, with special reference to the Peace River region of Alberta, is emphasized.

Marra, M. C., & Carlson, G. A. (1987). The Role of Farm Size and Resource Constraints in the Choice Between Risky Technologies. Western Journal of Agricultural Economics, 12, 109- 118.

This paper investigates the relationship between farm size and technology adoption by applying a model recently developed by Just and Zilberman to the choices of a sample of southeastern soybean farmers. The adoption of double cropping soybeans with wheat is evaluated with an expanded model which includes availability of specialized equipment and human capital. It has found that the empirical farm size-technology adoption relationship is consistent with risk aversion and a high covariance of returns between old and new technologies. Accounting for human and physical capital differences across farms improves the power of the hypothesis tests.

Marv Anderson & Associates Limited (1981). Factors Affecting Summerfallow Acreage In Alberta. Edmonton: Environment Council Of Alberta.

This report presents information about one activity that influences the effectiveness and efficiency of agricultural activities. The report is intended to identify and quantitatively determine to what extent various factors affect the summerfallow acreage in Alberta.

McCartney, L. (1984). Prairie Summerfallow Intensity: An Analysis of 1981 Census Data (Working Paper No. 8, Reference Number 21-X-506 E)). Ottawa: Statistics Canada, Agricultural Statistics Division, Crops Section.

This descriptive study provides background information for the current debate on the benefits and costs of the summerfallow practice in the prairies. The study focuses mainly on dryland grain farms with some land in fallow. The relation between the ratio of summerfallow to cultivated area (called summerfallow intensity) and the following nine variables is examined: farm cultivated area, farm organization, land tenure, age of operator, days of off-farm work, fertilizer and agricultural chemical expenses, machinery value and gross farm sales. Data are analyzed by soil zone, a proxy for soil moisture. Cross tabulation and correlation are statistical tools used.

The findings document that summerfallow practice varies by soil zone and province. Saskatchewan farms are significantly more oriented toward the practice and have the least reduction in area fallowed. Cross tabulations show that, in the Brown and Dark Brown zones, intensity is unrelated to changes in most of the nine variables. In the Black an Gray zones, general tendencies are detected which are frequently small in magnitude. Summerfallow intensity trends upward with increasing usage, and consistently trends downward with increasing farm cultivated area, ag chemical expenses per acre, machinery value per acre and gross sales. For fertilizer expense per acre in the Black zone, the intensity trend is not only consistent but significant in magnitude.

McConnell, K. E. (1986). An Economic Model of Soil Conservation: Reply. American Journal of Agricultural Economics, 68, 743- 744.

See McConnell (1983)

McConnell, K. E. (1983). An Economic Model of Soil Erosion. American Journal of Agricultural Economics, 65, 83- 89.

By introducing soil depth and soil loss into a simple model of agricultural production, this paper seeks to determine when the private path of erosion differs from the socially optimal path. Considering the depletion of soil only and abstracting from the environmental disruption caused by erosion, the paper argues that under most institutional arrangements the social and private rates of erosion are the same. The paper concludes that public policy should be directed toward reducing erosion only when it leads to significant pollution externalities. (see also: Kiker and Lynne, "An Economic Model of Soil Erosion: Comment", AJAE 65: 739- 742, and McConnell, "An Economic Model of Soil Erosion: Reply", AJAE 65: 743- 744.)

Miller, M. H. (1985). Soil Degradation in Eastern Canada: Its Extent and Impact. Canadian Journal of Agricultural Economics, 33 (Proceedings Issue), 7.

Molberg, E. S., McCurdy, E. V., Wenhardt, A., Dew, D. A., & Dryden, R. D. (1967). Minimum Tillage Requirements for Summerfallow in Western Canada. Canadian Journal of Soil Science, 47, 211-216.

Experiments at seven locations in Western Canada between 1956 and 1961 indicate that three or four tillage operations were usually enough for satisfactory weed control on summerfallow, and generally provide highest yields of grain. Two tillage operations were not sufficient. The herbicides that were available did not control all of the weeds that were present. Nitrate nitrogen accumulation at the end of the summerfallow period was greater when weeds were adequately controlled by tillage than with incomplete control. Different amounts of tillage had little effect on soil moisture conservation. The use of herbicides without tillage resulted in inadequate weed control in most years and slightly less moisture was stored.

Mumey, G. A., Bauer, L., & Boyda, A. (1988). An Estimate of Risk and Returns From Cropping Alternatives (Project Report No. 88-01, Farming for the Future Report 87-0139). Edmonton: University of Alberta, Department of Rural Economy.

"The purpose of this study is to increase understanding of risk in crop production on the individual farm. Variation in farm income from expectation is studied throughout the Province of Alberta for 1 years, using local production data from the Alberta Wheat Pool. From this information, estimates of farm risk (with confidence levels) are formed for each of 13 census districts in the Province that have major crop production." (pg 1)

Narayanan, A. V. S. (1985). Long-term On-farm Economic Effects of Cropland Erosion in the Black Soil Zone of Alberta. Canadian Farm Economics, 20(2), 27- 37.

"Over the long- term, the conservation management system, by virtue of its lower topsoil erosion rates and productivity mitigating impacts, narrows its gap in annualized net returns and land values with the conventional system. This effect is better pronounced when the differences in erosion rates are higher. The magnitude of this effect is basically dependent on the depth of topsoil and the yield response (decrease) to topsoil depletion through erosion. In the black soil zone, the reasonably good depth and fertility of topsoil considerably slow down the transition of erosion phases and its impact on productivity levels over time, as reflected by only a small change in annualized net returns over the 50- year planning horizon." (pg 36)

Nash, J. M. (1990, May 21). It's Ugly, But It Works. Time, 139,

"Fears about the environment fuel a revolution on the farm."

Nielsen, E. G., Miranowski, J. A., & Morehart, M. J. (1989). Investment in Soil Conservation and Land Improvements, Factors Explaining Farmer's Decisions (Agricultural Economic Report Number 601). Washington, D.C.: United States Department of Agriculture, Economic Research Service.

Expected income and real interest rates are among economic factors that influence farmer's decisions to invest in land improvements, including soil conservation, drainage, and land clearing. Programs that remove land from production, higher land prices relative to land improvement costs, Government cost-sharing of conservation expenditures, and specific land characteristics (such as slope) also encourage investments in conservation and other improvements. This study is the first to use national data to examine the role of economic and related factors in explaining farmer's investments in conservation and other improvement projects.

Novak, F. S., Armstrong, G. W., Taylor, C. R., & Bauer, L. (1994). An Analysis of Alternative Cropping Decision Rules. Agricultural Systems, 46, 19- 31.

The research reported here measures the effect on the probability distribution of the present value of after- tax income of several different cropping decision systems in Alberta. Dynamic flex-cropping decision rules generate higher levels of return and less downside risk than all other alternatives considered here. Dynamic decision models which ignore taxes and the stochastic dynamic nature of prices produce suboptimal results relative to models which consider these factors and relative to a fixed rotation decision rule. This suggests that careful attention must be paid to the factors included in these models if they are to generate rules which will improve the risk return trade off for farm managers.

Oberg, N. B. (1991). Farm Machinery Depreciation: Empirical Estimates of Mean and Variance. Edmonton: University of Alberta, Department of Rural Economy (MAg Thesis).

This study outlines methodology for estimating real economic depreciation for farm equipment at any point throughout its useful lifetime. Methodology involves identifying the mean of real depreciation rates reflected in historical data; and then measuring dispersion around this mean with an adjusted standard deviation.
The mean depreciation rate for equipment can be regarded as an estimate of future real value loss for specific models studied, and for similar machines of different manufacture. The adjusted standard deviation can be interpreted as a measure of risk associated with holding an investment in farm equipment.

The methodology is termed "diagonal depreciation". Its format permits examination of two forces affecting depreciation - the process of aging; and the passage of time. Experiments conducted indicate that aging is the major cause of value loss; and changing conditions through time cause most of the dispersion around mean rates, and is the major source of investment risk.

Orlick, Charles C. (1995). Risk and Return Comparisons of Crop Rotations and Tillage Systems for Selected Areas in Alberta. Edmonton: University of Alberta, Department of Rural Economy (MSc Thesis).

The focus of this study is to examine the risk and return trade-offs for various crop rotations and tillage systems. The geographic area represented in this study is contained within four soil, and five climatic zones within the province of Alberta. The predominant crops grown in these areas (i.e. spring wheat, barley, and canola) were used to derive cost estimates that reflect agronomic processes.

The results obtained from each of the areas indicate that several generalizations can be made about the interaction of crop rotations, tillage systems, and farm size. Firstly, the size of predicted net revenue increases and the probability of generating a negative net revenue decreases as one moves north from the Brown soil zone into the Dark Brown and Black soils. Secondly, as one moves from the Brown soil zone through to the Black soil zone, less significance can be placed on fallow crop rotations. Lastly, at the current price of fallow herbicides, conventional tillage systems have a cost advantage over the alternatives tested here.

Pagoulatos, A., Debertin, D. L., & Sjarkowski, F. (1989). Soil Erosion, Intertemporal Profit, and the Soil Conservation Decision. Southern Journal of Agricultural Economics, 21, 55- 62.

This study developed an intertemporal profit function to determine optimal conservation strategies under alternative scenarios with respect to crop prices, relative yields, and other assumptions. Special emphasis was placed on determining from the analysis when the switch over from conventional to soil- conserving practices should take place. Technological change was incorporated by allowing crop yields to vary over time. Our analysis thus provides a new, more precise measurement of the cumulative net benefit differential. The optimal period for switch over from conventional to soil- conserving practices was found to vary depending on the assumptions made about corn prices and discount rates. Empirical results were based on an erosion damage function (EDF) for Western Kentucky corn production.

Phillips, R. E., Blevins, R. L., Thomas, G. W., Frye, W. W., & Phillips, S. H. (1980). No-Tillage Agriculture. Science, 208, 1108- 1113.

The no-tillage cropping system, a combination of ancient and modern agricultural practices, has been rapidly increasing in use. By the year 2000, as much as 65 percent of the acreage of crops grown in the United States may be grown by the no-tillage practice. Soil erosion, the major source of pollutants in rural streams, is virtually eliminated when no-tillage agriculture is practiced. The no-tillage system reduces energy input into corn and soybean production 7 to 18 percent, respectively, when compared to the conventional tillage system of moldboard plowing followed by discing. In addition, crop yields are as high as or higher than those obtained with traditional tillage practices on large areas of agricultural land.

Pope, R. D., & Just, R. E. (1991). On Testing the Structure of Risk Preferences in Agricultural Supply Analysis. American Journal of Agricultural Economics, 73,

Risk preferences broadly affect many economic decisions when markets are incomplete. Common representations of risk preferences are constant absolute, relative, and partial relative risk aversion. Each of these preference classes has distinct impacts on choice. An economic test for distinguishing the class of preferences is proposed and implemented for potato supply response in Idaho. The data reject constant absolute and partial relative risk aversion and are congruent with constant relative risk aversion.

Prairie Farm Rehabilitation Administration (1982). Land Degradation and Soil Conservation on the Canadian Prairies. : Government of Canada, Regional Economic Expansion, PFRA, Soil and Water Conservation Branch.

"This report highlights the extent and nature of these soil degradation issues which threaten the future productivity of the prairie agricultural land base. It also outlines the implications of soil degradation for the national economy."(pg 2).

Prato, T. (1990). Economic Feasibility of Conservation Tillage with Stochastic Yields and Erosion Rates. North Central Journal of Agricultural Economics, 12, 333- 344.

This paper examines the extent to which stochastic variation in crop yields and erosion rates affect the economic feasibility of, and farmer's willingness to adopt, minimum and no tillage in a northern Idaho watershed. Stochastic variation in yield is evaluated by sampling an empirical frequency distribution of the rate of yields between conservation and conventional tillage. Variability in yield due to tillage system and weather are separated from variability caused by soil type and management. Stochastic variation in erosion rates is determined by sampling the distribution of erosion prediction errors for the Universal Soil Loss Equation. Expected utility maximization is used to identify the optimal choice of tillage systems for different risk preferences. Stochastic variation in yield due to tillage practice and rainfall was found to have a proportionately greater effect on yield than errors in predicting erosion rates. For the soils, crops and land treatment practices evaluated, risk averse farmers would prefer conventional tillage to minimum and no tillage.

Rahm, M. R., & Huffman, W. E. (1984). The Adoption of Reduced Tillage: The Role of Human Capital and Other Variables. American Journal of Agricultural Economics, 66, 405- 413.

This paper presents a model of adoption behavior and explains differences econometrically in farmers' decisions to adopt reduced- tillage practices and in the efficiency of farmers' adoption decisions. The empirical results, obtained from microdata, show that the probability of adopting reduced tillage in corn enterprises differs widely across farms and depends on soil characteristics, cropping systems, and size of farming operation. The results also show that the farmers' schooling enhances the efficiency of the adoption decision.

Rennie, D. A. (1985). Soil Degradation, A Western Perspective. Canadian Journal of Agricultural Economics, 33(Proceedings Issue), 19-29.

Soil degradation in western Canada Has been documented with varying degrees of reliability. For the first time, a detailed estimate of the costs of degradation have been arrived at, and these total on an annual basis somewhat in excess of $1 billion. Farming methods incompatible with the soils and environment, are the major reason for the critical decline in soil quality. Of significance also, is the unacceptably low allocation of research resources, not only to soil degradation, but to soil research in general.

Rutledge, P. L., & Russell, D. G. (1971). Work Day Probabilities for Tillage Operations in Alberta (Research Bulletin 71-1). Edmonton: University of Alberta, Department of Agricultural Engineering.

Weather parameters such as rain fall, temperature, and wind affect the moisture content of the soil, which in turn influences the operation of tillage and seeding machinery. A high soil moisture content may reduce field tractability and increase the risk of soil structure damage, thereby preventing tillage and seeding operations. The number of days in a particular calendar period available for tillage and seeding is therefore dependant upon the weather.

Since the size of machinery system required to complete a given task is inversely proportional to the amount of time available, it is necessary to have an estimate of available time before the least cost machinery system can be determined. This bulletin provides work day probabilities for a number of areas in the Province of Alberta based on research by the authors, part of which has been published (See references 36 and 38). These probabilities may be used to estimate available field time.

Seitz, W. D., & Swanson, E. R. (1980). Economics of Soil Conservation from the Farmers Perspective. American Journal of Agricultural Economics, 62, 1084- 1088.

"Examination of the private economics of soil conservation is particularly germane at this time of policy reassessment under the provisions of the Soil and Water Resources Conservation Act of 1977. An understanding of farmers' perceptions of their economic interests is essential in the development of policy instruments that will achieve social objectives." (Pg 1084)

Setia, P. (1987). Consideration of Risk in Soil Conservation Analysis. Journal of Soil and Water Conservation, 42, 435- 437.

Farm-level soil conservation decisions with uncertain income are examined. Results from a stochastic economics model show that the variability in farm income due to crop prices, crop yield, weather and farmers' risk attitudes influence the selection of a soil conservation management system. Public conservation programs can be more effective if they are based on analyses considering uncertainty. Two decision criteria, expected utility maximization and safety first, were selected to compare the ranking of certain management systems under each criteria.

Setia, P. P., & Johnson, G. V. (1988). Soil Conservation Management Systems Under Uncertainty. North Central Journal of Agricultural Economics, 10, 111- 124.

Success of a soil conservation program depends on the number of acres on which recommended practices are implemented. If risk considerations are introduced in formulating plans to control soil loss, whether individuals will implement the desired management system(s) to achieve conservation objectives established for the region is an unclear factor. This paper illustrates how expected utility maximization and safety- first decision criteria influence the selection of a soil conservation management system under uncertainty.

Sidey, H. (1992, June 29). Revolution on The Farm. Time, 141, 54- 57.

"The plow is being displaced by new techniques that protect the land and promise even more abundant crops."

Siemens, J. C., Hoeft, R. G., & Pauli, A. (1993). Soil Management. Moline, IL: Deere & Company Service Publications.

Singh, B. (1991). The Long- Term Effects of Tillage and Residue Management on the Soil Physical Environment and on Barley Growth. Unpublished Doctoral Dissertation, University of Alberta, Department of Soil Science, Edmonton.

"Conservation tillage systems, including no- tillage, have a great potential on the Canadian prairies where problems generally associated with conventional tillage systems (wind and water erosion, compaction, organic matter decline, soil water deficiency, reduced crop yields, etc.) are becoming common. Scientific research into the long-term effects of tillage-residue systems on soil physical environments and barley (Hordeum vulgare L.) growth under the agroclimatic and soil conditions of Central Alberta (cool temperature, Cryoboreal subhumid environment, inherently well-aggregated soil with high organic matter content) is scant. However, such information is vital for understanding system behavior as well as in assessing suitability of different management systems in this region, especially considering the site-specificity associated with such systems. Such information is also essential in developing and validating process-oriented crop growth models with a view to understand and predict the soil and crop responses to tillage and residue management in an agroecological perspective. The information will also be useful in understanding the response of other components of the soil environment (soil fertility, soil biological, etc.) to these tillage-residue systems." (pg 5).

Smith, E. G., Peters, T. L., Zentner, R. P., Larney, F. J., Lindwall, C. W., Moulin, A. P., & Bowren, K. E. (1994). Economics of Conservation Tillage Systems in Dry and Humid Regions of the Canadian Prairies (CAESA Project No. RES-004-93). : Canada-Alberta Environmentally Sustainable Agriculture Agreement.

This report examined the economic performance of tillage management systems for summerfallow - spring wheat rotations at two sites. The first was the Dark Brown soil zone, using 16 years of summerfallow - wheat and summerfallow - barley data from a site near Lethbridge, Alberta. The second was the Black soil zone, using 25 years of summerfallow - wheat data from a highly fertile silty clay soil near Melfort, Saskatchewan.

The Lethbridge site had eight tillage systems, including conventional, minimum and zero tillage. Conventional systems include one-way disc, Heavy duty cultivator and wide blade during the fallow phase. Minimum till systems had one tillage pass and the remainder of the weed control was by herbicide. The zero tillage systems used herbicides only to control weeds. The tillage plots were split into two during the crop phase with half seeded to wheat and half seeded to barley. On average, production was highest on the minimum till and lowest on the zero till treatments, but generally not significantly different. The economic results showed that the returns were highest for the conventional till systems and lowest for the zero till, but over 16 years the difference between the conventional and reduced tillage systems declined as more cost effective herbicide control was used. The substitution of herbicides for mechanical tillage provided some resource savings for the reduced tillage systems, but these were more than off-set by higher herbicide costs. The minimum and zero tillage systems had returns that were $20 to $40/ha lower than the conventional till systems. Changes in the prices of wheat and barley had little impact on the relative profitability because of the small yield differences that existed among treatments. Herbicide expenditures were the primary factor limiting the profitability of minimum and zero tillage. If the herbicide costs of controlling weeds during the summerfallow phase were kept low, the economic returns from minimum tillage was comparable to conventional tillage.

The Melfort site had seven tillage management systems for summerfallow - spring wheat. During 1969-76, areas planted to wheat had the seedbed prepared with a cultivator and harrow. After 1977 one-half of each plot received conventional seedbed preparation and the other half was sprayed with herbicide and zero till seeded. Overall, wheat yields averaged 2916 kg/ha for tillage-only, 2957 kg/ha for reduced tillage (combinations of tillage and herbicides), and 3016 kg/ha for herbicide only treatments. During 1977-73, preparation of a tilled seedbed significantly increased yields (compared to zero till seeding) in 8 of 17 years, but it resulted in significantly lower yields in 5 other years. Results of the economic analysis showed that average variable and total costs for the complete rotation systems were lowest for the tillage only treatment ($138/ha), intermediate for reduced tillage ($147 to $159 /ha), and highest for herbicides only ($163 to $175 /ha). Although the substitution of herbicides for mechanical tillage provided resource savings of up to $7 /ha because of fewer field operations, this was more than offset by increased expenditures for herbicides. Net returns (at a wheat price of $147 /t) were generally highest for tillage only (avg. $76 /ha) and lowest for the herbicide-only treatments in which paraquat or glyphosate was used in combination with bromoxynil plus MCPA ester (avg. $47 /ha) or with dicamba plus 2,4d ester (avg. $51 /ha) for summerfallow weed control. The reduced tillage systems generally produced net returns that averaged $1 to $12 /ha lower than the traditional tillage system. Changes in wheat price had little impact on the relative profitability of the tillage management systems because of the small yield differentials that existed. The maximum expenditure that could be made to break even with the tillage-only treatment ranged from $25 to $35 /ha for the reduced tillage systems, and from $36 to $42 /ha for the herbicide-only systems.

It was concluded from the study that although the substitution of herbicides for some or all of the mechanical tillage of summerfallow is attractive to producers from an agronomic and soil conservation perspective, the absence of significant and consistent yield advantages, and the high expenditures for herbicides remain as major deterrents to widespread adoption of conservation tillage management for fallow-type cropping systems in this region. Producers will continue to have an economic incentive to use conventional tillage on summerfallow-cropping systems until herbicide costs in the summerfallow phase can be reduced.

Smith, E. G., & Shaykewich, C. F. (1990). The Economics of Soil Erosion and Conservation on Six Soil Groupings in Manitoba. Canadian Journal of Agricultural Economics, 38, 215- 231.

The effect of soil erosion on optimal cropping and tillage practices are determined using a dynamic linear programming model. The analysis recognizes the effect that current soil erosion has on future production. The productivity declines in the model from soil erosion are estimated from a study that artificially eroded soil at six sites. The optimal cropping practices indicates that minimum tillage is the best way to reduce soil erosion. Nonerrosive crops such as hay or zero tillage practices are not as profitable as minimum tillage with cereal grain oil- seed crop rotations. The value of soil conserved by the least erosive practices (zero tillage and/or hay production) is less than the additional costs or lower returns of the practice. The marginal user cost of soil ranges from $0.00 per tonne to $0.99 per tonne and the total user cost from $0.00 to $2.55 per hectare per year, depending on the soil grouping. The marginal user cost of soil is affected by the productivity impact of erosion, prices of commodities, fertilizer prices, technology and the discount rate. The $0.00 values are from a soil grouping that had limited data from two contrasting years.

Sparrow (Chairman), H. O. (1984). Soil at Risk: Canada's Eroding Future. Ottawa: The Senate of Canada, Standing Senate Committee on Agriculture, Fisheries and Forestry.

"The Committee's major purpose in this report is to take the reader on the equivalent of an airplane ride over Canada to make clear what soil degradation is and how serious it is in all regions of the country. By increasing the awareness of this situation the Committee hopes to help make soil conservation a national issue. Our soils are at risk. Our future is eroding. It is time for action." (pg vii)

Statistics Canada (1994). Consumer Prices and Price Indexes (Catalogue 62-010 Quarterly). Ottawa, On.: Government of Canada.

Statistics Canada (1991). Farm Input Price Index (Catalogue 62-004 Quarterly). Ottawa: Government of Canada.

Statistics Canada, (1992). Agricultural Profile of Alberta, Part 1 and Part 2 (catalogue No. 95-382 and 95-383). Ottawa, On.: Government of Canada.

Statistics Canada, (1994). Agriculture Economic Statistics (Catalogue No. 21-603E). Ottawa, On.: Government of Canada.

Statistics Canada, (1992). Trends and Highlights of Canadian Agriculture and its People (Catalogue 96-303E. Ottawa, On.: Government of Canada.

Stonehouse, D. P. (1991). The Economics of Tillage for Large-scale Mechanized Farms. Soil & Tillage Research, 20, 333- 351.

Economically rational farmers base tillage choice decisions on comparisons of resource requirements, production costs, crop yields and short term net returns across alternative systems. Also deserving consideration are the adverse effects of tillage on soil erosion and longer term productivity, which in turn affect longer term net returns, and the comparative riskiness of tillage alternatives, as measured by variability of net returns. Most empirical evidence indicates the superiority of conservation tillage systems for both row crops and small grains, especially where produced in warm climates, on shallow soils, and on sloping terrain. The same conservation tillage systems tend to carry a higher risk loading, so that risk- averse farmers may prefer more erosive conventional tillage systems, despite the lower profitability.

Toman, M. A. (1994). Economics and "Sustainability": Balancing Trade-offs and Imperatives. Land Economics, 70, pg 399- 413.

The concept of "sustainabiliy" has been increasingly invoke in scholarly and public policy debates. Discussion has been hampered, however, by uncertainty and lack of uniformity in the meaning of sustainability. This paper seeks to identify some common ground among economists, ecologists, and environmental ethicists. Two issues seem salient: requirements for intergenerational equity and the definition of "social capital" to be provided to future generations. A concept of "safe minimum standard," which has received at least some recognition in the ecology, philosophy, and economics literatures, may provide the beginnings of a common ground for debate about sustainability. (JEL Q2)

Toogood, J. A. (1989). The Story of Soil and Water Conservation in Alberta (AGDEX 570-2). Edmonton: Alberta Agriculture and Canada-Alberta Soil Conservation Initiative.

Ulrich, A. J. (1986). Minimizing Tillage in Saskatchewan: Some Economic Considerations. Saskatoon: University of Saskatchewan, Department of Agricultural Economics.

This is a Canadian computer simulation model, similar to SOILEC.

Vaillancourt, G. (1994). Farm Machinery Costs as a Guide to Custom Rates. Edmonton: Alberta Agriculture, Food and Rural Development.

"This publication provides technical information on current machinery price, repair rates, performance, capacity fuel consumption and fuel price. The information is organized into fixed and variable costs to provide a basis for budgeting machinery costs. The cost calculations are intended to be used as approximate cost figures.... In addition, The 1993 custom rates have been included for comparison." (pg v)

Van Kooten, G. C. (1990). Soil Conservation and Sustainable Agriculture on the Canadian Great Plains: An Alternative View (FMSA Discussion Paper No. 1). Vancouver, B.C.: University of British Columbia, Department of Agricultural Economics.

The focus of this paper is on soil erosion in the Great Plains region of Canada, particularly in Saskatchewan. I show that, while farmers recognize that their agronomic practices result in soil erosion, the problem is not as severe in terms of their financial losses (out- of- pocket expenses) as has been suggested by a number of Canadian studies. This is the main reason why soil erosive practices continue. Further, I argue that chemicals are a poor substitute for more intensive farm management that can be used to control soil degradation without the on- farm and external (off- site) costs associated with increased chemical use.

I begin by reviewing recent evidence on soil erosion in Saskatchewan, its costs and the influence of government programs. Then, the economics of recommended soil conservation strategies for the region are examined. Flex-cropping based on a dynamic optimizing model is suggested as an inexpensive and viable alternative to both the current, soil erosive crop rotation and the proposed conservation alternatives. Finally, I make some recommendations for research that will prove helpful in moving toward sustainable agriculture in the dryland cropping region of western Canada.

Van Vurren, W. (1985). Soil Erosion: The Case for Market Intervention. Canadian Journal of Agricultural Economics, 33(Proceedings Issue), 41- 62.

This paper investigates the consequences of soil erosion in the dominant corn producing region of Southern Ontario. The paper examines especially, how corn yield and unit production cost of corn have been affected in the presence of soil erosion. The paper mentions several reasons why it is unlikely that the market will exert the necessary inducements for making needful adjustments in soil and crop management decisions.

Walker, D. J., & Young, D. L. (1986). The Effect of Technical Progress on Erosion Damage and Economic Incentives for Soil Conservation. Land Economics, 62, 83-93.

"The role of technology in the conservation adoption decision is explored to see if policy implications for the control of erosion in the region can be drawn from the analysis." (pg 83).

Weersink, A., Walker, M., Swanton, C., & Shaw, J. (1992). Economic Comparison of Alternative Tillage Systems under Risk. Canadian Journal of Agricultural Economics, 40, 199- 217.

Stochastic dominance efficiency criteria are used to rank the net farm return distribution for four different tillage systems under six different farm scenarios. Pairwise comparisons of tillage systems are carried over incremental upper and lower risk- aversion coefficient (RAC) bounds identified for each farm scenario, based on size and spread of the outcome distributions to identify regions where dominance may switch between tillage systems. Ridge- till systems are generally the dominant tillage system for all farm scenarios considered. No- till systems on clay loam soils are more dominant in the risk- preferring range and less dominant in the risk- averse range, which relates to the relatively larger range of net return values and smaller mean net return values generated by this tillage system. Conversely, the moldboard plow and chisel plow systems are more dominant in risk- aversion intervals and less dominant in the risk- preferring intervals for clay loam soils. In sandy soil scenarios, the ridge-till and no- till systems are dominant over the two fall tillage systems for all farm sizes, indicating that these tillage systems are more competitive with conventional tillage systems in lighter soil type situations. A sensitivity analysis between moldboard plow and no- till systems indicates that no-till would dominate in risk- preferring intervals, and an increase in no-till net farm returns of $16 per acre would change dominance in favor of no- till in risk- averse interval space.

Weisensel, W. P., & Van Kooten, G. C. (1990). Estimation of Soil Erosion Time Paths: The Value of Soil Moisture and Topsoil Depth Information. Western Journal of Agricultural Economics, 15, 63- 72.

Rates of soil erosion in the dryland cropping region of Saskatchewan are investigated under alternative cropping strategies. Chemical fallow is examined as an alternative to tillage fallow for moisture and soil conservation. Conclusions include: (a) flexible cropping increases net discounted returns and substantially reduces soil erosion compared to the predominant crop rotation; (b) chemical fallow is a viable alternative to tillage fallow but only when topsoil already has been eroded substantially; and (c) an increase in the discount rate is soil conserving, since it causes producers to plant more often rather than fallow.

Williams, J. R. (1988). A Stochastic Dominance Analysis of Tillage and Crop Insurance Practices in a Semiarid Region. American Journal of Agricultural Economics, 70, 112-120.

Stochastic dominance analysis for tillage in the semiarid conditions of the central Great Plains indicates that risk- averse managers would prefer conservation tillage for wheat and grain sorghum with and without the use of crop insurance instead of the traditional conventional dryland wheat- fallow cropping system. Higher yields in conjunction with reduced fuel, labor, and repair costs more than offset increased chemical costs of the conservation systems. Increased yields generally are attributed to the soil moisture conservation characteristic of the conservation tillage systems.

Williams, J. R., Llewellyn, R. V., & Mikesell, C. L. (1989). An Economic Risk Analysis of Conservation Tillage for Wheat, Grain Sorghum, and Soybeans in the Great Plains. Journal of Soil and Water Conservation, 44, 234- 239.

Conservation tillage systems are compared with conventional tillage systems for northeastern and west central Kansas. Slightly higher net returns were found for no- till soybeans and grain sorghum systems in northeastern Kansas as well as higher levels of risk relative to conventional systems, making conventionally tilled continuous grain sorghum the preferred system among risk averse managers. In west central Kansas, wheat- grain sorghum- fallow rotations showed highest returns. When risk is considered, the conventional tillage system is preferred for this crop rotation. For both locations studied, the difference in tillage systems when risk is considered is small due to the fact that small changes in costs or yields could change the preference for one tillage system versus another.

Woloshyn, P. A. (1990). Fixed Cost Compensation in Farmland Expropriation. Edmonton: University of Alberta, Department of Rural Economy (MSc Thesis).

The acquisition of farmland by Alberta Transportation is necessary for highway, overpass, and other related construction projects throughout the province of Alberta. In 1979 the Land Compensation Board ruled that "fixed costs" should be compensated in addition to fair market value for the land. There were no set guidelines for such compensation and ad hoc measures were subsequently used for determining the money value of fixed costs to be paid. This analysis is based upon the theory of production and welfare economics. The study is designed to determine the appropriate compensation for landowners/ farmers who have had a portion of their land taken by expropriation and have endured a loss in addition to the market value of land. Non land fixed costs constitute these additional costs to the landowner. Capital investment analysis is used in this study to derive the net present value of the change in fixed costs and machinery repair cost as a result of a partial taking. It is this change in the cost structure which determines the appropriate level of compensation (in addition to market value of land) to the landowner. Compensation levels varied as a result of the size of the taking, the size of the farm, the geographical location of the farm, and the cultural practices common to the area. Under scenarios where farm machinery could be re- sized after the partial taking compensation would be lower. However, with takings between 1 and 20 acres (the most common) very few re- sizing options were available due to the "lumpiness" of farm equipment. Fixed cost compensation amounts ranged from $190 per acre in the light soil regions of southeastern Alberta to over $400 per acre in the heavy soils in the Peace River region.

Young, D. L. (1979). Risk Preferences of Agricultural Producers: Their Use in Extension and Research. American Journal of Agricultural Economics, 61, 1063- 1070.

"The specific objectives of this paper re: (a) to review and evaluate critically the current state of knowledge on risk preference measurement methods and empirical results for individual producers, and (b) to suggest directions for future research and extension applications requiring information on risk preferences of individual producers. The implications of aggregate (industry) risk preferences as in risk supply response studies will not be included in this review."

Young, D. L., Kwon, T., & Young, F. L. (1994). Profit and Risk for Integrated Conservation Farming Systems in the Palouse. Journal of Soil and Water Conservation, 49, pg 601- 606.

This paper evaluates the economic performance of 12 farming systems field tested from 1986 to 1991 in the Palouse region of southeastern Washington. These systems comprised two rotations (monoculture wheat (Triticum aestivum) and wheat-barley (Hordeum vulgare)- peas (Pisum sativum)). The systems also included two tillage intensities (conservation and conventional) and three management levels. Based upon prices and program provisions projected for 1991- 95, the conservation tillage/ winter wheat-spring barley-spring pea system at maximum weed management dominated all others in high profitability and had low economic risk. Furthermore, this system satisfied soil conservation compliance. It also reduced nitrogen use compared to monoculture wheat. There are at least three potential explanations of the income-stabilizing advantage of the optimal conservation cropping system. The conservation systems yielded relatively better in dry years and withstood cold damage to winter wheat better, especially in the severe 1990-91 winter. The three-crop rotation also fostered disease resistance under the moist, high- residue seedbed of conservation tillage.

Zentner, R. P., Bowren, K. E., Stephenson, J. E., Campbell, C. A., Moulin, A., & Townley-Smith, L. (1990). Effects of Rotation and Fertilization on Economics of Crop Production in the Black Soil Zone of North-Central Saskatchewan. <u>Canadian Journal of Plant Science</u>, <u>70</u>, 837- 851.

Zentner, R. P., Brandt, S. A., Kirkland, K. J., Campbell, C. A., & Sonntag, G. J. (1992). Economics of Rotation and Tillage Systems for the Dark Brown Soil Zone of the Canadian Prairies. <u>Soil & Tillage Research</u>, <u>24</u>, 271- 284.

The influence of tillage on the economic performance of two rotation systems, fallow- oilseed- wheat (Triticum aestium L.) (F-O-W) and oilseed- wheat- wheat (O-W-W), was assessed in a 12 year study carried out on a medium textured, Orthic Dark Brown soil at Scott, Saskatchewan. Oilseeds were flax (Linum usitatissimum L.) and canola (Brassica campestris L.), alternated in the oilseed year to minimize potential problems with disease and weeds. Economic calculations (expressed in Canadian dollars) were based on 1990- 1991 input costs and product prices. Gross returns averaged 46% higher for O-W-W than for F-O-W systems (average $310/ha versus $213/ha), and were significantly higher for O-W-W in 8 out of 12 years. Tillage management did not influence gross returns from F-O-W; for O-W-W, zero tillage resulted in higher gross returns than conventional tillage in 3 out of 12 years. Nonetheless, in both rotations gross returns tended to be higher with zero tillage, reflecting higher grain yields owing to improved soil moisture conditions. Annual production costs were higher for O-W-W than for F-O-W rotations (average $217/ha versus $166/ha) because of greater requirements for machine operations and other purchased inputs. Production costs were also higher for zero- compared with conventional- tillage management (average $183/ha versus $149/ha in F-O-W, and $225/ha versus $209/ha in O-W-W, respectively). Compared with conventional tillage, zero tillage provided savings in labor, machine operation, and machine overheads (average $7- $10/ha) but these were more than offset by higher herbicide

costs. Net returns were generally highest for O-W-W systems. In the O-W-W rotation zero tillage was more profitable than conventional tillage if herbicide costs were reduced by 15% or more from their 1990- 1991 cost levels; at higher herbicide costs, conventional tillage as superior. The results also showed that producers who are risk averse are not likely to use zero- tillage management with F-O-W rotation owing to the higher costs for weed control on summer fallow. Such producers would more likely choose a F-O-W rotation with conventional- tillage management if expected product prices were low: as price increases, they would probably consider using the O-W-W rotation with either type of tillage management. We conclude that, in contrast to the past, there is some economic incentive for producers in this region to adopt cropping systems with improved soil conserving features.

Zentner, R. P., Dyck, F. B., Hanford, K. R., Campbell, C. A., & Selles, F. (1993). Economics of Flex-cropping in Southwestern Saskatchewan. Canadian Journal of Plant Science, 73, 749- 767.

The economic returns and riskiness of spring wheat (Triticum aestivum L.) production using fixed sequence rotations were compared to flexible cropping systems wherein the annual crop/fallow decisions are based on the level of available water at or near the time of planting. The study used 25 yr of data from a long-term crop rotation experiment on a medium textured, Orthic Brown Chernozemic soil at Swift Current, Saskatchewan. Fixed cropping systems included fallow- wheat (F-W), fallow- wheat- wheat (F-W-W) and continuous wheat (CW), while flex- cropping systems included 2YR-IF, 3YR-IF, and CW-IF. The 2YR-IF system permitted the entire farm to be cropped when available spring water in stubble was favorable, but if water was unfavorable, 50% of the area was fallowed. The 3YR-IF system permitted two-thirds of the land area to be cropped whenever spring water was favorable, but only one- third of the area was cropped if water was unfavorable. Under CW-IF, the entire farm was cropped in years when spring water was favorable; it was fallowed in years when water was not favorable. Each flex- cropping system was constructed using two decision criteria: (I) available soil water (0- 120 cm depth) in stubble measured about 1 May (SSW), and (ii) SSW plus precipitation received from date of spring soil sampling up to 31 May (TSW). Five threshold levels of available water were defined for each decision criteria, with SSW ranging between 35 and 95 mm and TSW ranging between 65 and 125 mm. The systems were evaluated at wheat prices of $110, $147, and $184/t, calculated with and without all- risk crop insurance. Expected net return were generally higher for the flexible systems at all wheat prices. Income variability for flex- cropping systems was usually much lower than for CW, and it was often as low as that of the traditional F-W system which is known for its low income variability. This was particularly true when flex- cropping was combined with all- risk crop insurance. The TSW decision criterion was usually superior to SSW, because it was more highly correlated with final grain yields than was SSW. Higher wheat prices would encourage profit maximizing producers to select the more intensive cropping systems (CW-IF) and to use lower threshold water

levels on which to base their decisions. Producers with low to moderate aversion to taking risk would favor selection of cropping systems that maintained some land in fallow each year (eg. 3YR-IF). Such producers would also choose higher threshold water levels on which to base their decisions to crop stubble areas and include all- risk crop insurance in their production plan. Only producers who are moderate to highly risk averse would choose F-W and, to a lesser extent, F-W-W. In all cases the optimum flex- cropping systems used fallow less frequently than is the tradition in the region. The study concluded that widespread use of flex- cropping practices by producers in southwestern Saskatchewan could increase farm- level net returns and reduce risks of financial loss, while potentially reducing soil degradation.

Zentner, R. P., & Forsberg, B. (1988). Economics of Reduced Tillage Systems in Saskatchewan (Saskatchewan Agricultural Research Fund Technical/ Final Report Number S-86-04-0017). Saskatoon: University of Saskatchewan, Department of Agricultural Economics.

This report is a brief summary of the initial findings for a long- term study (1956 to 1988) of soil erosion. This study deals with the economics aspects of varied top soil depth and its influences upon the financial well being of prairie farmers in the dark brown soil zone.

Zentner, R. P., & Lindwall, C. W. (1978). An Economic assessment of Zero Tillage in Wheat- Fallow Rotations in Southern Alberta. Canadian Farm Economics, 13(6), 1-6.

The economic feasibility of using herbicides to replace mechanical tillage operations was assessed for two- and three-year spring wheat rotations at Lethbridge, Alberta. The results indicate that moisture conservation, grain yields, and erosion resistance can be improved with zero tillage. In addition, substantial savings in labor, fuel and oil, machine repairs, and overhead costs can be achieved. Widespread adoption of zero tillage will, however, depend on individual farm characteristics and whether producers can purchase effective herbicides for less cost than the savings in labor and machinery services coupled with the increased returns from higher yields.

Zentner, R. P., Selles, F., Campbell, C. A., Hanford, K., & McConkey, B. G. (1992). Economics of Fertilizer- N Management for Zero-Tillage Continuous Spring Wheat in the Brown Soil Zone. Canadian Journal of Soil Science, 72, 981- 995.

Optimum use of fertilizer inputs requires consideration of factors that influence plant response and those that govern the decisions of producers. The response of spring wheat (Triticum Aestivium L.) to soil water and fertilizer N (FN) was assessed in a 9- yr zero- tillage study conducted on a medium- texture, Orthic-Brown Chernozem at Swift Current, Saskatchewan. These data were used to assess he economic merit and risk considerations of alternative fertilizer- N management systems when combined with snow- trapping to enhance soil- water reserves. The fertilizer- N systems included rates from 100 kg/ha; spring versus fall applications, and deep banding versus surface broadcasting. Tall strips of cereal stubble (40- 60 cm tall by 90- 120 cm wide, spaced every 6 m and running perpendicularly to prevailing winds) were used for snow trapping and compared with stubble cut at a uniform standard height of 15- 20 cm. The results showed that optimum fertilizer- N rates (FN) varied directly with soil water (SW) reserves (available water in 0- 120 cm depth measured in spring) and the probability distribution for 1 May to 31 July precipitation, and inversely with soil N (SN) NO_3N in 0- 6- cm depth measured in the previous fall), ratio of fertilizer- N cost to wheat price, and the level of risk aversion held by producers. The optimum FNs were highest for spring and fall banding; they were 3- 14 kg/ha lower for spring broadcasting and 7- 22 kg/ha lower with fall broadcasting. The optimum rates increased 3.7- 5.7 kg N/ha for each 10- mm increase in SW, with the higher rates associated with high SN. The FNs declined 5 kg/ha for each additional year that the land was cropped continuously. For producers seeking to maximize expected profit or those with low risk aversion, the optimum FNs were considerably higher than those recommended by the Saskatchewan Soil Testing Laboratory (SSTL). In contrast, the FNs for producers with high risk aversion were generally lower than those of SSTL. The SSTL recommended rates were most appropriate for producers with medium risk aversion. The study found no single combination of timing and method of fertilizer- N placement to be superior in all cases. Spring and fall banding generally provided higher net margins than broadcasting fertilizer N when SW and wheat prices were high, whereas spring broadcasting was best when SW and wheat rices were lower. The economic benefit from snow trapping averaged \$9- \$32/ha depending on FN and wheat price; however, there was little benefit or a small loss in some years when infiltration of meltwater was low or winter snowfall was minimal.

Zentner, R. P., Sonntag, B. H., Bole, J. B., & Pittman, U. J. (1979). An Economic Assessment of Dryland Cropping Programs in the Prairie Provinces: Expected Net Incomes and Resource Requirements. <u>Canadian Farm Economics</u>, <u>14</u>(4), 8- 19.

The principal factors influencing the selection of cropping programs in the different soil- climatic areas of the Prairie Provinces are expected net income, seasonality of resource requirements, and income variability or risk. This article is focused on expected net incomes and resource requirements for case farms in three case farms in three soil zones. A subsequent article will examine income variability on these farms.

Zentner, R. P., Sonntag, B. H., Bole, J. B., & Pittman, U. J. (1979). An Economic Assessment Of Dryland Cropping Programs in the Prairie Provinces: Income Variability. <u>Canadian Farm Economics</u>, <u>14</u>(6), 9- 19.

Substantial differences exist among rotations, crop combinations, and soil zones in expected net incomes, seasonal resource use, and income variability. Hence a variety of cropping programs can be expected on farms in the Prairie Provinces.

Zentner, R. P., Sonntag, B. H., & Lee, G. E. (1978). Simulation Model For Dryland Crop Production in the Canadian Prairies. Agricultural Systems, 3, 241- 251.

Modern agriculture is characterized by rapid technological change. These new technologies complicate decision- making for farm managers. Effective decision-making in this environment requires a systematic means of evaluation- one that attempts to evaluate the consequences of various management and production choices before resources are committed. The systems model described in this paper is considered to be an important step in this direction. The model provides a means for testing new production alternatives for cereal and oilseed crops in western Canada with out actual farm application and thus eliminating some of the trial and error associated with conventional decision- making methods. It does not replace the farm manager as the decision maker but it does provide information to facilitate his management function.

Zentner, R. P., Spratt, E. D., Reisdorf, H., & Campbell, C. A. (1987). Effect of Crop Rotation and N and P Fertilizer on Yields of Spring Wheat Grown on a Black Chernozemic Clay. Canadian Journal of Plant Science, 67, 965- 982.

Abridged Abstract: The effects of crop sequence, rotation length, and fertilizer on yields of spring wheat were examined for 14 crop rotations over a 25- yr period on a Black Chernozemic heavy clay soil at Indian Head, Saskatchewan. ... Yields of fallow- and stubble-wheat were generally maintained over time with application of recommended rates of N and P fertilizers, or by inclusion of legume-forage crops in the rotation, but yields of unfertilized stubble-wheat declined with time possibly reflecting declining soil fertility.

Zentner, R. P., Stephenson, J. E., Johnson, P. J., Campbell, C. A., & Lafond, G. P. (1988). The Economics of Wheat Rotations on a Heavy Clay Chernozemic Soil in the Black Soil Zone of East-Central Saskatchewan. Canadian Journal of Plant Science, 68, 389-404.

The effects of changes in product prices and input costs on the economic performance of 14 spring wheat (Triticum Avesitum L.) rotations on a calcareous Black chernozemic heavy clay soil at Indian Head, Saskatchewan were examined over 25 yr. The rotations comprised fertilized and unfertilized treatments and several mixed cereal- oilseed and cereal- legume systems. In 1960- 1977 the fertilized rotations received N and P according to the generally recommended rates for the region, but during 1978- 1984 fertilizer was applied based on soil tests which resulted in substantially higher rates of N for stubble crops. For of the rotations showed good economic performance under most reasonable economic situations. These included fertilized fallow- wheat- wheat (F-W-W), fertilized continuous wheat, unfertilized sweet clover [melelotus officinalis (L.) Lam.] green manure- wheat- wheat (Gm-W-W), and unfertilized fallow- wheat-wheat- legume hay- hay- hay (F-W-W-H-H-H). During the first 18 yr, Gm-W-W provided the highest net income for wheat prices ranging from 73 to 221 $/t; F-W-W-H-H-H generally ranked second highest. During the last 7 yr, fertilized continuous wheat was most profitable for wheat prices greater than $180/t. Continuous wheat, F-W-W, and F-W-W-H-H-H were about equal and provided the highest net income for wheat prices between 145 and 180 $/t, while at wheat prices below 145 $/t net income was highest for the legume- containing rotations. Except for the fallow- wheat rotation, higher economic benefits were obtained when fertilizer was applied based on soil tests than when based on the general recommendations for the region. Further, the application of fertilizer reduced the cash cost per unit of wheat produced for the intensive crop rotations. Rotations containing high proportions of fallow or legume crops generally had the lowest frequency and risk of financial loss.

Zentner, R. P., Tessier, S., Peru, M., Dyck, F. B., & Campbell, C. A. (1991). Economics of Tillage Systems for Spring Wheat Production in Southwestern Saskatchewan (Canada). Soil & Tillage Research, 21, 225- 242.

The economic performance of continuous wheat (Triticum aestivum L.) and fallow- wheat rotations grown under conventional, minimum- and zero- tillage management practices on silt loam, sandy loam and heavy clay in southwestern-Saskatchewan was determined during the relatively dry period of 1982- 1988. The costs and returns for each rotation- tillage system were evaluated annually based on 1989- 90 prices and cost conditions, and for various other plausible scenarios. Gross returns on silt loam were higher for continuous wheat (average $228/ha) than for fallow- wheat systems (average $155/ha). On sandy loam, gross returns were similar for all cropping systems (average $112/ha); on the heavy clay, they were higher for fallow- wheat than for continuous wheat ($139 versus$119/ha). Conservation tillage management increased gross returns over that obtained with conventional tillage only in years when the growing season temperatures were high and precipitation was poorly distributed, or when the 21- month summerfallow period was droughty. On silt loam, gross returns were significantly lower with conservation tillage in as many as 3 of 7 years. On silt loam, net returns were highest for conventional tilled continuous wheat when wheat prices were > $175/ha; at lower wheat prices, conventionally tilled fallow- wheat was the most profitable. On the other soils, minimum- and zero- tillage fallow- wheat provided the highest net returns at all wheat prices tested, with minimum tillage being slightly better at low wheat prices, but at these sites conventionally tilled fallow- wheat was not studied. The cost of production was highest for continuous wheat and for zero- tillage management. For fallow- wheat systems, conservation tillage required lower expenditures than conventional tillage for fuel, labor, machine repair and machine overheads; costs for minimum tillage averaged $9/ha and for zero tillage $15/ha lower on silt loam. These savings were more than offset by increased herbicide costs which averaged $26 and $64/a higher for minimum- tillage and zero- tillage systems, respectively. We conclude that producers in southwestern Saskatchewan who are motivated primarily by short- term profit will find little incentive to adopt conservation tillage systems for spring wheat production, unless they are situated on soils that have already incurred severe soil loss or the soils are highly prone to further erosion losses.