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Agricultural Policies and Soil Degradation in Western Canada: An Agro-Ecological Economic Assessment (Report 4: Modifications to CRAM and Policy Evaluation Results)

(Technical Report 1/95)

Project Team:
Aziz Bouzaher, Jason F. Shogren, Derald Holtkamp, Philip Gassman,
David Archer, P. Lakshminarayan, Alicia Carriquiry, Randall Reese, Dharmaraju Kakani
Resource and Environmental Policy Division, Center for Agricultural and Rural Development
Iowa State University, Ames, IA 50011

William H. Furtan
Department of Economics, University of Saskatchewan, Saskatoon, Saskatchewan

R. Cèsar Izaurralde
Department of Soil Science, University of Alberta, Edmonton, Alberta

Jim Kiniry
USDA-ARS, Grassland Research Laboratory, Temple, Texas

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FOREWORD

The Policy Branch of Agriculture and Agri-Food Canada has a mandate to provide the Government of Canada with timely information on the impacts that proposed new policies could have on the agricultural sector, or what the possible outcome would be if existing policies and programmes are altered. Increasing emphasis is being placed on the interrelationships between environmental stability and the farm management practices promoted by agricultural policies. However, to date there has been a lack of quantitative tools which could be used to address this issue.

This is a one of a series of five Technical Reports which document an integrated agro-ecological economic modelling system based on the Canadian Regional Agricultural Model (CRAM) and the Erosion Productivity Impact Calculator (EPIC). The system incorporates a multidisciplinary approach that can be used to simultaneously assess the economic and the soil erosion impacts of agricultural policies on the Prairies. It provides a link between the scientific investigation of the erosion process on a micro-scale or field level, and the higher level of aggregation such as the regional, provincial and national levels of interest to policy makers. The model provides a quantitative tool which can contribute additional information to the analysis of the economic and the environmental impacts of agricultural policy decisions.

The initial development of the modelling system was contracted to the Center for Agricultural and Rural Development at Iowa State University, with collaboration from the Policy and Research Branches of Agriculture and Agri-Food Canada. This system represents the first step in the development of quantitative tools needed for the environmental assessment of agricultural policies. The Department is committed to expanding this capability to provide scientifically based information for assessing the sustainability of the sector.

Brian Paddock
Director
Economic Policy Analysis and Innovation Division
Policy Branch

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I. Introduction

Increasing pressure is being placed on policymakers to develop agricultural policies that are economically efficient and environmentally sustainable. This trend is a result of growing public concern over soil degradation processes such as wind and water erosion and nonpoint source pollution originating from agricultural chemical use and their potential impacts on human health and ecological integrity. To address these concerns, improved analytical tools are needed that can provide reliable estimates of economic and environmental impacts of proposed agricultural policies.

This report describes the application of an integrated agro-ecological modelling system that has been constructed around Agriculture Canada's Canadian Regional Agriculture Model (CRAM) (Webber et al. 1986 and Horner et al. 1992) to analyze the economic and environmental impacts of proposed agricultural policies for the prairie provinces of Alberta, Saskatchewan, and Manitoba. A schematic of the conceptual framework is shown in Figure 1, which was discussed in detail in Agriculture Canada (1993a). The integrated modelling system consists of an agricultural decision component and an environmental component as depicted in Figure 1. The agricultural decision component is a modified version of CRAM called Resource Sensitive CRAM (RS-CRAM), that enhances the model's input substitution capacity and introduces a calculation of producer risk into agricultural decisions. The environmental component consists of wind and water erosion metamodels (summary response functions) developed on the basis of an experimentally designed set of simulations performed with the Erosion Productivity Impact Calculator (EPIC). The EPIC model has been described by Williams et al. (1984), Williams (1990), and Agriculture Canada (1993b). An in-depth description of the development and structure of the environmental metamodels is provided in Agriculture Canada (1994).

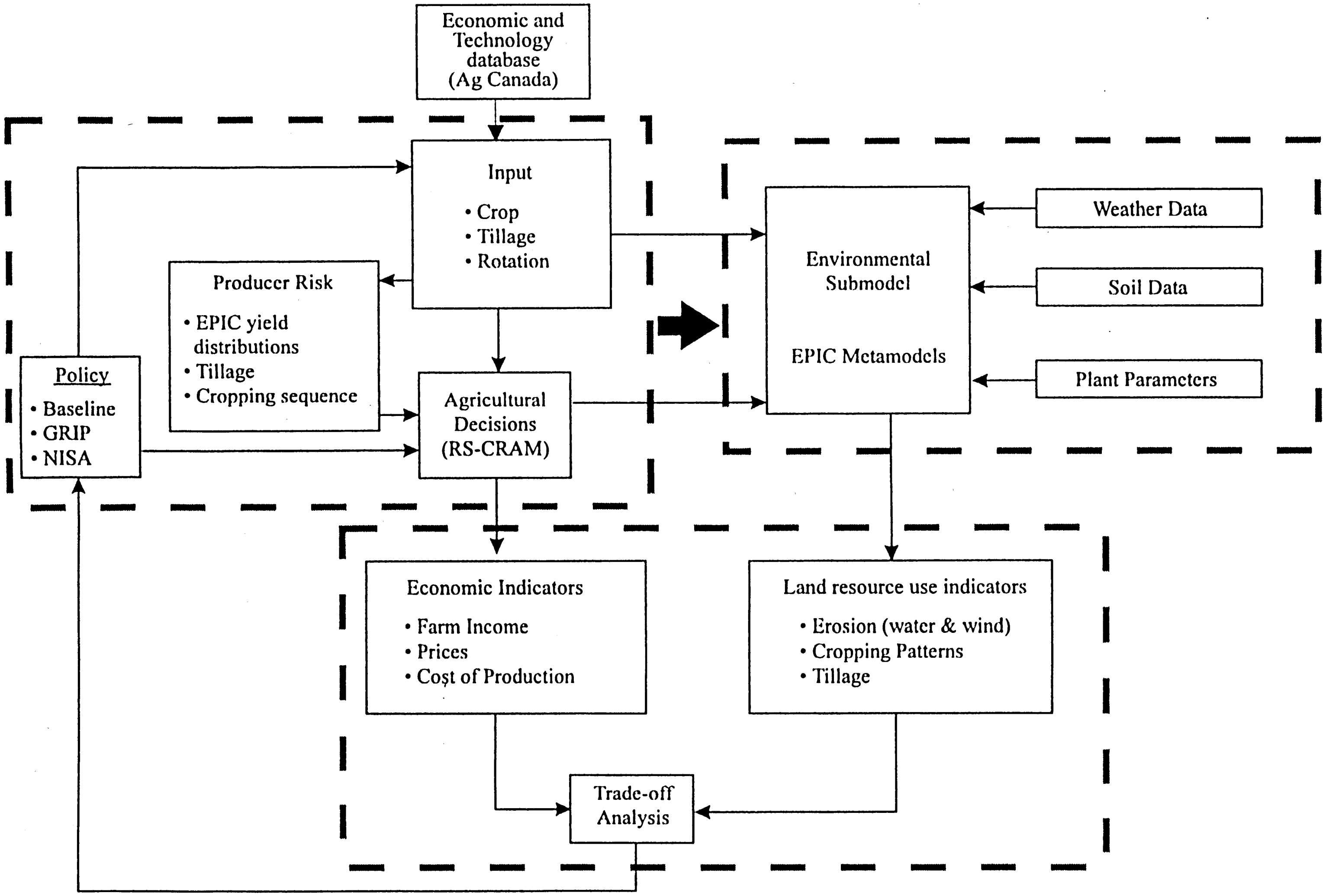

Figure 1. General conceptual framework

The enhancement of input substitution in RS-CRAM allows for the simulation of alternative tillage systems, which have a direct impact upon the levels of crop residue left on the soil surface and subsequently the amount of wind and water erosion that occurs. Costs for three representative tillage systems (conventional, reduced, and no-till) are incorporated into the model, and the tillage systems are simulated in the environmental component.

The producer risk component is built into RS-CRAM by modifying the CRAM objective function to account for expected -- rather than deterministic -- yields and returns, and by adding a risk premium term to the objective function. Based on the assumption that producers are risk averse, this module allows for an explicit method of predicting producer responses to the introduction of different policies that affect the variability of producers' net returns. Two such policies are modelled in the RS-CRAM framework: crop insurance, which reduces the revenue risk that producers face from yield variability; and the Gross Revenue Insurance Program (GRIP), which reduces producers' exposure to both yield and price variability. Time series of estimated commodity prices and EPIC generated yields are important inputs to the insurance and risk calculations in RS-CRAM.

Finally, the environmental metamodels are linked into RS-CRAM to provide estimates of wind and water erosion impacts based on changes in production decisions predicted by the economic decision component in response to policy shocks. The basic procedure is outlined in Figure 2, which shows how information flows from the economic component to the environmental component after a policy scenario has been simulated in RS-CRAM. The environmental component consists of environmental metamodels that are constructed on the basis of a set of statistically designed simulations performed with EPIC, a model previously developed

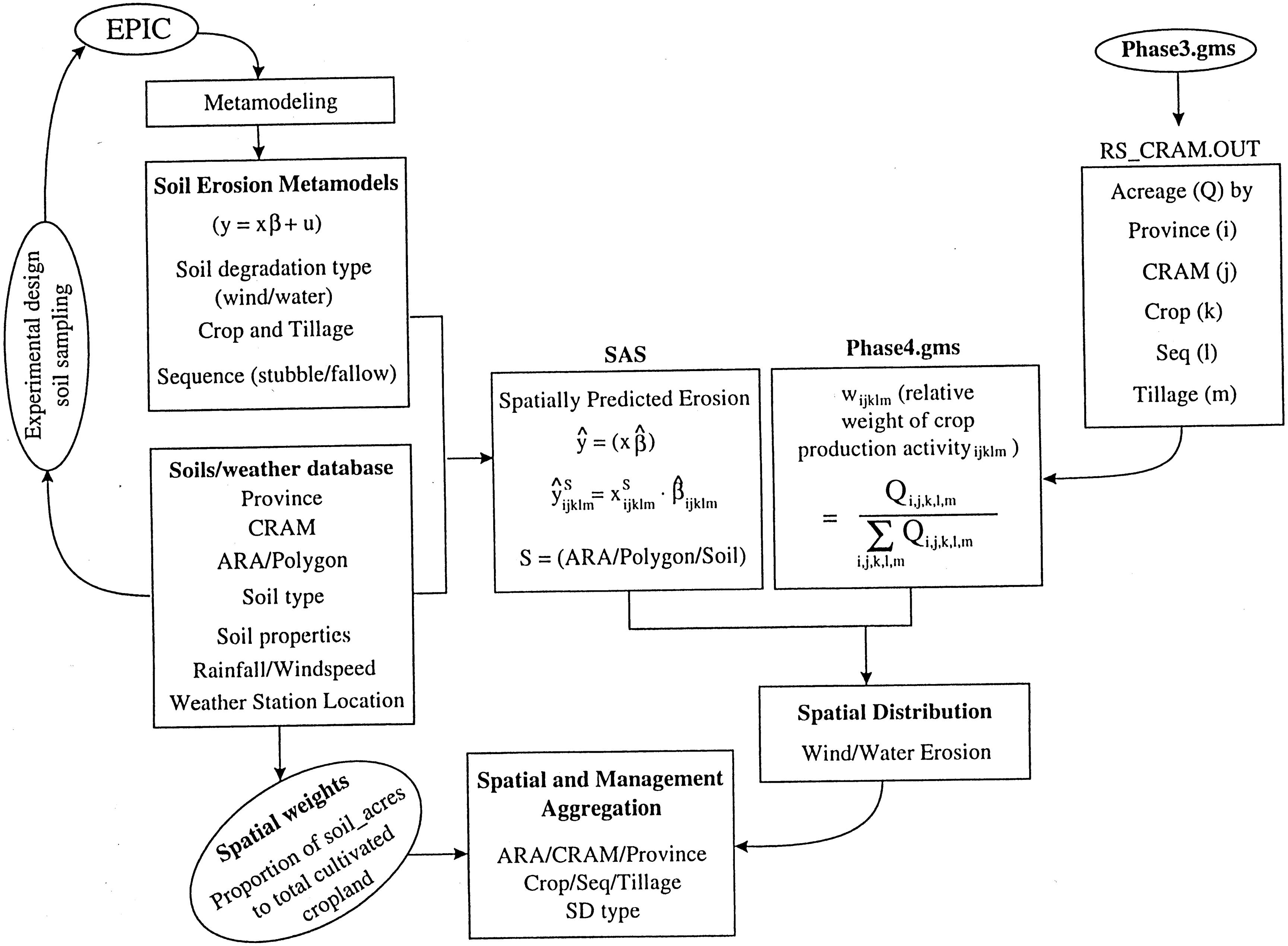

Figure 2 Flowchart of EPIC-Metamodel-RS-CRAM Integration

by the USDA-ARS, to estimate the long-term impacts of erosion upon soil productivity (Williams et al. 1984). A detailed description of EPIC and results of initial tests of the model for different conditions in Western Canada are given in Agriculture Canada (1993b).

The system is initiated by defining the policy, or set of policies, to be evaluated. The policy scenario being simulated is then imposed on RS-CRAM, where management decisions are simulated. At the completion of the simulation run, RS-CRAM outputs management parameters in the form of areas seeded according to tillage practice, crop, and crop sequence (crop following fallow or stubble). These parameters are then passed along to the environmental metamodels. Land resource use indicators in the form of water and wind erosion estimates are output from the environmental metamodels. A trade-off analysis is then performed to evaluate the overall economic and environmental impacts of the simulated policy scenario. The system is configured in a manner that provides flexibility to perform repeated policy scenarios without having to rerun the EPIC model. The system also provides environmental impact data at the soil polygon level, which can then be aggregated and displayed at any level of resolution needed for policy analysis.

The key scenario evaluated with the integrated system is an assessment of the resource implications of the Gross Revenue Insurance Plan (GRIP) in the prairie provinces[1]. Concern has been expressed that GRIP is not resource neutral and will influence the intensification of production on environmentally sensitive lands, leading to higher erosion rates and increased soil degradation. Because producer responses to reductions in risk are critical to evaluating the impacts of GRIP and crop insurance, two sensitivity analyses are performed to gauge the model's

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[1] Originally, it was also intended to evaluate the Net Income Stabilization Account (NISA), that was designed to protect eligible producers against income volatility. However, a well-developed theoretical framework does not currently exist for NISA, so it cannot be evaluated with the current integrated system.

sensitivity to estimated risk parameters in the model. Additional simulations are performed to assess the sensitivity of the system to variations in assumptions about tillage and crop mix distributions.

This report describes the enhancements that have been made to CRAM in order to construct the integrated modelling system and the application of the system for GRIP and the other scenarios. The report is divided into the following sections: (1) the Resource Sensitive CRAM, (2) model calibration, (3) policy and sensitivity analysis results, (4) recommendations for future research, and (5) summary.

II. The Resource Sensitive CRAM

A.1 Changes to the CRAM Structure: RS-CRAM

Changes to the structure of the model and its linkage to EPIC culminated in a new, resource sensitive version of CRAM -- RS-CRAM. Changes to the structure of CRAM are confined to CRAM regions within the provinces of Alberta, Saskatchewan and Manitoba. Changes are limited to crop production activities for major crops including two added by CARD (lentils and field peas). The crops are wheat, barley (coarse grains), flax, canola, field peas, lentils, and an aggregate "other crops". Modifications to the structure occur in four areas.

First, three alternative tillage practices defined as conventional, medium and no-till are modeled where, previously, a single average or representative tillage system was defined for each crop production activity. Second, lentils and field peas are removed from the "other crops" aggregate and explicitly added to the list of crop production activities. Activities for lentils and field peas on stubble and for lentils on summerfallow are included. The inclusion of tillage and new crops expands the list of crop production activities in RS-CRAM to 718. The third area of modification is the explicit inclusion in returns to crop production activities in the prairie provinces of revenues from crop insurance, GRIP, or both. Finally, price and yield risk are incorporated into the model.

A.1.1 Tillage Specification

Broad definitions for these specific tillage systems are based on recommendations by Dumanski (1992). The conventional tillage system includes combinations of tillage operations that leave less than 30 percent of the plant residue on the soil surface. Reduced tillage systems leave more than 30 percent but less than 70 percent of the residue on the surface. No-till systems leave more than 70 percent of the residue on the surface. In RS-CRAM, crop production activities previously defined by region and crop, including a distinction between summerfallow and stubble, (Horner et. al 1992) are now further defined by tillage practice. Where CRAM defined two activities for a particular crop (e.g., wheat on stubble, wheat on fallow), RS-CRAM defines six activities for the same crop (e.g., wheat on stubble with conventional tillage, wheat on fallow with no-till, etc.).

A major challenge to adding tillage is presented by the fact that RS-CRAM, as well as the previous version of CRAM, utilize a Positive Mathematical Programming (PMP) framework (Howitt 1991). The PMP approach specifies a regional crop specific supply function (marginal factor cost of land) to a set of observed data on prices, costs, yields and area. PMP has two basic components: 1) an LP calibration phase that constrains crop production activity levels to observed base period levels and 2) the PMP model. Constraints in the calibration phase restrict crop production areas to observed levels of cropland seeded in 1991. The resulting marginal values of these constraints are then used to derive coefficients for the PMP model. The introduction of tillage presents problems for the calibration process because observed data for crop production by crop sequence (fallow or stubble) and tillage are unavailable. A similar problem occurs in the previous version of CRAM where observed data on crop areas by summerfallow and stubble are not available. Crop areas by summerfallow and stubble are derived in a "pre-calibration" run according to the relative returns of each crop on fallow and stubble and the observed relative amount of all crops grown on fallow and stubble. In RS-

CRAM, tillage area is allocated to summerfallow and stubble activities of the same crop in the same proportions. The proportions of each crop under each tillage system are specified according to observed data on aggregate tillage in each region (Agriculture Canada, 1993). All area not seeded is assumed to be fallowed.

Other parts of RS-CRAM are not impacted by the addition of this tillage specification. The demand, transportation and livestock sectors are structurally unaffected. Where linkages between these sectors and the crop production sector occur, only aggregate crop areas are used.

A.1.2 Addition of Lentils and Field Peas

Crop production activities for lentils are added for summerfallow and stubble. Activities for field peas are added for stubble only. PMP calibration for both crops is performed in the same manner as for other crops. The demands for lentils and field peas are recorded at the national level and are completely disposed of in the national market. Prices for both crops are specified as perfectly inelastic. Transportation from the regional to national level for both crops is included. In RS-CRAM, there is no direct interaction of either lentils or field peas with the livestock sector.

A.1.3 Returns to Crop Production with Crop Insurance and GRIP

The 1992 baseline for the analysis performed by CARD assumes 100 percent participation in crop insurance. Indemnity payments and the producer share of premiums are calculated explicitly for the baseline in RS-CRAM. A more detailed discussion of these calculations can be found in section III.A of this report. Previously, payments from crop insurance were summed with payouts from several other programs including the Western Grain Stabilization Act, Agricultural Stabilization Act, Federal and Provincial Red Meat Stabilization Program, etc., into a single government payment (Horner et. al. 1992). In Alberta, Saskatchewan and Manitoba, these aggregate payments are replaced by the net of crop insurance indemnity payments less the producer share of premiums. In other provinces, the government payments used in the previous version of CRAM are left in the model.

GRIP is evaluated as a policy scenario. One hundred percent participation is assumed and the 1991 GRIP is modeled. Indemnity payments and premiums are calculated for each of the crop production activities. The calculations are presented in Appendix E of this report. As in the crop insurance calculations, government payments from other programs are omitted in estimating government payments for the insured crops.

A.1.4 Risk

Because crop insurance and GRIP are designed to reduce the fluctuations in returns experienced by producers, producer response to risk is modeled in RS-CRAM. The methodology used was devised by Hazell and Scandizzo (1974, 1977). It is the most practical method of including price and yield risks in the objective function of a sector model with endogenous commodity prices (Hazell and Norton 1986). The methodology closely follows that used by House (1989) in the USMP regional agricultural model.

Time series of yields, prices, costs and insurance parameters are used for calculating producer returns to crop production activities from the market and insurance programs for a 13 year period (1980-1992). Yields are simulated in EPIC and mean-adjusted to more closely correspond to yields previously used in CRAM (see section A.2.2). The time series of market returns and insurance payments are subsequently used to estimate the expected net returns (average over all years) and the variance-covariance matrix of net returns to crop production. The objective function for RS-CRAM with all of the modifications described above and a description of the risk parameters are given in Appendix E of this report.

A.2 Additions and Updates to CRAM Database

Four major sets of data in CRAM are either added or modified: land use patterns, crop yields, costs of production, and insurance data. Updated and new data sets are reproduced in Appendix A. Sources for these data, along with descriptions of data manipulation, are listed in Table A1.

A.2.1 Land Use Patterns

Table A2 shows land area by class (cropland, hayland, pasture, and unimproved pasture), which defines the land available for production. The dimensions of this table in GAMS are unchanged from the previous version of CRAM. The numbers in the table are updated to include current data from the 1991 Agricultural Census.

The proportion of land in summerfallow is used to allocate land to summerfallow for the PMP calibration. It too is has the same dimensions as in the previous version of CRAM. The values are simply updated using 1991 census data. Table A3 indicates the proportion of seeded areas in each region. Since all cropland not seeded is assumed to be fallowed, the share of cropland fallowed in each region is equal to one minus the percentage given in Table A3.

For each region, the proportion of land planted under the three tillage systems (Table A4) is used along with the area of cropland seeded to each crop (Table A5) to establish base period activity levels in the pre-calibration and calibration phases of the PMP process. The dimensions of the Table A5 in the GAMS source code are the same as in the previous version of CRAM, but values for lentils and field peas have been added. Again, the values are from the 1991 census. For calibration purposes, the total cropland area from Table A2 is multiplied by the share of cropland seeded from Table A3 to get the total seeded area in each region. Next, because the sum of seeded areas by crop in Table A5 may not agree with the total cropland area for a region computed above, the share of total seeded area for each crop is computed using the census data from Table A5 and then multiplied by the total seeded area to arrive at a consistent allocation of land among crops in each region. Seeded area by crop is next subdivided into areas by crop and tillage practice using the ratios from Table A4. In each region, total fallowed area by tillage practice, derived from Tables A2, A3, and A4, is allocated to a set of three summerfallow activities, one for each tillage system. The final allocation of cropland among the model's remaining crop activities is the determination of areas by crop sequence for each crop/tillage combination. This is accomplished by constraining the total area of all crops planted on fallow and under a particular tillage system to equal the area allocated to the summerfallow activity for that tillage system. The model then chooses the optimal allocation of fallowed area to each crop/tillage combination in the region. Cropland not placed in an "on fallow" activity is allocated to "on stubble" activities according to the remaining area assigned to the crop/tillage combination. Allocation by crop sequence is thus accomplished not on an historical basis, but on a theoretical basis.

A.2.2 Crop Yields

Time series of crop yields are estimated by EPIC using actual growing conditions experienced in the various regions (Agriculture Canada 1994) and then adjusted for consistency with census data. The adjustment process is discussed in detail in section II.B of this report. The yields are by region, crop, crop sequence, tillage and year (1980-92). They are used for calculating the returns of the crop production activities from the market and for calculating long-term average yields needed to determine the time series of premiums and indemnity payments for the crop and GRIP insurance programs. The time series of market returns and insurance payments are then used to estimate the expected returns along with the variance-covariance matrix of returns to crop production. The means of these yield time series are also used in the RS-CRAM objective function as expected yields. Expected yields are listed in Appendix A for each activity in tonnes per hectare.

A.2.3 Crop Production Costs

Crop production costs by region, crop and tillage[2] are based on the costs in the previous version of CRAM with adjustments made for tillage. Costs sought by region, crop, and tillage are based on small sample sizes and generally inconsistent. Crop costs in the prior version of CRAM are considered accurate, but are not given by tillage and are unavailable for lentils and field peas. Because machinery fuel, machinery repair and chemical costs are the major costs that vary by tillage, these costs are differentiated by tillage. To do so, ratios for repair, fuel, and

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[2] A time series of costs are not included in the calculation of net returns. Because producers face certain costs of production at the time they are making most of their production decisions, the costs do not contribute to the uncertain fluctuations in net income that producers face. Consequently, constant costs are used to estimate the EV parameters in the objective function.

chemical costs are computed using Saskatchewan survey data (Schoney 1993). For each of these three categories, the area-weighted average costs for all crops on conventional tillage, on reduced tillage, and on no-till are computed. Ratios of costs for conventional relative to reduced tillage and for no-till relative to reduced tillage are then calculated from these averages. The costs obtained from CRAM are assumed to be representative of reduced tillage systems for each category. To obtain conventional tillage costs, the CRAM costs in each category are multiplied by the conventional:reduced tillage ratios. No-till costs are computed using the no-till:reduced tillage ratios. Although the ratios are computed from Saskatchewan data, the same ratios are used for all three provinces. These ratios appear in Table 1. Average costs for each activity appear in Appendix B.

For crop costs not available in the prior version of CRAM (lentils and field peas) the costs are extracted from Schoney (for Saskatchewan and Manitoba) and data provided by Agriculture Canada for Alberta. Tillage differentiation of these costs is achieved by the same process as for other crops. In their original form, the costs for lentils in Alberta are not differentiated by crop sequence. It is therefore necessary to differentiate costs for lentils on stubble and lentils on fallow using ratios computed from the survey data for lentils in Saskatchewan.

Table 1. Ratios used to differentiate costs by tillage

Category	INTL	MDTL	NOTL
Chemicals	0.8449	1	1.0931
Fuel	1.0532	1	0.7522
Repair	1.1931	1	0.8995

A.2.4. Insurance Data

Crop insurance prices obtained from Agriculture Canada are given in Table A6 by province, crop, and year. The crop insurance prices along with all of the other insurance data are new additions to the CRAM framework. The previous version of the model contained none of the insurance data. The crop insurance prices are used for calculating premiums and indemnity payments with crop insurance in the net returns time-series. They are multiplied by the difference between the long-term average yield, times the coverage level, and the actual yield to determine indemnity payments. The mean indemnities and premia for each insured activity then enter the objective function. These expected payments and producer premia appear in Appendix C.

Index moving average prices (IMAP), by crop and year, are given in Table A7. They are used for calculating premiums and indemnity payments under GRIP. The IMAPs are multiplied by the long-term average yields and the coverage level to determine the target revenues. The GRIP premiums are also functions of the IMAPs and appear with other insurance computations in Appendix D.

Premium percentages provided by the provincial Crop Insurance Corporations appear in the RS-CRAM source code by region, crop and year. They are included for both crop insurance and GRIP. For crop insurance the percentages are multiplied by the coverage level, the long-term average yield and the crop insurance prices to calculate the premiums. For GRIP, the percentages are multiplied by the coverage level, the long-term average yield and the IMAP to calculate the premiums.

For all insured crops other than lentils and field peas, regional farmgate market prices are estimated by subtracting the transportation costs[3] in CRAM from port prices provided by Agriculture Canada (Table A8). Prices for lentils and field peas were provided by Agriculture Canada at the provincial level (Table A9). Each region within a province uses the same provincial average farmgate price for these two crops. They are used to calculate the time series of returns from the market as well as the indemnity payments under GRIP.

B. The Integration of EPIC Yields into RS-CRAM

EPIC yield data are generated from the same experimentally designed set of EPIC simulations that are used to construct the environmental metamodels. A spatial and temporal weighting process is used to aggregate the yield data to the RS-CRAM region level, as discussed in sections II.B. and IV.B.1. of Agriculture Canada (1994). Two problems are encountered in interfacing the EPIC yields with RS-CRAM: (1) the EPIC yields are consistently higher than the previous 10-year average census yields used in CRAM and (2) the EPIC predicted wheat and canola yields are consistently lower on fallow as compared with stubble outside of the Brown soil zone, which is not consistent with initial expectations.

Examination of the EPIC yield results confirms that the model is clearly responding to climatic and productivity differences between the major soil zones, as discussed in section IV.B. in Agriculture Canada (1994). It is concluded that the model is underpredicting the benefits of fallow in the Dark Brown soil zone, where fallowing is known to result in definite yield

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[3] Handling costs are not deducted from the port prices in deriving farmgate prices. Farmgate prices differ according only to transportation costs since all other costs can be arbitraged by producers, who, in practice, may choose to forego local storage at a regional hub and ship directly to port facilities.

improvements. It is unclear as to how much benefit would be derived from using fallow in the Black and Gray soil zones, although it is probable that EPIC is overpredicting the yields on stubble. Because of the uncertainty of the benefits of fallow in some of the regions of the Prairies, it was decided to maintain the relative yield differences between the EPIC predicted wheat and canola yields on fallow and stubble. The adjustment process maintains several important characteristics of the yield time-series produced by EPIC: (1) the year-to-year variations, (2) relative differences due to tillage practice, (3) relative differences due to crop sequence, and (4) relative differences due to region, climate, and soil characteristics.

Several reasons are also discussed in section IV.B. in Agriculture Canada (1994) as to why EPIC generally overestimates crop yields. It is necessary to reduce the magnitude of the yields to be more consistent with those available in the census data to avoid distortions in RS-CRAM. The mean EPIC yield over time is computed for each activity (wheat/stubble/no-till, etc.) and compared to historical average yield for the corresponding crop aggregate (wheat, barley, canola, and flax). A single adjustment factor is then calculated from these differences for each crop and applied to every EPIC activity yield corresponding to that crop. These adjustment factors are shown in Table 2. This process thus preserves the relationships generated by EPIC among crop sequences and tillage practices. EPIC yields for lentils and field peas are adjusted so that aggregate production in RS-CRAM matches historical production. This is accomplished by first computing aggregate production for these crops based on the EPIC yields and RS-CRAM baseline acreages. These production levels are then divided by the historical national production of each crop for 1991-92. All EPIC yields for lentils and field peas are then divided by these ratios. This is particularly important for lentils, where a factor of 3.4 is required to bring the predicted yields in line with the historical production data[4].

Table 2. Factors used to adjust EPIC yields to census data

Region	WHEATHQ	BARLEY	FLAX	CANOLA
AL.2	1.232	1.075	1.265	1.790
AL.3	1.524	1.474	1.988	2.304
AL.4	1.595	1.573	1.652	2.175
AL.5	1.165	1.356	1.483	1.954
AL.6	1.566	1.507	1.585	2.048
AL.7	1.300	1.649	2.156	2.179
SA.1	1.729	1.706	1.361	2.412
SA.2	1.578	1.536	1.535	1.934
SA.3	1.725	1.581	1.556	3.941
SA.4	1.581	1.442	1.186	2.315
SA.5	1.531	1.514	1.267	1.996
SA.6	1.636	1.563	1.288	2.132
SA.7	1.539	1.470	1.330	1.942
SA.8	2.118	1.499	1.181	2.012
SA.9	1.483	1.534	1.258	1.946
MA.1	1.418	1.364	1.105	2.981
MA.2	1.419	1.478	1.149	3.104
MA.3	1.624	1.193	1.118	2.730
MA.4	1.591	1.151	1.081	2.789
MA.5	1.858	1.268	1.089	3.150
MA.6	2.078	1.374	1.243	3.411

These adjustments preserve the EPIC predicted effects of tillage on crop yields, as well as the predicted relative differences between fallow and stubble cropped yields for canola, lentils, and wheat. These adjusted yields result in RS-CRAM yields that are not the same as the census

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[4] Considerable effort was spent to add lentils to EPIC modelled crops. EPIC yield estimates for lentils were especially high, however, compared to the other crops. It is not clear why this is the case. Further refinement and calibration of the lentil crop parameters, and other EPIC crop parameters, is required for future applications of the system.

yields but much closer in magnitude. While this process does not appear to have introduced any systematic bias into the model baseline, yields for fallow activities are often much lower than those used in the prior version of CRAM. Yields for stubble activities are often much higher than those used earlier. This could result in the model favoring stubble activities in policy scenarios to a greater extent than if the old yields are used. Because insufficient data exists on crop sequencing, it is impossible to judge the magnitude of any such bias. Adjusted EPIC yields are also extrapolated to other CRAM regions for which wheat on fallow, canola on fallow and stubble, and flax activities are not simulated in EPIC. It is a necessary step to include these activity/region combinations for accounting purposes in RS-CRAM (the model assumes a small minimum number of hectares per activity). In most cases, these crop and crop sequence activities will have minimal impacts on any policy analysis.

Insurance payments (premiums) by producers and payouts (indemnities) are simulated in RS-CRAM for the period 1980-92 using the adjusted EPIC yield simulations. Both a 13-year distribution of yields, as well as a 10-year moving-average yield for each year of the 1980-92 time period, are required to perform the risk calculations[5]. Ideally, the ten-year moving average yields would be computed by calculating the average yield over 1970-79 for 1980, 1971-1980 for 1981, and so forth. However, the EPIC yields are computed for those years that are available from climatic data in the ARA database (Kirkwood et al. 1993), which cover the 31-year time period 1955-85. A pairwise t-test performed on the EPIC yield distributions reveals that there is no statistical difference between the average yields calculated for the first ten years as

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[5] The ten-year moving averages are used in RS-CRAM as the long-term average yields (LTAY) to determine the insurance payments time-series. The 13 annual yields for each activity are also used to determine annual insurance payments, as well as market net returns. Expected yields used in the objective function are the means of these 13-year distributions. .

compared to the third ten years, between the first 10 years and the second ten years, etc[6]. Thus, the 23-year 1963-85 EPIC yield distributions are assumed to be representative of the 1970-92 RS-CRAM time period and are used to compute the ten-year moving averages. Likewise, the 13-year 1973-85 EPIC yield distributions are assumed to be representative of the 1980-92 yield distribution period required for the optimization component of RS-CRAM.

C. Incorporation of the Environmental Metamodels

Degradation of prairie soils from agricultural production is a major concern in the western provinces. The primary degradation problems observed in the prairie provinces are wind and water erosion, salination, compaction, and organic matter depletion (PFRA 1990). For this project, the primary degradation indicators are water and wind erosion. The approach to modeling soil degradation within the proposed framework is based on summarizing properly calibrated EPIC simulations using the techniques of metamodels (Bouzaher 1992; Bouzaher et al. 1993). EPIC simulations are based on a statistical design incorporating soil layer and landform, climate, crops, and management practices from Alberta, Saskatchewan, and Manitoba. Use of metamodels allows researchers to focus only on key physical and management parameters that are policy relevant, facilitate computational efficiency and model linkages, and permit the integration of field-level data in regional analyses.

A policy scenario with an integrated system of models requires a mutually consistent combination of policy, environmental, management, and technological parameters and behavioral equations. To simulate each and every possible combination of these factors is impractical,

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[6] While historical yields may exhibit trends over time, EPIC simulations do not exhibit any such trends.

especially in a system requiring both timely integration of diverse process models and integration of outcomes over a distribution of diverse input sets. Statistically validated metamodels ease the computational burden while capturing the key process characteristics.

Given the outputs of EPIC simulation, we can specify an analytic metamodel with relatively few inputs, x_1 through x_k. Let the metamodel explaining the simulated outcome be represented as:

$$y = f(x_1, x_2, ..., x_k, u),$$

where u is the stochastic disturbance term. We can use standard statistical and econometric procedures to identify and estimate the function f as a predictor of y.

The estimated metamodel for wind erosion is

$$\begin{aligned}(Y_{wind})^{\lambda}_{crop,\, seq} = {} & a_0 + a_1(RAIN) + a_2(UAV) + a_3(LATI) \\ & + a_4(SAND) + a_5(OMBD) + a_6(DRTIL) + a_7(DNTIL) + \mu_{1i}\end{aligned}$$

where Y_{wind} is wind erosion (t/ha), seq is the stubble/fallow sequence, λ is the optimal transformation parameter equal to 1/4, the a_i's are the regression coefficients, RAIN is the average annual rainfall (mm), UAV is the average annual wind speed (m/s), LATI is a proxy variable for weather station location (degrees), SAND is the soil sand content (%), OMBD is an interaction term of organic matter (%) and bulk density (t/m^3), DRTIL and DNTIL are dummy variables which measure the erosion rates relative to conventional tillage, and u_{1i} is the unknown error term. Similarly, the estimated metamodel for water erosion is

$$\begin{aligned}(Y_{water})^{\lambda}_{crop,\, seq} = {} & b_0 + b_1(RAIN) + b_2(LATI) + b_3(SLOPE) \\ & + b_4(OMBD) + b_5(RCN) + b_6(DRTIL) + b_7(DNTIL) + \mu_{2i}\end{aligned}$$

where Y_{water} is water erosion (t/ha), the b_i's are the regression coefficients, SLOPE is the landform slope gradient (%), and RCN is the runoff curve number that is used as a proxy to capture the hydrologic effects (i.e., partitioning of precipitation between runoff and infiltration) on water erosion.

These metamodels for wind and water erosion have been validated using standard validation procedures such as cross-validation and validation with observed data (Agriculture Canada 1994). The estimated metamodels are linked to RS-CRAM for evaluating alternative policy options, including GRIP, industrial crops, and tillage. However, the valid range of these models is restricted to the range from which model parameters have been estimated. Predictions outside of the estimation range will require additional EPIC calibrations and runs to extend the metamodels' interpolation range.

D. Aggregation and Linkages between Economics and Environment

Linkage between the economic and environmental components is accomplished by passing information on the mix of management practices and cropping patterns for every CRAM region and policy scenario to the metamodels to evaluate degradation impacts (Figure 2). This linkage is the fundamental relationship between farmer responses to agricultural policies and the impacts of these responses on resource use. The linkage of multi-disciplinary models is crucial to economic and environmental policy evaluation of trade-offs. The economic model RS-CRAM is defined at the CRAM production region level, while the environmental metamodels are specified for the soils in the landscape polygon level. In order to compare environmental indicators with economic indicators in a consistent manner for each policy scenario, the environmental indicators must be aggregated from the landscape polygon level to the CRAM production region level. This is a multiple step process that begins with inputting predicted RS-CRAM cropping patterns and tillage distributions to the metamodels, and then aggregating the environmental indicators back up to the production regions or provinces.

The initial step in estimating environmental outcomes for a given policy scenario is to input the predicted RS-CRAM cropping patterns and tillage distributions into the metamodel of interest for <u>every</u> ARA, landscape polygon, and soil combination available in the environmental database that exists within the CRAM production region. In this step, it is assumed that the cropping and tillage practices are evenly distributed across all soils and landscape polygons within the RS-CRAM region.[7] In reality, cropping patterns and management systems are not evenly distributed within individual CRAM regions, due to differences in soil zones and other environmental features. However, it is not currently possible to account for these differences with the integrated modeling system.

Formally, the economic and environmental linkages can be described in the following way. Let:

$Q^{p}_{\alpha j}$ = Vector of management practices $\alpha=[k\ l\ m]$ where k is crop, l is stubble fallow sequence, and m is tillage practice, in CRAM region j, under policy scenario p;

$SD^{p}_{t\alpha js}$ = Soil degradation type t, from management practice vector α, on soil type s, in CRAM region j, under policy scenario p;

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[7] Ideally one may want to generate the crop and tillage mix at the landscape polygon level. Because it is difficult to construct and solve economic models at the landscape polygon level, this assumption has to be made.

A_{sj} = Acreage of soil type *s*, in CRAM region *j*;

E_{sj} = Vector of environmental factors in soil type *s*, in CRAM region *j*;

$w^{p}_{\alpha j}$ = $Q^{p}_{\alpha j} \,/\, \sum_{\alpha} Q^{p}_{\alpha j}$, Relative weight of management practice vector α, in CRAM region *j*, under policy scenario *p*; and

v_{sj} = $A_{sj} / \sum_{s} A_{sj}$, the relative weight of soil type *s* in CRAM region *j*.

Then, the linkage between the economic and environmental components can be expressed as:

$$SD_{t\alpha js} = F_{t}(\alpha(j),\ E_{sj})$$

where F_t is the metamodel estimated, for soil degradation type *t*, from EPIC output.

The soil degradation indicators can be aggregated in several ways, and particularly across management practices (by degradation type, soil type, CRAM region, and policy): which is the policy specific spatial distribution of soil degradation indicator. The distribution information is useful for targeting purposes since it identifies the number of vulnerable soils under alternative policies for a given soil degradation benchmark.

Across soil type (by degradation type, CRAM region, and policy):

$$SD^{p}_{tj} = \sum_{s} v_{sj} * SD^{p}_{tjs}\,.$$

This is the potential environmental indicator for evaluating alternative policy options. By measuring the shift in the level of this indicator from the baseline (status-quo) inferences can be drawn about the environmental soundness of a given policy.

Clearly, the level of aggregation will depend on the type of analysis desired, at the soil level, ARA level, CRAM region level, or province level. The framework developed here allows generation of soil degradation indicators at the lowest level of aggregation, by soil type. Here, crop and tillage weighted erosion rates are estimated for each landscape polygon-soil type combination available in the total population of the environmental database for each scenario. These are then aggregated to the ARA/CRAM/Province level using weights based on the total cropped acres of each soil type in each landscape polygon.

III. Policy and Sensitivity Analysis Results

This section presents the results of one policy scenario (GRIP) and four sensitivity runs. Results from the policy scenario are compared to the baseline solution of RS-CRAM, which embodies an assumption of crop insurance, but no revenue insurance. The policy scenario is a simulation of GRIP -- in which revenue insurance is added to crop insurance. Two of the sensitivity analyses are variations on the GRIP policy scenario and involve changing the value of the risk aversion coefficient used in the objective function. For both of these changes, the GRIP policy scenario and baseline are run again to determine the model's sensitivity to risk aversion estimates. The third sensitivity run involves changes in tillage practices and is run with only crop insurance. The final sensitivity run is an industrial crops scenario, in which the aggregate acreages of flax and canola for all of Canada are increased by 50 percent.

Results of these analyses are presented in several tables and are briefly discussed in this section. Some baseline calculations are presented in appendices. Appendix B lists the expected production activity yields for each crop activity by province, CRAM region, crop and sequence, and tillage practice. Yields are in metric tons per hectare, except for "other crops" activities, which are in dollars per hectare. Appendix C lists baseline average total costs per hectare, in dollars. Appendix D lists estimated average insurance indemnities and premia for crop insurance and for GRIP. Appendix F lists endogenous market crop prices from the baseline in dollars per tonne. Appendix G provides detailed erosion impacts at the provincial and regional levels. Finally, Appendix H provides a brief description of how to execute the system of GAMS and SAS script files to produce a baseline, policy results, and environmental impacts.

The baseline solution assumes 100 percent participation in crop insurance for the insured crops in the prairie provinces. Time series of net returns to each insured activity are generated using the data discussed in section II and the formulas for baseline net returns given in Appendix E. From these time series, a variance-covariance matrix of net returns under crop insurance is computed and added to the model's objective function. Expected indemnity and premium payments are computed as the means of their respective time series simulated over the period 1980-92 using the same data. It should be noted that net returns and mean insurance payments are computed from simulations of the time series, not directly from historical observations, which are largely unavailable at the level of detail required for RS-CRAM. The variance-covariance matrix of net returns and the expected insurance payments are entered into the objective function and the model is solved to produce a baseline solution.

For the GRIP analysis, these time series of net returns and insurance payments are recomputed using simulations of the 1991 GRIP program. A new variance-covariance matrix and expected GRIP payouts and premia then replace their corresponding elements in the model's objective function. The model is run again to obtain a GRIP solution. Results of this solution are compared to those of the baseline solution.

For the two GRIP sensitivity analyses, GRIPNR and GRIPHR, the coefficient of absolute risk aversion, or ϕ, (see Appendix E) is changed in both the baseline and GRIP objective functions. It is necessary to rerun the baseline for these changes because the magnitude of ϕ is an underlying assumption about producer responsiveness to risk and insurance programs. The baseline allocation of land to fallow and stubble activities for a given crop is slightly affected by the magnitude of ϕ, but the aggregate areas of cropland allocated to specific crops, crop sequences, and tillage practices are not changed. Both models are run again, and the new results of each are compared to gauge the impacts of GRIP. Baseline environmental indicators, however, are not re-estimated. In all sensitivity analyses described here, changes in soil degradation are computed using the original baseline solution. It is unlikely that any additional information could be obtained by recomputing erosion estimates for alternative baselines in these sensitivity analyses.

The tillage scenario, TILL, requires a new baseline solution to be generated using an alternative assumption on the allocation of cropland to the three tillage practices in each region. The scenario is run assuming crop insurance only, so the time series of net returns do not necessarily need to be re-estimated. The primary aims of this exercise are to determine the model's capacity to accommodate large shifts in tillage assumptions and to reflect the corresponding changes in soil degradation one would expect under such changes. Results of this solution are compared to that of the original baseline model.

For the industrial crops scenario, INDCROP, the baseline model is modified by adding a constraint to the economic model that forces a 50 percent increase over the baseline in acres seeded to flax and canola. Areas seeded to other crops are then reallocated according to their relative net returns. The solution to this model is then compared to the original baseline.

A. GRIP

The 1991 Gross Revenue Insurance Plan (GRIP) is modeled for Saskatchewan, Alberta, and Manitoba following the same principles as crop insurance in the baseline[8]. In the same manner as for crop insurance alone, a time series of simulated net returns for each risky activity under GRIP is estimated according to formulas given in Appendix E. Annual net returns for 1980-1992 are simulated assuming 100 percent participation in both GRIP and crop insurance. Mean indemnities and premiums are computed for each activity time series, and the variance-covariance matrix for the objective function is re-estimated using these simulations. Estimated mean indemnities and premiums are given in Appendix C by activity.

Table 3 indicates that GRIP has little overall impact on the share of aggregate seeded acres under each tillage system in the prairie provinces. Area under conventional tillage (INTL) increases by 145 thousand hectares over the baseline value of 14.7 million hectares. While area under reduced tillage (MDTL) increases by only about a third as many hectares as conventional tillage, and no-till (NOTL) area increases by only 11 thousand hectares, the percentage changes in areas under each tillage practice are about the same. In absolute terms, GRIP seems to favor conventional tillage, but in relative terms, there is no significant shift toward conventional tillage. The PMP formulation used in RS-CRAM may limit the responsiveness in input substitution compared to results obtained under a simple LP model. Because each activity is associated with a nonlinear marginal (factor) cost curve, shifts in marginal returns to an activity do not necessarily result in shifts from one set of corner solutions to another, i.e., discrete shifts from one tillage practice to another. Responses to policy shocks are continuous and thus likely to be

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[8] The GAMS script file GRIP.GMS contains code for the 1992 GRIP in Saskatchewan as well as for the 1991 GRIP. The 1992 computations are commented out, though. The analysis was performed only for the 1991 program.

less dramatic than under a Leontieff technological representation. This is especially true when costs and returns do not differ greatly across tillage practices, as is usually the case in RS-CRAM.

Table 3. Tillage distribution on seeded acres, GRIP scenario (thousand hectares)

	BASE	GRIP	DIFF	% DIFF
INTL	14,700	14,845	145	0.99
MDTL	5,993	6,049	56	0.94
NOTL	1,211	1,221	11	0.87
COMTL[a]	2,053	1,984	-68	-3.33

[a] COMTL refers to composite tillage for crops/regions where three separate tillage practices are not modelled. For the Prairies, only "other crops" are not broken down by the three tillage practices.

Table 4 shows a shift in crop sequencing away from fallowing. Area planted on fallow under GRIP falls by 179 thousand hectares from a baseline of 7.8 million. This implies an equal reduction in the area of cropland being fallowed. Area planted on stubble increases by 323 thousand hectares from a baseline of 16 million. This shift away from fallow and towards stubble provides most of the decline in total erosion under GRIP relative to the baseline. About 60 percent of the net shift toward stubble planting comes from wheat and the largest shifts occur in Saskatchewan.

Table 5 shows net changes in seeded acres of each crop for the three prairie provinces. GRIP tends to favor barley, lentils, and flax relative to other crops in the baseline. Changes in total production (Table 6) follow suit because yields (Table 7) are negligibly altered. Because market crop prices are left relatively unchanged in the model by GRIP, almost all of the increase

Table 4. Fallow/stubble distribution, GRIP scenario

	BASE	GRIP	DIFF	% DIFF
Area by Crop Sequence	thousand hectares			
Fallow	7,864	7,685	-179	-2.3
Stubble	16,092	16,415	322	2.0
Total	23,957	24,100	143	0.6
Percent on stubble				
WHEAT	56	56	0	
CANOLA	43	41	-2	
LENTILS	83	83	1	
Total	67	68	1	

Table 5. Crop acreages, GRIP scenario

	BASE	GRIP	DIFF	% DIFF
	thousand hectares			
WHEAT	13,682	13,577	-105	-0.8
BARLEY	4,011	4,281	270	6.7
FLAX	557	597	40	7.2
CANOLA	3,025	2,959	-66	-2.2
LENTILS	331	398	67	20.3
FLDPEAS	297	302	5	1.8
OTHER	2,053	1,984	-68	-3.3
HAY	2,520	2,511	-9	-0.3
Total	26,476	26,611	134	0.5

in net income per hectare is due to increased returns from revenue insurance relative to crop insurance alone. Table 8 shows that, while net income per hectare increases for all crops, the biggest increases in per hectare net income are in barley and lentils, the crops whose areas increase most under GRIP. Barley is a marginal crop in some regions, with a significantly declining market price in recent years. The IMAP support prices in recent years thus tend to support barley net incomes significantly when the average indemnity payments are computed. Similarly, high IMAP prices for lentils increase net activity returns per hectare for that crop.

Table 6. Crop production, GRIP scenario

	BASE	GRIP	DIFF	%DIFF
		thousand tonnes		
WHEAT	24,241	24,063	-178	-0.7
BARLEY	9,728	10,367	639	6.6
FLAX	570	611	40	7.1
CANOLA	3,600	3,524	-76	-2.1
LENTILS	343	410	67	19.7
FLDPEAS	446	452	6	1.4
OTHER (thou. $)	792,831	769,684	-23,147	-2.9

Table 7. Crop yields, GRIP scenario

	BASE	GRIP	DIFF	%DIFF
		tonnes per hectare		
WHEAT	1.8	1.8	0.0	0.0
BARLEY	2.4	2.4	0.0	-0.2
FLAX	1.0	1.0	0.0	-0.1
CANOLA	1.2	1.2	0.0	0.1
LENTILS	1.0	1.0	0.0	-0.5
FLDPEAS	1.5	1.5	0.0	-0.4
OTHER ($/ha)	386.3	387.9	1.7	0.4

Areas planted to flax and, to a lesser extent, field peas also increase due to relatively large increases in per hectare net returns. While net returns per hectare also increase for wheat and canola, the relative increases in net returns are smaller than for the other crops. Thus, the model indicates that wheat and canola are relatively less attractive at the margin under GRIP than are the other crops competing for the same cropland. Accordingly, wheat and canola acreages decline slightly under GRIP.

Table 8. Net crop income, GRIP scenario

	BASE	GRIP	DIFF	% DIFF
		thousand dollars		
Aggregate				
WHEAT	2,739,154	2,851,868	112,715	4.1
BARLEY	468,737	566,487	97,749	20.9
FLAX	142,055	164,360	22,305	15.7
CANOLA	751,056	772,372	21,316	2.8
LENTILS	81,683	115,900	34,217	41.9
FLDPEAS	49,935	54,748	4,813	9.6
OTHER	505,334	502,911	-2,424	-0.5
AL	1,674,119	1,768,064	93,945	5.6
SA	2,285,507	2,456,707	171,200	7.5
MA	778,328	803,874	25,546	3.3
Total	4,737,953	5,028,645	290,691	6.1
Per Hectare			dollars per hectare	
WHEAT	200	210	10	4.9
BARLEY	117	132	15	13.2
FLAX	255	275	20	8.0
CANOLA	248	261	13	5.1
LENTILS	247	291	44	17.9
FLDPEAS	168	181	13	7.7
OTHER	246	253	7	3.0

The reduction in revenue risk provided by GRIP reduces the aggregate risk premium significantly relative to yield protection alone. This term represents the amount of money producers would demand from the market as compensation for undertaking risky production activities. The risk term may thus be interpreted as an opportunity cost to producers. The lower value indicates a higher willingness on the part of producers to undertake riskier production activities, and thus a lower opportunity cost associated with revenue risk. Table 9 shows a 43 percent reduction, equivalent to 24 million dollars. Producers in Alberta tend to benefit relatively more than those in Saskatchewan and Manitoba in terms of risk reduction, although GRIP increases net incomes relatively more for Saskatchewan producers (Table 8).

Table 9. Aggregate risk premium, GRIP scenario

	BASE	GRIP	DIFF	% DIFF
		thousand dollars		
AL	15,921	8,330	-7,591	-47.7
SA	31,257	17,745	-13,512	-43.2
MA	9,207	5,887	-3,320	-36.1
Total	56,385	31,961	-24,423	-43.3

The environmental impacts of GRIP do not appear to be dramatic, although they are slightly favorable in terms of soil erosion by both wind and water. The favorable net impact is largely due to the decline in fallowed area noted above. Increased area planted under conventional tillage offsets this impact somewhat, but not enough to cause an increase in soil degradation. Tables G1-G6 show declining overall soil erosion rates in all three provinces. Soil loss reductions are largest in Alberta, where wind erosion falls by 1.4 percent and water erosion falls by 2.2 percent. Moreover, erosion falls in all seven CRAM regions of Alberta, and regions 3 and 5 show the greatest reductions among all regions of the Prairies in both wind and water erosion. Overall soil erosion in Manitoba and Saskatchewan falls by less than one percent under GRIP. The only CRAM regions where erosion increases are Saskatchewan region 2, where wind and water erosion increase by 1.4 and 1.3 percent, respectively, and Manitoba regions 3 and 4, where water erosion increases by about 0.3 percent.

B. Sensitivity of GRIP Results to Risk (GRIPNR and GRIPHR)

Two alternative baselines and GRIP runs are made to gauge the sensitivity of GRIP results to risk aversion parameters, particularly the coefficient of absolute risk aversion. In scenario GRIPNR (GRIP with No Risk aversion), the coefficient of absolute risk aversion is set to zero. Producers are thus assumed to be risk neutral and risk considerations are completely removed from the model formulation in GRIPNR. In scenario GRIPHR (GRIP with High Risk aversion), the estimated coefficient of absolute risk aversion is multiplied by 5, thus increasing the contribution of risk considerations to producers' decisions in the model. The higher magnitude of this coefficient reflects an alternative assumption about the degree of aversion producers have to taking risky decisions. This heightened aversion also implies that producers will demand a higher level of compensation from the market for taking risks. The magnitude of the risk term in the model's objective function thus increases with an increase in this coefficient, although not linearly due to the concave nature of the underlying utility functions of producers. For each scenario, a new baseline is computed to reflect the changed assumption on risk preferences.

Tables 10-15 (GRIPNR) and 16-22 (GRIPHR) show results for these scenarios. Each GRIP policy run is compared to its corresponding baseline, which differs in some respects from the baseline used for comparison in the other sensitivity analyses presented here. The results indicate that large changes in the risk aversion coefficient do not alter the direction of impacts of GRIP relative to crop insurance alone, but do accentuate the magnitudes of these impacts.

Table 10. Tillage distribution on seeded acres, GRIPNR scenario

	BASE	GRIPNR	DIFF	%DIFF
		thousand hectares		
INTL	14,700	14,837	137	0.93
MDTL	5,993	6,044	52	0.86
NOTL	1,211	1,221	10	0.81
COMTL	2,053	1,993	-59	-2.89

Table 11. Fallow/stubble distribution, GRIPNR scenario

	BASE	GRIPNR	DIFF	%DIFF
Area by Crop Sequence		thousand hectares		
Fallow	7,864	7,707	-157	-2.0
Stubble	16,092	16,388	296	1.8
Total	23,957	24,095	139	0.6
Percent on stubble				
WHEAT	55.6	56.2	0.6	
CANOLA	42.6	43.2	0.6	
LENTILS	82.8	81.7	-1.1	
Total	67.2	68.0	0.8	

Table 12. Crop acreages, GRIPNR scenario

	BASE	GRIPNR	DIFF	%DIFF
	thousand hectares			
WHEAT	13,682	13,585	-97	-0.7
BARLEY	4,011	4,259	247	6.2
FLAX	557	594	36	6.5
CANOLA	3,025	2,965	-60	-2.0
LENTILS	331	397	67	20.1
FLDPEAS	297	303	6	2.0
OTHER	2,053	1,993	-59	-2.9
HAY	2,520	2,515	-4	-0.2
Total	26,476	26,611	134	0.5

Table 13. Crop production, GRIPNR scenario

	BASE	GRIPNR	DIFF	%DIFF
	thousand tonnes			
WHEAT	24,241	24,074	-166	-0.7
BARLEY	9,727	10,311	584	6.0
FLAX	570	607	37	6.4
CANOLA	3,600	3,530	-70	-1.9
LENTILS	343	410	67	19.5
FLDPEAS	446	453	7	1.6
OTHER (thou. $)	792,867	772,804	-20,063	-2.5

Table 14. Crop yields, GRIPNR scenario

	BASE	GRIPNR	DIFF	%DIFF
	tonnes per hectare			
WHEAT	1.8	1.8	0.000	0.0
BARLEY	2.4	2.4	-0.004	-0.2
FLAX	1.0	1.0	-0.001	-0.1
CANOLA	1.2	1.2	0.001	0.1
LENTILS	1.0	1.0	-0.006	-0.5
FLDPEAS	1.5	1.5	-0.007	-0.4
OTHER ($/ha)	386.3	387.7	1.442	0.4

Table 15. Net crop income, GRIPNR scenario

	BASE	GRIPNR	DIFF	%DIFF
		thousand dollars		
Aggregate				
WHEAT	2,739,070	2,853,438	114,367	4.2
BARLEY	468,736	564,720	95,984	20.5
FLAX	142,055	164,051	21,996	15.5
CANOLA	751,056	773,580	22,524	3.0
LENTILS	81,683	115,734	34,052	41.7
FLDPEAS	49,934	54,787	4,852	9.7
OTHER	505,338	503,216	-2,122	-0.4
AL	1,674,119	1,768,238	94,120	5.6
SA	2,285,427	2,457,397	171,970	7.5
MA	778,327	803,891	25,563	3.3
Total	4,737,873	5,029,526	291,653	6.2
Per Hectare		dollars per hectare		
WHEAT	200	210	10	4.9
BARLEY	117	133	16	13.5
FLAX	255	276	21	8.4
CANOLA	248	261	13	5.1
LENTILS	247	291	44	18.0
FLDPEAS	168	181	13	7.6
OTHER	246	252	6	2.6

Table 16. Tillage distribution on seeded acres, GRIPHR scenario

	BASE	GRIPHR	DIFF	%DIFF
		thousand hectares		
INTL	14,700	14,955	255	1.73
MDTL	5,993	6,089	96	1.61
NOTL	1,211	1,230	19	1.55
COMTL	2,053	1,950	-103	-5.00

Table 17. Fallow/stubble distribution, GRIPHR scenario

	BASE	GRIPHR	DIFF	%DIFF
	thousand hectares			
Area by Crop Sequence				
Fallow	7,864	7,597	-267	-3.4
Stubble	16,092	16,626	534	3.3
Total	23,957	24,224	267	1.1
Percent on stubble				
WHEAT	55.6	56.8	1.1	
CANOLA	42.6	43.7	1.1	
LENTILS	82.8	81.8	-1.1	

Table 18. Crop acreages, GRIPHR scenario

	BASE	GRIPHR	DIFF	%DIFF
	thousand hectares			
WHEAT	13,682	13,561	-121	-0.9
BARLEY	4,011	4,442	431	10.7
FLAX	557	617	59	10.6
CANOLA	3,025	2,949	-76	-2.5
LENTILS	331	403	72	21.8
FLDPEAS	297	302	5	1.6
OTHER	2,053	1,950	-103	-5.0
HAY	2,520	2,520	0	0.0
Total	26,476	26,743	267	1.0

Table 19. Crop production, GRIPHR scenario

	BASE	GRIPHR	DIFF	%DIFF
	thousand tonnes			
WHEAT	24,241	24,048	-192	-0.8
BARLEY	9,727	10,740	1,012	10.4
FLAX	570	631	60	10.6
CANOLA	3,600	3,512	-88	-2.4
LENTILS	343	415	73	21.2
FLDPEAS	446	451	5	1.1
OTHER (thou. $)	792,868	758,162	-34,706	-4.4

Table 20. Crop yields, GRIPHR scenario

	BASE	GRIPHR	DIFF	%DIFF
		tonnes per hectare		
WHEAT	1.77	1.77	0.002	0.10
BARLEY	2.43	2.42	-0.007	-0.31
FLAX	1.02	1.02	-0.001	-0.05
CANOLA	1.19	1.19	0.001	0.07
LENTILS	1.04	1.03	-0.005	-0.50
FLDPEAS	1.50	1.49	-0.008	-0.51
OTHER ($/ha)	386.26	388.79	2.527	0.65

Table 21. Net crop income, GRIPHR scenario

	BASE	GRIPHR	DIFF	%DIFF
Aggregate		thousand dollars		
WHEAT	2,739,152	2,844,757	105,605	3.9
BARLEY	468,736	580,247	111,511	23.8
FLAX	142,055	166,416	24,361	17.2
CANOLA	751,056	768,989	17,933	2.4
LENTILS	81,683	117,221	35,538	43.5
FLDPEAS	49,934	54,732	4,797	9.6
OTHER	505,338	501,973	-3,365	-0.7
AL	1,674,119	1,769,077	94,959	5.7
SA	2,285,509	2,460,754	175,246	7.7
MA	778,327	804,503	26,175	3.4
Total	4,737,955	5,034,334	296,380	6.3
Per Hectare		dollars per hectare		
WHEAT	200	210	10	4.8
BARLEY	117	131	14	11.8
FLAX	255	270	15	5.9
CANOLA	248	261	12	5.0
LENTILS	247	291	44	17.9
FLDPEAS	168	181	13	7.9
OTHER	246	257	11	4.6

Table 22. Aggregate risk premium, GRIPHR scenario

	BASE	GRIPHR	DIFF	%DIFF
		thousand dollars		
AL	79,605	42,181	-37,423	-47.0
SA	156,281	90,889	-65,392	-41.8
MA	46,033	29,709	-16,324	-35.5
Total	281,919	162,779	-119,139	-42.3

Changes in planted acreages and shifts away from fallowing are larger in GRIPHR and smaller in GRIPNR compared to GRIP. Changes in proportions of crops planted to stubble are not significantly affected. Per hectare net returns are also relatively unaffected. However, due to the larger planted acreage increase under GRIPHR, the increase in aggregate net crop income (Table 21) is about 5.7 million dollars higher under GRIPHR than under GRIP (Table 8). Under GRIPNR, the increase in aggregate net crop income (Table 15) is about 1 million dollars lower than under GRIP. These results confirm that the model responds in the expected directions to changes in risk preferences.

Tables G1-G6 indicate that the sensitivity of changes in erosion indicators to changes in risk assumptions is much less predictable than the sensitivity of economic results. As expected, the reduction in water erosion at the provincial level is greater for GRIPHR and smaller for GRIPNR relative to GRIP in all three provinces. Wind erosion, however, falls by a greater amount under GRIPNR than under GRIP in Saskatchewan and Manitoba. Under GRIPHR, provincial level wind erosion is noticeably greater than under GRIP or GRIPNR in each province.

Closer examination of Tables G1-G6 reveals that the patterns of changes in erosion are less systematic at the regional level. In Saskatchewan region 2, for instance, wind erosion under GRIP increases by 1.4 percent (Table G3). Under GRIPHR, though, wind erosion falls by 1.2 percent. The same reversal is true for water erosion in that region (Table G4). In several regions, the higher risk coefficient dramatically increases the degree of soil degradation predicted by RS-CRAM.

The results of these two scenarios indicate that assumptions about producer's risk preferences can have significant impacts on the model's predictions, especially with respect to erosion indicators. While the magnitude of soil loss is fairly low in these three scenarios, the significant differences in erosion impacts between the scenarios indicate that for policies expected to have large impacts on erosion, risk assumptions matter.

C. Tillage Practice Sensitivity (TILL)

The sensitivity of baseline calibration to tillage practice assumptions is gauged by switching the percentage of cropland in each CRAM region under conventional tillage with the percentage under no-till for calibration of the PMP model. For example, suppose that under the baseline 60 percent of cropland in a CRAM region is under conventional tillage, 30 percent under reduced tillage, and 10 percent under no-till. Under the TILL scenario, 10 percent would be under conventional tillage, 30 percent under reduced tillage, and 60 percent under no-till. Historically, conventional tillage is applied to a much larger area than no-till in all regions (see Table A4). By substantially reducing the amount of land allocated to conventional tillage activities in the model and leaving marginal returns to all activities substantially unchanged, the slopes of the calibrated PMP marginal factor cost curves are substantially increased. Concomitantly, by substantially increasing the land area allocated to no-till activities, the marginal factor cost curves for no-till activities are substantially reduced. This scenario represents an alternative baseline because a fundamental assumption is altered. Results are presented in Tables 23-29 relative to the original baseline.

The net results of this change is a 13.4 million hectare shift of land from conventional tillage to no-till (Table 23). Because this run is an alternative baseline, aggregate stubble and fallowed areas (Table 24) and total area planted to each crop (Table 25) are constrained in the model to be at historical levels. The distribution of fallow and stubble land by crop, however, is not so constrained. Table 24 indicates that under this set of tillage assumptions, a larger share of lentils are planted on stubble than in the baseline, but that sequencing for wheat and canola are not impacted. Average barley yields (Table 27) are consistently higher on no-till versus conventional tillage. Other crop yields do not systematically vary to the degree barley yields do. Production of barley increases more than production of other crops (Table 26), due solely to the

Table 23. Tillage distribution on seeded acres, TILL scenario

	BASE	TILL	DIFF	% DIFF
	thousand hectares			
INTL	14,700	1,211	-13,489	-91.8
MDTL	5,993	5,993	0	0.0
NOTL	1,211	14,700	13,489	1,114.0
COMTL	2,053	2,053	0	0.0

Table 24. Fallow/stubble distribution, TILL scenario

	BASE	TILL	DIFF	% DIFF
Area by Crop Sequence	thousand hectares			
Fallow	7,864	7,864	0	0.0
Stubble	16,092	16,092	0	0.0
Total	23,957	23,957	0	0.0
Percent on stubble				
WHEAT	55.6	55.5	-0.1	-0.2
CANOLA	42.6	42.6	0.0	0.0
LENTILS	82.8	86.7	3.9	4.7

Table 25. Crop acreages, TILL scenario

	BASE	TILL	DIFF	%DIFF
	thousand hectares			
WHEAT	13,682	13,682	0	0
BARLEY	4,011	4,011	0	0
FLAX	557	557	0	0
CANOLA	3,025	3,025	0	0
LENTILS	331	331	0	0
FLDPEAS	297	297	0	0
OTHER	2,053	2,053	0	0
HAY	2,520	2,520	0	0
TOTAL	26,476	26,476	0	0

Table 26. Crop production, TILL scenario

	BASE	TIL	DIFF	%DIFF
	thousand tonnes			
WHEAT	24,241	24,238	-3	0.0
BARLEY	9,728	10,091	363	3.7
FLAX	570	570	-1	-0.2
CANOLA	3,600	3,598	-2	-0.1
LENTILS	343	345	2	0.6
FLDPEAS	446	443	-2	-0.5
OTHER (thou. $)	792,831	792,867	36	0.0

Table 27. Crop yields, TILL scenario

	BASE	TIL	DIFF	%DIFF
			tonnes per hectare	
WHEAT	1.77	1.77	0.00	-0.06
BARLEY	2.43	2.52	0.09	3.75
FLAX	1.02	1.02	0.00	-0.10
CANOLA	1.19	1.19	0.00	-0.08
LENTILS	1.04	1.04	0.01	0.68
FLDPEAS	1.50	1.49	-0.01	-0.53
OTHER ($/ha)	386.26	386.26	0.00	0.00

change in average yields. Similarly, net returns to barley production (Table 28) show the largest change, almost 10 percent compared to the baseline, due to the higher yields under no-till and to lower average costs for barley on no-till relative to conventional tillage. Net returns from crop insurance also increase slightly for barley relative to the baseline, on average, although not in every region. Eighty-five percent of the $53 million increase in aggregate net returns is due to higher returns to barley production; the remainder comes almost entirely from wheat production. The aggregate risk premium (Table 29) falls negligibly overall, but increases slightly for Alberta.

As expected, improvements in soil erosion are quite significant for this scenario. At the provincial level, reductions in wind erosion are highest in Manitoba (40 percent) and lowest in Saskatchewan (18 percent). Water erosion declines by 25 percent in Manitoba and Alberta and by 15 percent in Saskatchewan. There is a fairly high degree of variability in the magnitude of changes at the regional level, even within the same province. Without exception, however, all erosion indicators are favorable for this scenario.

Table 28. Net crop income, TILL scenario

	BASE	TILL	DIFF	%DIFF
	thousand dollars			
Aggregate				
WHEAT	2,739,154	2,750,670	11,516	0.4
BARLEY	468,737	514,338	45,600	9.7
FLAX	142,055	140,607	-1,448	-1.0
CANOLA	751,056	749,961	-1,095	-0.1
LENTILS	81,683	80,780	-902	-1.1
FLDPEAS	49,935	49,515	-420	-0.8
OTHER	505,334	505,338	4	0.0
AL	1,674,119	1,712,594	38,476	2.3
SA	2,285,507	2,296,975	11,468	0.5
MA	778,328	781,639	3,311	0.4
Total	4,737,953	4,791,209	53,255	1.1
Per Hectare	dollars per hectare			
WHEAT	200	201	1	0.4
BARLEY	117	128	11	9.7
FLAX	255	252	-3	-1.0
CANOLA	248	248	0	-0.1
LENTILS	247	244	-3	-1.1
FLDPEAS	168	167	-1	-0.8
OTHER	246	246	0	0.0

Table 29. Aggregate risk premium, TILL scenario

	BASE	TILL	DIFF	%DIFF
	thousand dollars			
AL	15,921	16,029	108	0.7
SA	31,257	31,093	-164	-0.5
MA	9,207	9,173	-34	-0.4
Total	56,385	56,295	-90	-0.2

D. Industrial Crops Sensitivity (INDCROP)

In this scenario, the aggregate acreages of canola and flax are forced to increase by 50 percent. The model is allowed to choose which regions in which to increase production. Results are presented in Tables 30-36. Less than 2 percent of the increased production goes to regions outside of the prairie provinces, to British Columbia. Table 32 shows that acreages of both crops increase by about 49 percent in the prairie region. Total seeded area falls by 361 thousand hectares, or 1.5 percent because land resources are being allocated in a nonoptimal manner relative to the baseline. A significant shift from stubble to fallow also occurs, largely due to the increase in canola area planted on fallow (Table 31).

Table 30. Tillage distribution on seeded acres, INDCROP scenario

	BASE	IND	DIFF	%DIFF
	thousand hectares			
INTL	14,700	14,522	-178	-1.2
MDTL	5,993	5,954	-39	-0.7
NOTL	1,211	1,210	-1	-0.1
COMTL	2,053	1,909	-143	-7.0

Table 31. Fallow/stubble distribution, INDCROP scenario

	BASE	INDCROP	DIFF	% DIFF
Area by Crop Sequence		thousand hectares		
Fallow	7,864	8,226	362	4.6
Stubble	16,092	15,369	-723	-4.5
Total	23,957	23,595	-362	-1.5
Percent on stubble				
WHEAT	56	56	0.2	
CANOLA	43	41	-1.5	
LENTILS	83	83	0.5	

Table 32. Crop Acreages, INDCROP scenario

	BASE	INDCROP	DIFF	%DIFF
		thousand hectares		
WHEAT	13,682	12,479	-1,203	-8.8
BARLEY	4,011	3,278	-734	-18.3
FLAX	557	831	273	49.0
CANOLA	3,025	4,521	1,496	49.5
LENTILS	331	309	-22	-6.5
FLDPEAS	297	268	-29	-9.7
OTHER	2,053	1,909	-143	-7.0
HAY	2,520	2,520	0	0.0
TOTAL	26,476	26,115	-362	-1.4

Table 33. Crop production, INDCROP scenario

	BASE	IND	DIFF	%DIFF
	thousand tonnes			
WHEAT	24,241	22,049	-2,192	-9.0
BARLEY	9,728	7,908	-1,819	-18.7
FLAX	570	841	271	47.5
CANOLA	3,600	5,334	1,734	48.2
LENTILS	343	321	-22	-6.3
FLDPEAS	446	402	-44	-9.9
OTHER (thou. $)	792,831	740,322	-52,509	-6.6

Table 34. Crop yields, INDCROP scenario

	BASE	IND	DIFF	%DIFF
		tonnes per hectare		
WHEAT	1.77	1.77	-0.01	-0.27
BARLEY	2.43	2.41	-0.01	-0.50
FLAX	1.02	1.01	-0.01	-1.03
CANOLA	1.19	1.18	-0.01	-0.86
LENTILS	1.04	1.04	0.00	0.25
FLDPEAS	1.50	1.50	0.00	-0.18
OTHER ($/ha)	386.26	387.79	1.53	0.40

Table 35. Net crop income, INDCROP scenario

	BASE	INDCROP	DIFF	%DIFF
	thousand dollars			
Aggregate				
WHEAT	2,739,154	2,661,832	-77,321	-2.8
BARLEY	468,737	423,535	-45,203	-9.6
FLAX	142,055	125,637	-16,418	-11.6
CANOLA	751,056	796,803	45,747	6.1
LENTILS	81,683	79,893	-1,789	-2.2
FLDPEAS	49,935	48,211	-1,723	-3.5
OTHER	505,334	497,707	-7,627	-1.5
AL	1,674,119	1,647,051	-27,068	-1.6
SA	2,285,507	2,233,009	-52,498	-2.3
MA	778,328	753,560	-24,768	-3.2
Total	4,737,953	4,633,619	-104,334	-2.2
Per Hectare	dollars per hectare			
WHEAT	200	213	13	6.6
BARLEY	117	129	12	10.6
FLAX	255	151	-104	-40.7
CANOLA	248	176	-72	-29.0
LENTILS	247	258	11	4.6
FLDPEAS	168	180	12	6.9
OTHER	246	261	15	5.9

Table 36. Aggregate risk premium, INDCROP scenario

	BASE	INDCROP	DIFF	%DIFF
	thousand dollars			
AL	15,921	15,148	-773	-4.9
SA	31,257	31,610	353	1.1
MA	9,207	8,351	-856	-9.3
Total	56,385	55,108	-1,276	-2.3

As resources are directed away from the optimal crop mix and toward flax and canola, yields (Table 34) fall slightly for all crops except lentils and other crops, which increase by less than half a percent. Production (Table 33) of every crop but flax and canola also falls. The production of flax and canola increases by less than 50 percent because of lower yields for those crops.

Large shifts in land resources lead to significant shifts in average costs per hectare. Increased acreages of flax and canola significantly increase per hectare costs for those crops, especially flax. Production costs per hectare for flax increase between 60 and 130 percent, with the largest increases in Alberta. Production costs generally increase less for canola than for flax, but some regions of Alberta and Saskatchewan still see increases of 70-130 percent. Because output prices do not change much, these increased costs lower net returns per hectare to flax and canola (Table 35). Net income per hectare falls 41 percent for flax and 29 percent for canola. For flax, this large cost increase results in lower aggregate net income, which falls $16 million, more than 11 percent compared to the baseline. Aggregate canola net income increases by only 6.1 percent, or $46 million. As less productive land is diverted from production of other crops, average costs fall and net income per hectare increases for all the other crops. The acreage and yield reductions in these crops, however, result in lower aggregate net incomes for all crops other than flax and canola, and aggregate net crop income for the Prairies falls by 2.2 percent, or $104 million. The aggregate risk premium falls with lower seeded area (Table 36).

The loss in producer surplus from this shift in production should not be interpreted to mean that such a shift would never be profitable. Flax and canola acreages are increased by command here, not by increases in relative prices for these crops. If producer prices and market demand were to increase sufficiently for these crops, it is still possible that producers would find such a shift optimal. The purpose of this exercise is not to predict outcomes of shifts in industrial crops production, but to see if the model responds correctly to an arbitrary shock in resource allocation.

Overall soil erosion increases for this scenario. At the provincial and regional level, however, environmental results are mixed. Water erosion is higher in all three provinces, although some regions experience a small improvement in water erosion. Wind erosion increases in Alberta and Manitoba, especially in some regions, but falls slightly in Saskatchewan. The changes result not only from shifts in the types of crops grown, but also from changes in fallowed area and tillage practices.

E. Distribution of Environmental Impacts

The soil loss metamodels provide a wealth of information on the environmental impacts of agricultural policies and the response of the RS-CRAM system to different assumptions. Erosion indicators are computed at the soil polygon level and can be aggregated to the Agricultural Resource Area (ARA), CRAM region, and provincial levels for geographical and policy analysis. The erosion results may be further categorized by erosion type (wind or water), policy, crop, crop sequence, and tillage practice. There are thus myriad ways of presenting the erosion results of a policy scenario, and the choice of presentation depends on the objectives of the policy under study. Detailed distributions can be used to identify and target particular sensitive areas. For example, water erosion could be aggregated at a level compatible with watershed analysis. The more aggregate indicators can be useful for regional or provincial soil conservation policy formulation.

Several graphs are given here to demonstrate the system's capabilities and the options available to users of RS-CRAM. Figures 3 and 4 illustrate the cumulative frequencies of soil loss[9] first by policy, then by erosion source, and finally by province for the Baseline and GRIP scenarios. Figure 3(A) shows the cumulative frequency of soil loss due to wind erosion in each province under Baseline conditions. Consider a loss of 5 tons per hectare (the vertical line in Figure 3(A)) as a standard level of erosion. The figure indicates that under Baseline conditions, 13 percent of the soil polygons in Manitoba, 7 percent of the soil polygons in Alberta, and 32 percent in Saskatchewan exceed the erosion standard. Figure 3(B) may be interpreted in the same manner for the frequency of soil loss due to water erosion under Baseline conditions. The aggregate resource neutrality of GRIP is clearly demonstrated by comparing Figure 4 to Figure 3. The frequency distributions at the provincial level are essentially identical for both scenarios, indicating that no significant changes occur in the area of land under risk due to wind or water erosion when revenue insurance is added to crop insurance under the GRIP policy.

Figures I.1 through I.4 in Appendix I provide an alternative way to organize the same information presented in Figures 3 and 4. Cumulative distributions for all scenarios are presented on the same graph for each erosion source and province. Figure I.1(A), for example, shows the cumulative frequency of wind erosion per hectare in Alberta Baseline, GRIP, TILL, and INDCROP scenarios. The highest proportion of soil polygons at risk appears to be found under the INDCROP scenario. Figure I.1(B) shows the same sort of results for water erosion in

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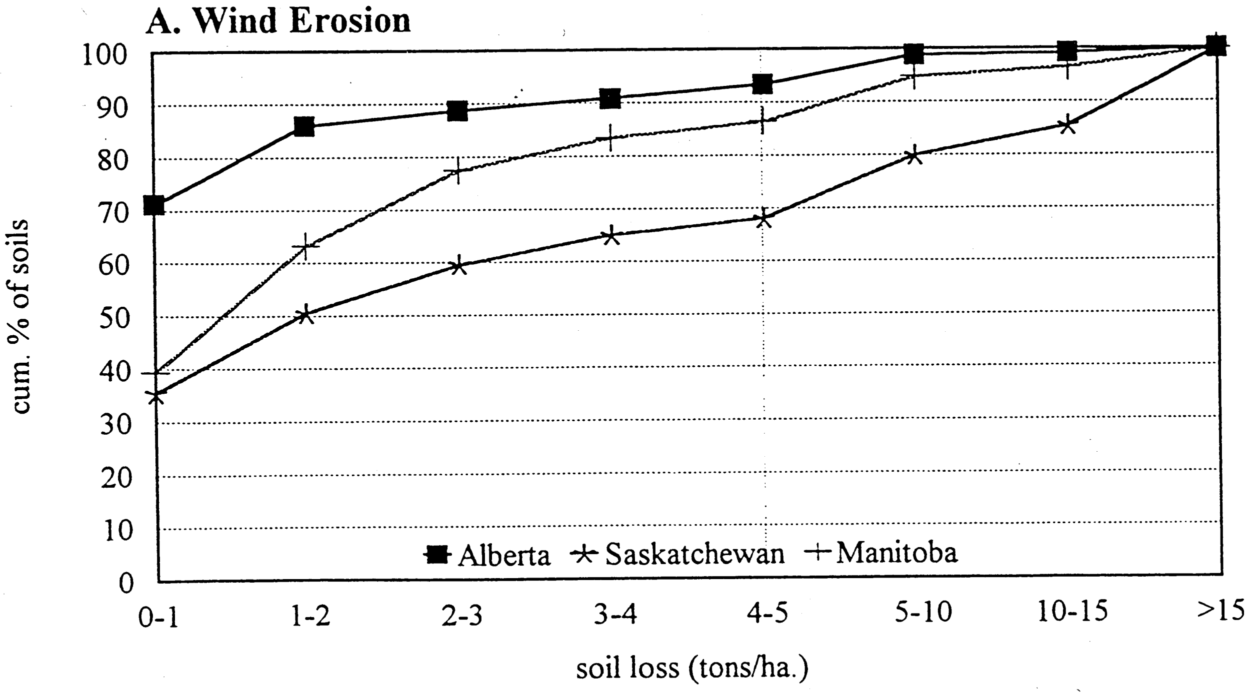
[9] In these erosion frequency distribution figures, the distribution closest to the horizontal axis is indicative of the highest erosion levels.



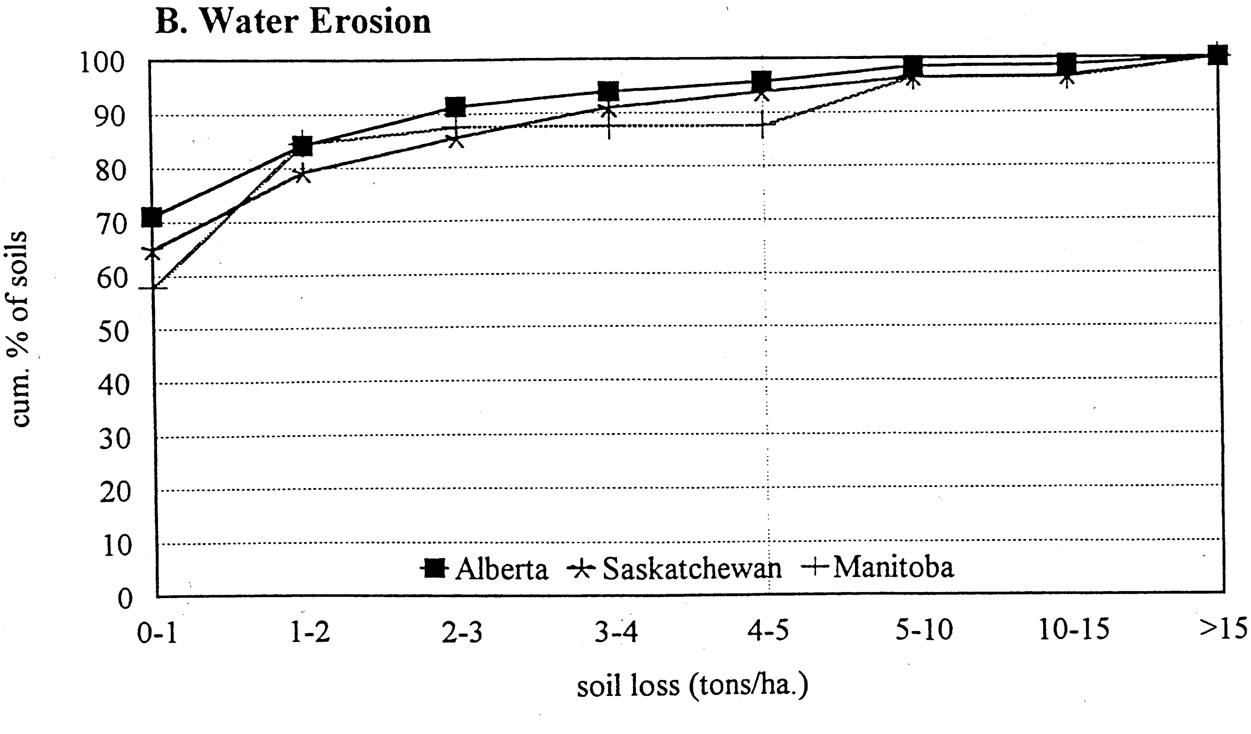
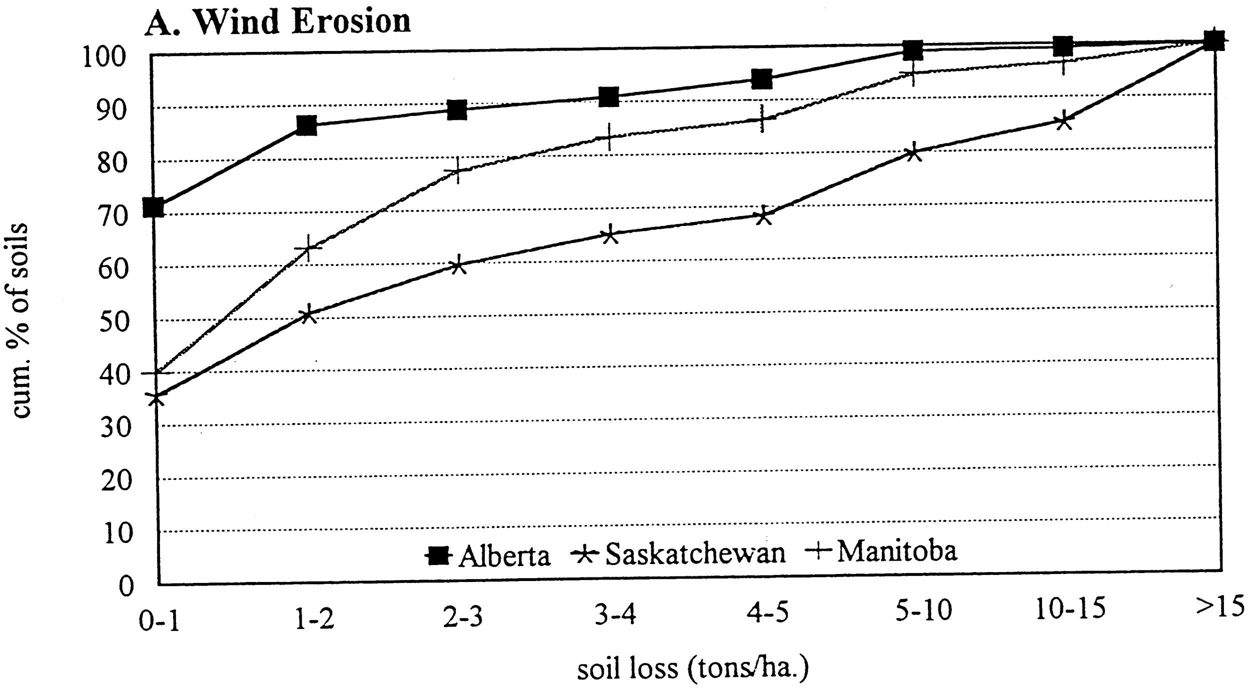


Figure 3. Cumulative Frequency Distribution of (A) Wind Erosion and (B) Water Erosion in the Baseline



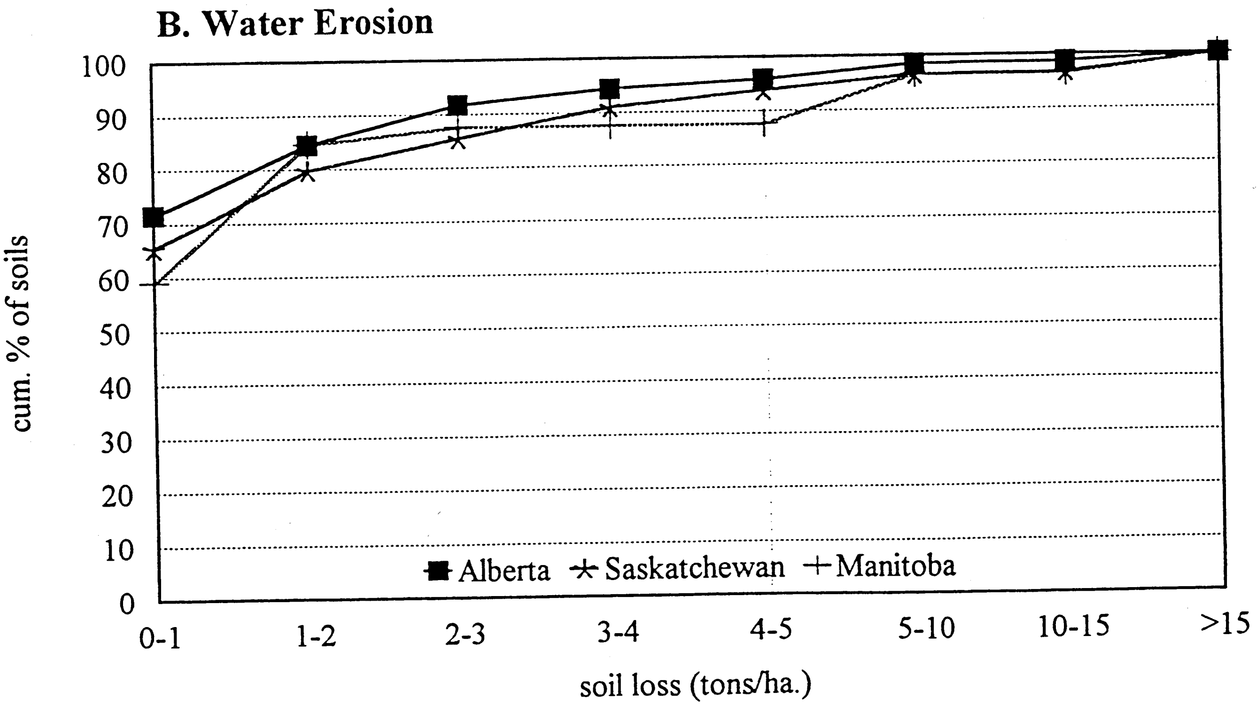


Figure 4. Cumulative Frequency Distribution of (A) Wind Erosion and (B) Water Erosion Under GRIP

Alberta. Figure I.2 shows the distributions by policy for Saskatchewan, and Figure I.3 for Manitoba.

In addition to detailed information by policy and province, distributions can be generated for individual crops by policy, tillage system, crop sequence, and province. Figure I.4, for example, gives the Baseline cumulative frequencies by tillage practice for wheat grown on stubble in Manitoba. Frequencies are shown only for conventional and no-till practices. Soil loss from both wind and water erosion is higher on land planted to conventional rather than no-till systems. A similar figure could be produced at the CRAM region or ARA level if such detail were desired.

F. Graphical Summary and Tradeoff Analysis

The various scenarios presented in this report are not necessarily comparable because baseline assumptions differ slightly in some cases. However, it is useful to compare the impacts predicted in each scenario to see how the model responds to the various conditions imposed on its structure. Figures 5 through 10 allow us to compare economic results across scenarios. Figure 11 further illustrates the tradeoffs between overall economic welfare and soil degradation impacts.

Figures 5, 6, and 7 illustrate the changes in cropping patterns predicted by the model. Figure 5 shows the impacts on total seeded area for each scenario relative to the baseline scenario. All three GRIP scenarios increase total seeded area, with the largest increase occurring under the assumption of a high risk aversion coefficient. Only the industrial crops scenario shows a decline in aggregate seeded area. Figure 6 illustrates changes in the distribution of land by crop sequence. The area of crops planted on stubble increases in all three GRIP scenarios relative to the baseline, and declines substantially under the INDCROP scenario as the additional canola area is planted to canola on summerfallow more often than to canola on stubble. Figure 7 shows the impacts on overall tillage distribution relative to the baseline scenario. The TILL scenario is omitted from the graph to preserve scale. In absolute terms, the biggest changes occur in areas planted to conventional tillage systems, primarily because more land is planted under such systems to begin with. Once again, the largest changes occur under the GRIPHR set of assumptions.

Figures 8, 9 and 10 compare welfare indicators for the various scenarios. Figure 8 indicates that the impacts of risk on producer surplus are not large for the TILL and INDCROP scenarios. For the GRIP and GRIPHR scenarios, however, the changes to the aggregate risk premium indicate that producer surplus is significantly impacted by changes in the level of risk reduction due to insurance programs. Moreover, the degree to which producers are assumed to be risk averse impacts the level of the aggregate risk premium, as indicated by the larger impact on aggregate risk under GRIPHR than under GRIP. Figure 9 shows that the largest increases in producer surplus for crop producers in the prairie provinces occur under the three GRIP scenarios. A much smaller increase occurs under the TILL scenario, and the INDCROP scenario results in a decline in producer surplus as land is forced away from optimal levels without compensating increases in unit returns to flax and canola. In terms of overall welfare as measured by total economic surplus for consumers as well as all producers across Canada, Figure 10 shows the biggest gains in the GRIP scenarios. Overall welfare increases for the TILL scenario, but declines significantly for the INDCROP scenario. The decline in overall welfare due to

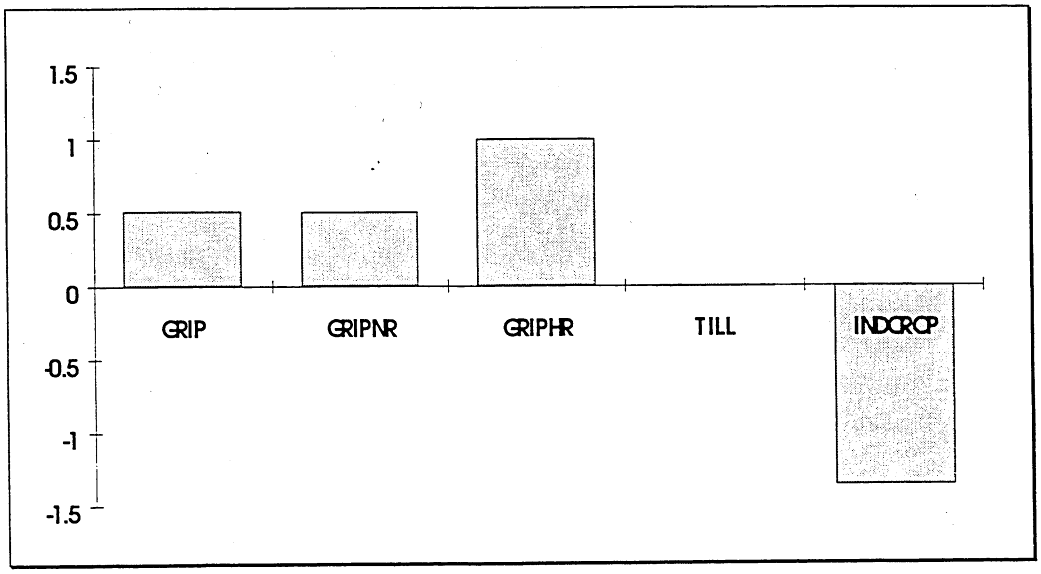


Figure 5. Seeded area by scenario, percentage changes from Baseline.

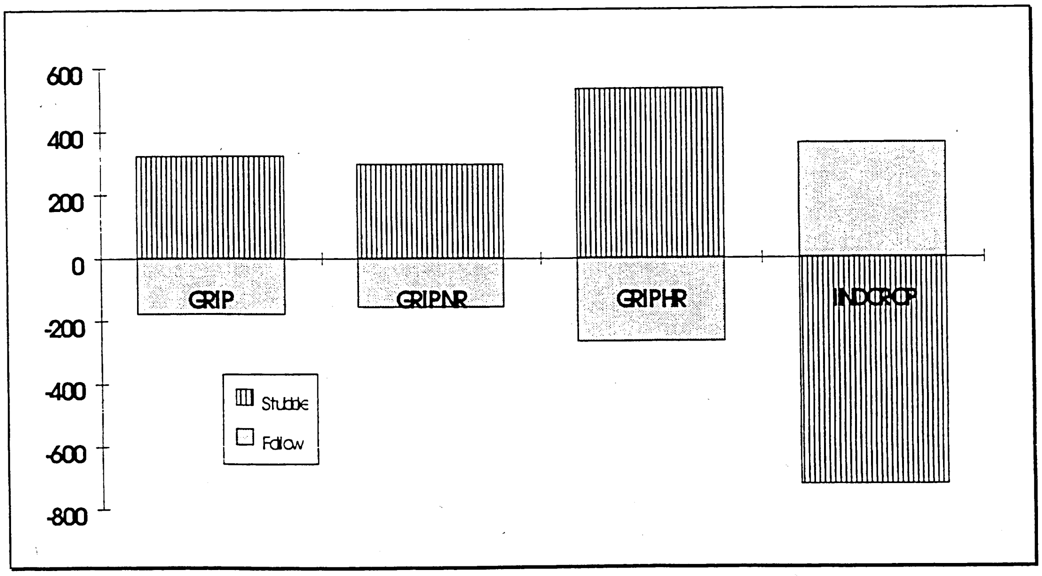


Figure 6: Stubble and fallow areas by scenario, changes from Baseline in thousand hectares.

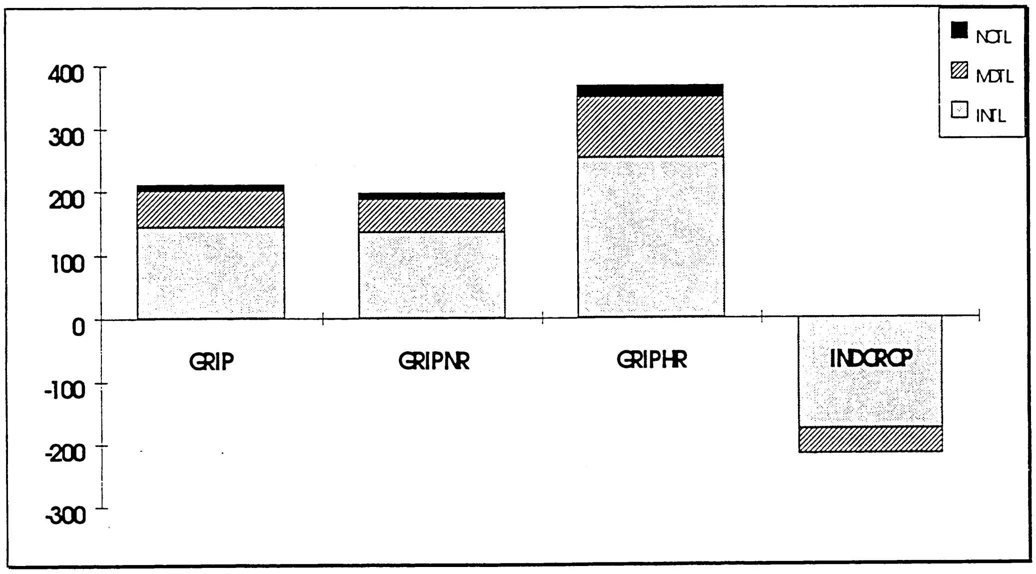


Figure 7: Tillage area by scenario, changes from Baseline in thousand hectares

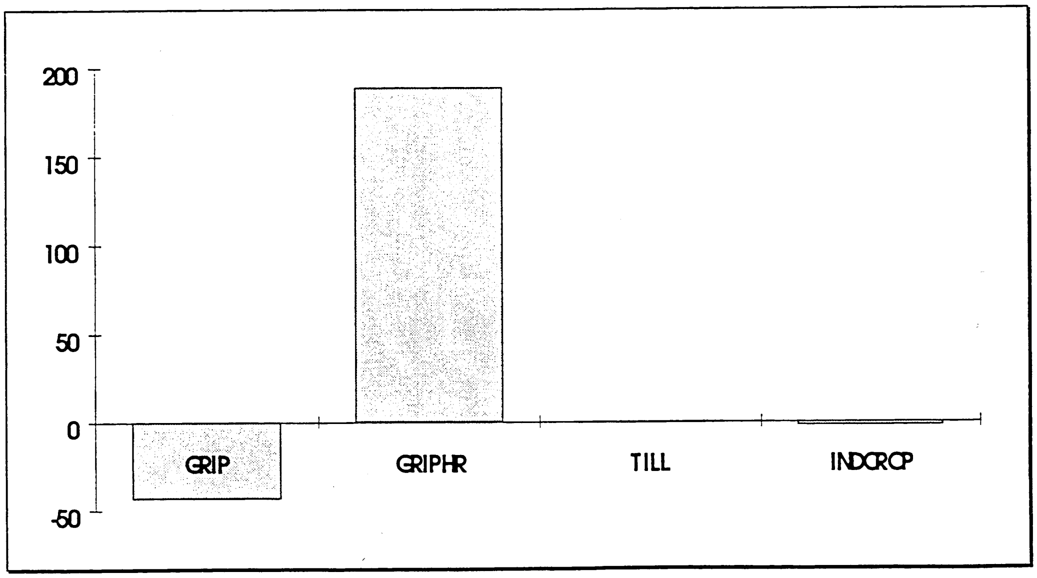


Figure 8. Aggregate risk premium by csenario, percentage difference from Baseline

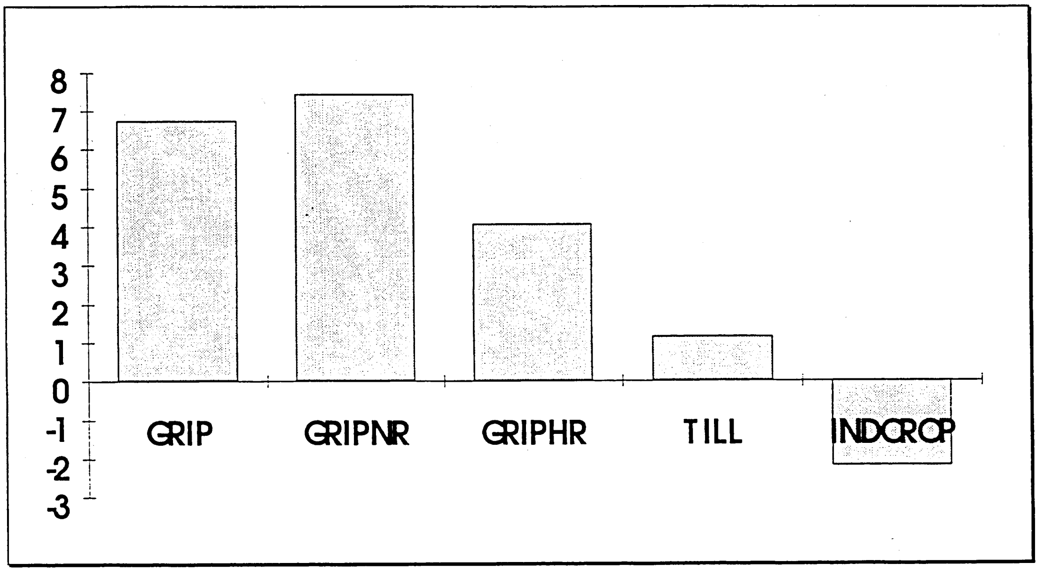


Figure 9. Crop producers' surplus by scenario, percentage difference from Baseline

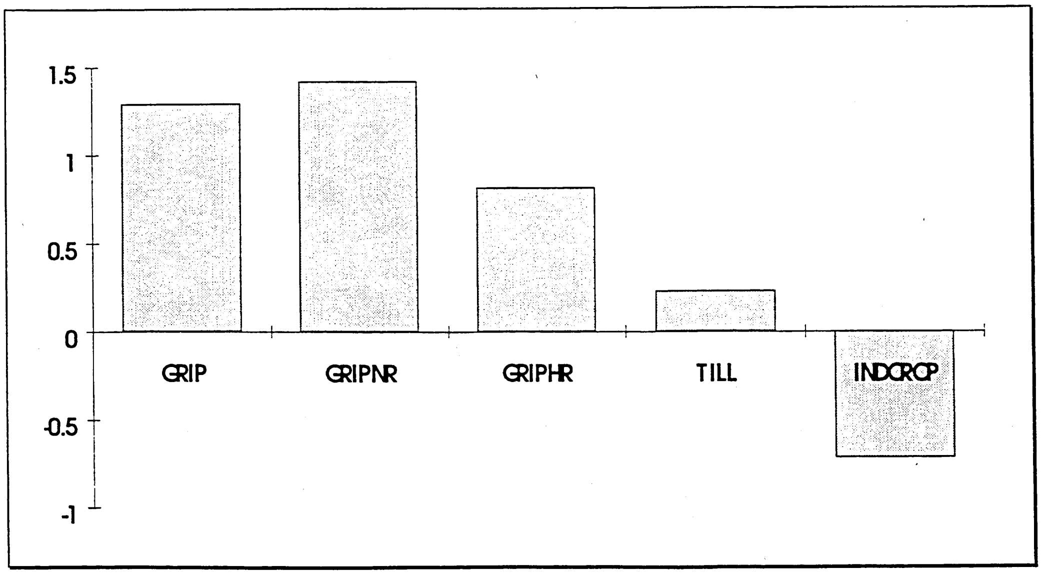


Figure 10. Consumer and producer surplus by scenario, percentage difference from Baseline

INDCROP indicates that losses in producer surplus are not compensated for by increases in consumer surplus that arise from the increased availability of flax and canola. Losses in the availability of other crop products may, on the whole, reduce consumer surplus as well as producer surplus.

Finally, Figure 11 illustrates the tradeoffs between soil degradation and economic welfare for the various scenarios. Total economic surplus (producer plus consumer surplus including risk adjustments) increases along the vertical axis and total soil loss increases along the horizontal axis. If policies are compared only on the basis of these two factors, one policy can be judged superior to another if the corresponding point in Figure 11 lies above (higher surplus) and to the left (lower erosion) of another. The Baseline is represented by point BL. Only the industrial crops scenario, represented by point INDC, is unambiguously worse than the baseline since it lies below and to the right of BL. GRIP may be judged superior to the Baseline and industrial crops scenarios since it is less erosive and produces a higher level of economic surplus than either scenario.

The remaining scenarios, TILL, GRIPNR, and GRIPHR are represented in Figure 11 as well, but are not strictly comparable to the other scenarios because their baseline economic assumptions differ. The position of these points with respect to total soil loss, however, can be instructive. The TILL scenario is obviously far less erosive than any other scenario and the three GRIP scenarios are only slightly less erosive than the baseline. Moreover, total soil loss among the three GRIP scenarios is fairly similar. Even though underlying assumptions regarding producer risk preferences differ among the three GRIP scenarios, one can conclude from Figure 11 with some confidence that the GRIP policy is superior to the Baseline regardless of the risk assumption.

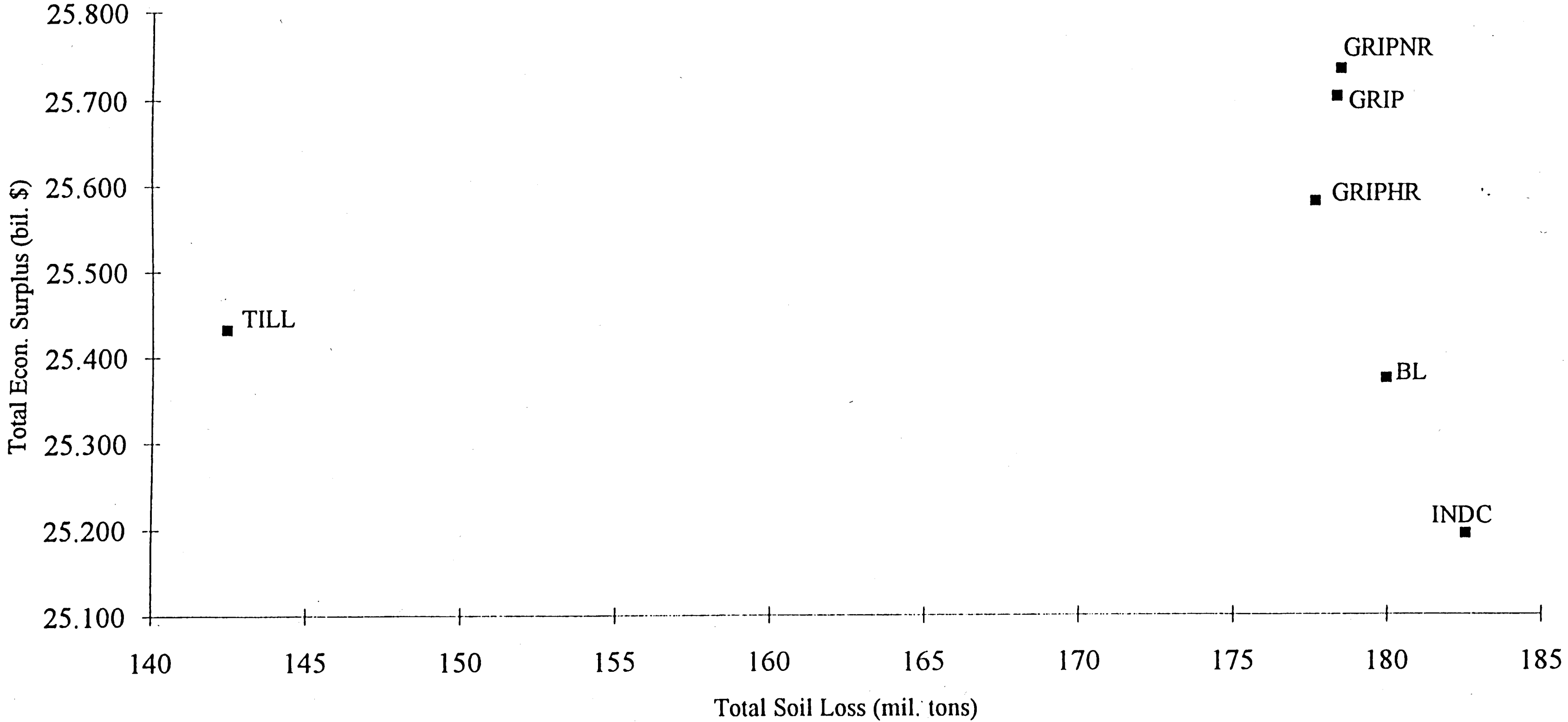


Figure 11. Trade-offs Between Total Economic Surplus and Total Soil Loss from Wind and Water Erosion

IV. Recommendations for Future Improvements

Several recommendations are given here for improving the application of RS-CRAM within the overall integrated modelling system. These recommendations are focused on data inputs and additional structural enhancements to RS-CRAM. The recommendations are as follows:

(1) Improved cost estimates are needed. The survey data obtained from Schoney (1993) used in this study do not provide reasonable or consistent estimates with respect to tillage practices in many cases.

(2) In conjunction with the cost data, reliable estimates of fertilizer use rates are needed in order to accurately account for nutrient loadings in different production regions. This would complement recommendation 3 for the environmental component, in which it was recommended that regionally specific management systems be simulated in EPIC.

(3) Improved reconciliation between EPIC generated yields and the historical average yields used in CRAM, especially with respect to lentils. Reconciliation is critical for proper estimates of insurance premiums and payouts as well as net returns, as used in variance calculations.

(4) Hay acreages in RS-CRAM are presently determined as a function of the demand from the livestock sector. Instead, hay should be treated like other cropping activities so that hay area can respond to the export demand for dehydrated alfalfa.

(5) Sunflower and fall rye cropping activities should be built into RS-CRAM. This will require reliable cost data to describe these activities (which are presently not available).

(6) The costs and yields for the "other crops" category in the prairie provinces need to be adjusted for lentils and field peas.

(7) Calibration would be facilitated by selectively omitting cropping activities with very small acreages. Primarily, these are cropping activities that are characterized as fallow and/or no-till cropping, that cover relatively small areas in certain production regions. These activities with small areas make PMP calibration difficult.

(8) Crop specific estimates of tillage percentages would improve model response to policy shocks. Percentages are presently assumed to be the same for all crops in a given CRAM region.

(9) Data for demand, transportation, and all livestock data were not updated for the 1992 base year. These data should be updated.

(10) Government payments data for non-insurance crops and for regions outside the Prairies needs to be revised for programs that are still in place or that have been eliminated. Similarly, payments to insured crops need to be revised to include payments from other government programs.

V. Summary

An integrated agro-ecological modelling system is constructed around a revised version of Agriculture Canada's CRAM, to allow for the assessment of economic and environmental impacts of proposed policies for the prairie provinces. The system consists of two major components: (1) an agricultural decision component which is RS-CRAM (Resource Sensitive CRAM), and (2) an environmental component that consists of an environmental database and environmental metamodels for wind and water erosion. The wind and water erosion metamodels are constructed on the basis of an experimentally designed set of EPIC simulations, and prove to be very statistically robust.

Several additions and enhancements are made to the original CRAM in order to develop RS-CRAM: (1) three levels of tillage are specified for each of the cropping activities (except 'other crops'), (2) lentils and field pea cropping activities are incorporated and other cropping activities are modified, (3) the yield inputs are modified to reflect EPIC estimated impacts of tillage, and stubble versus fallow cropping, (4) crop and GRIP insurance are explicitly modeled, and (5) a risk component is added to the model structure.

Evaluations of GRIP and four sensitivity scenarios are performed with the integrated system. Results generally follow expectations. GRIP raises producer incomes and overall welfare[10] (as measured by consumer plus producer surplus), and also tends to slightly lower overall erosion as total fallowed area declines. The model also proves to be robust with respect

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[10] The increase in consumer plus producer surplus includes the government contributions to GRIP. Therefore, the increase in welfare represents an improvement for the grains and oilseeds sector, but not necessarily for the economy as a whole.

to changes in assumptions on the magnitude of risk aversion, the distribution of tillage practices within CRAM regions, and changes in the allocation of cropland to industrial crops (flax and canola).

REFERENCES

Agriculture Canada. 1993a. “Agricultural Policies and Soil Degradation in Western Canada: An Agro-Ecological Economic Assessment (Report 1: Conceptual Framework).” Technical Report 2/93, Policy Branch, Ottawa, Ontario.

Agriculture Canada. 1993b. “Agricultural Policies and Soil Degradation in Western Canada: An Agro-Ecological Economic Assessment (Report 2: The Environmental Modelling System).” Technical Report 5/93, Policy Branch, Ottawa, Ontario.

Agriculture Canada. 1994. "Agricultural Policies and Soil Degradation in Western Canada: An Agro-Ecological Assessment (Report 3: The Integration of the Environmental and Economic Components)." Technical Report 1/94, Policy Branch, Ottawa, Ontario.

Bouzaher, A. and J.F. Shogren. 1992. “Modeling Nonpoint Source Pollution in an Integrated System.” Presented at The International Workshop on Environmental Policy Modeling, Steamboat Springs, Colorado.

Bouzaher, A., P.G. Lakshminarayan, R. Cabe, A. Carriquiry, P.W. Gassman, and J.F. Shogren. 1993. “Metamodels and Nonpoint Pollution Policy in Agriculture.” *Water Resources Research* 29(6): 1579-1587.

Brooke, Anthony, David Kendrick, and Alexander Meeraus. 1988. *GAMS: A User's Guide.* The Scientific Press Redwood City, CA.

Dumanski, J. 1992. Personal Communication. Centre for Land and Biological Resources Research, Agriculture Canada, Ottawa, Ontario.

Gameda, S. 1993. Personal Communication. Land Resource Research Centre, Research Branch, Agriculture Canada, Ottawa, Ontario.

Hazell, Peter B.R., Roger D. Norton. 1986. *Mathematical Programming for Economic Analysis in Agriculture*. Macmillan Publishing Co. New York, New York.

Hazell, P.B.R., P.L. Scandizzo. 1974. "Competitive Demand Structures under Risk in Agricultural Linear Programming Models." *American Journal of Agricultural Economics*. 56:235-44.

__________ 1977. "Farmers' Expectations, Risk Aversion, and Market Equilibrium under Risk." *American Journal of Agricultural Economics*. 59:204-19.

Horner, G.L., J. Corman, R.E. Howitt, C.A. Carter and R. J. MacGregor. 1992. The Canadian Regional Agriculture Model Structure, Operation and Development. Agriculture Canada, Ottawa Ontario.

House, Robert M. 1989. Risk Analysis in the USMP Regional Agricultural Model. Conference Proceedings. Southern Regional Research Project, S-232 1989 Annual Meeting, Sanibel Island, Florida.

Howitt, R. 1991. "Positive Mathematical Programming: University of California, Davis. Department of Agricultural Economics, . Working Paper No. 91-9. Davis, California.

Kirkwood, V., A. Bootsma, R. de Jong, J. Dumanski, J.C. Hiley, E.C. Huffman, A. Moore, C. Onofrei, W.W. Pettapiece, B. Vigier. 1993. "Documentation of the Database Files Associated with the Agroecological Resource Area Maps for Alberta, Saskatchewan, and Manitoba (Draft)." Centre for Land and Biological Resources Research, Agriculture Canada, Ottawa, Ontario.

Murtagh, Bruce A., and Michael A. Saunders. 1987. *Minos 5.1 User's Guide.* Technical Report SOL 83-20R. Stanford University. Stanford, CA.

PFRA (Prairie Farm Rehabilitation Administration). 1990. "Prairie Soils: The Case for Conservation." PFRA Soil and Water Conservation Service. Regina, Saskatchewan.

Schoney, Richard. 1993. Personal Communication. University of Saskatchewan, Saskatoon.

Webber, R.J., J.D. Graham, and K.K. Klein. 1986. "The Structure of CRAM: A Canadian Regional Agricultural Model." Department of Agricultural Economics, University of British Columbia, Vancouver, British Columbia.

Williams, J.R., C.A. Jones, and P.T. Dyke. 1984. "A Modeling Approach to Determining the Relationship Between Erosion and Soil Productivity." *Trans. ASAE* 27(1):129-144.

Williams, J.R. 1990. "The Erosion-Productivity Impact Calculator (EPIC) Model: A Case History." *Phil. Trans. R. Soc. Land. B* 329:421-28.

APPENDIX A

Updates and Additions to RS-CRAM Data Base

Table A.1. Additions and updates to CRAM database (GAMS table or parameter name in parentheses)

	Source	Remarks
<u>Land Use Patterns</u> Crop Acreage (TABLE CROPAC92)	Census 1991 Delivered by: Bruce Junkins (AG CANADA)	If area for any crop is less than 1 percent of the total area cropped in the region, the crop area was adjusted to equal 1 percent of the total cropped area in the region.
Proportion of Total Cropped Area Planted (PARAMETER PLANDUSE)	Census 1991 Delivered by: Bruce Junkins (AG CANADA)	Entered as delivered.
Land Use by Region and land class (TABLE LANDUSE)	Census 1991 Delivered by: Bruce Junkins (AG CANADA)	Entered as delivered.
Historical Harvested Areas for Saskatchewan (TABLE ACRE) Used only for 1992 version of GRIP	"Unknown" Delivered by: Bruce Junkins (AG CANADA)	Data for 1980 to 1990 were delivered. 1990 values used for 1991 and 1992. For Lentils and field peas, 1991 census values were used for every year. Other gaps were filled using most recent prior and subsequent year, where data were provided.
Tillage Ratios Tillage percentage (TABLE TI1)	"Unknown" Delivered by: Bruce Junkins (AG CANADA)	Values for no-till for SA regions 2, 4, & 7 seemed high. Set equal to 7 percent, at suggestion of AG CANADA. Excess no-till assigned to reduced till. Same aggregate tillage ratio is used for all crops.
<u>Yields</u> Crop yield time series (TABLE CROPYLDTS)	EPIC (CARD)	EPIC yields for wheat, barley, flax, and canola are adjusted to more closely correspond to historical average yields in each CRAM region. The mean EPIC yield over time was computed for each activity and compared to historical average yield for the corresponding crop aggregate (wheat, barley, etc.). A single adjustment factor is then calculated from these differences for each crop and applied to every EPIC yield corresponding to that crop. This process thus preserves the relationships generated by EPIC among crop sequences and tillage practices. EPIC yields for lentils and field peas were adjusted so that aggregate production in RS-CRAM matches historical production.

Table A.1 (continued)

	Source	Remarks
<u>Costs of Production</u> Variable Costs of Crop Production (TABLE CROPCSTHA)	(1) Data for SA: University of Saskatchewan Cost of production survey data. Delivered by: Dr. Richard Schoney (University of Saskatchewan, Saskatoon)	Costs sought by region, crop, and tillage are based on small sample sizes and generally inconsistent. Crop costs in the version of CRAM, prior to RS-CRAM, are considered accurate, but are not by tillage. Because machinery fuel, machinery repair and chemical costs are the major costs that vary by tillage, these costs are differentiated by tillage. To do so ratios for repair, fuel, and chemical costs are computed using SA survey data sent by Dr. Richard Schoney. These ratios are multiplied by the crop costs in the version of CRAM, prior to RS-CRAM, to differentiate them by tillage. The same ratios are used for SA, MA, and AL. For crop costs not available in the version of CRAM, prior to RS-CRAM (lentils and field peas) the costs are extracted from survey costs sent by Dr. Richard Schoney (for SA and MA) and data sent by Doug Barber (for AL).
	(2) Data for AL: “Unknown” Delivered by: Doug Barber (AG CANADA)	
<u>Insurance Data</u> Premium Percentages (TABLE PREMPCT)	AL: Alberta Crop Insurance Corporation SA: Saskatchewan Crop Insurance Corporation MA: Manitoba Crop Insurance Corporation Delivered by: Hartley Furtan, University of Saskatchewan	The original premium percentages for crop insurance by risk region, converted to CRAM regions using weights provided by Rick Steinke (CWB). The GRIP premium percentages received by province and same percentage applied to all CRAM regions within each province.
GRIP Indexed moving average prices (TABLE IMAP1)	AG CANADA Delivered by: Rick Steinke (CWB)	Entered as delivered.
Farm gate prices for crops: Port prices (TABLE PORTPRICES) Transport cost index (PARAMETER CROWRATE) Lentils and field peas farm level prices (TABLE OTMAP)	“Unknown” Delivered by: Robert MacGregor	Port prices and an index of transportation costs are provided. Transportation costs from farm to provincial hub and from provincial hub to ports are computed and deducted from the port prices, to arrive at the farm gate prices. For lentils and field peas, farm level prices are provided.
Crop yield insurance prices, max price option (TABLE INSPRICE)	"Unknown" Delivered by : Robert MacGregor	Prices are the same for all CRAM regions within a given province. Missing data are filled using prices from adjacent regions.

Table A.2 Land class areas by region, 1991 (hectares)

Region	CROPLAND	HAYLAND	PASTLAND	UNIMPLND
AL.1	1,220,789	83,607	199,790	2,127,175
AL.2	1,935,739	134,762	167,495	968,675
AL.3	959,549	177,600	184,171	994,949
AL.4	2,181,338	209,111	301,535	859,858
AL.5	865,901	416,798	342,814	532,356
AL.6	691,018	446,702	340,061	677,124
AL.7	1,426,979	286,278	206,613	513,962
SA.1	1,484,496	76,065	69,706	342,605
SA.2	1,738,962	46,159	50,569	224,943
SA.3	3,415,375	115,348	192,913	1,429,495
SA.4	1,057,684	53,276	121,585	1,036,883
SA.5	2,513,524	134,146	132,669	468,711
SA.6	2,518,695	122,197	106,323	413,269
SA.7	1,956,829	31,669	82,410	446,693
SA.8	1,583,574	134,605	74,994	155,665
SA.9	1,921,837	231,327	244,487	879,451
MA.1	1,516,253	173,635	96,594	445,972
MA.2	711,025	167,404	94,999	515,875
MA.3	618,025	76,670	44,521	131,187
MA.4	755,239	40,428	18,779	80,316
MA.5	366,836	84,657	18,837	102,588
MA.6	381,081	155,098	67,561	474,566

Source: 1991 Agricultural Census.

Table A.3. Portion (percent) of the total cropped area that is planted to crops

Province	CRAM Region	Percent of cropped area planted to crops[a]
Alberta	1	0.6133
	2	0.7103
	3	0.9108
	4	0.8612
	5	0.9357
	6	0.8767
	7	0.8534
Saskatchewan	1	0.7009
	2	0.6483
	3	0.5756
	4	0.5571
	5	0.7684
	6	0.6778
	7	0.6162
	8	0.8316
	9	0.8294
Manitoba	1	0.9105
	2	0.8824
	3	0.9732
	4	0.9868
	5	0.9493
	6	0.9147

[a] From Gameda (1993).

Table A.4. Proportion of tillage systems by prairie province and CRAM region based on 1991 census[a]

Province	CRAM Region	Conventional	Reduced	No-Till
Alberta	1	63.2	27.6	9.2
	2	62.8	31.9	5.3
	3	79.6	37.2	1.7
	4	73.2	25.1	1.7
	5	85.3	13.8	0.8
	6	83.4	15.7	1.0
	7	81.9	16.5	1.5
Saskatchewan	1	65.3	28.2	6.5
	2	54.9	38.1	7.0
	3	58.8	28.3	12.8
	4	52.0	41.0	7.0
	5	73.1	21.1	5.8
	6	60.7	29.3	10.1
	7	51.2	41.8	7.0
	8	74.9	21.6	3.4
	9	73.0	24.7	2.3
Manitoba	1	63.1	31.5	5.4
	2	74.0	23.5	2.5
	3	67.4	26.9	5.7
	4	63.9	31.1	5.1
	5	69.3	24.9	5.8
	6	71.5	22.7	5.8

[a] From Gameda (1993).

Table A.5. 1991 Census acreages used in RS-CRAM (thousand hectares)

REGION	WHEAT	BARLEY	FLAX	CANOLA	LENTILS	FLDPEAS	OTHER	TOTAL
AL.1	538.20	55.44	2.58	28.76	0.65	0.33	102.11	728.07
AL.2	819.50	315.01	8.96	104.13	1.83	4.40	83.19	1337.03
AL.3	302.06	387.89	1.07	74.31	0.56	3.29	80.72	849.89
AL.4	703.30	463.89	9.16	407.26	1.20	15.79	226.10	1826.71
AL.5	125.26	421.77	0.76	120.72	0.30	16.71	102.36	787.86
AL.6	85.12	267.92	0.89	96.15	0.15	10.44	128.48	589.14
AL.7	462.67	214.86	4.35	342.22	0.11	14.80	145.26	1184.26
SA.1	804.60	70.58	17.03	37.05	5.64	0.94	75.91	1011.75
SA.2	932.64	49.35	14.43	12.43	28.91	2.53	55.97	1096.27
SA.3	1703.38	72.21	8.17	6.09	32.35	0.98	88.50	1911.66
SA.4	486.78	27.33	0.48	1.94	2.15	0.39	54.35	573.03
SA.5	1122.96	279.39	50.30	310.11	15.65	14.30	85.54	1878.26
SA.6	1226.20	171.87	19.98	119.13	42.47	3.30	77.09	1660.04
SA.7	832.24	134.92	8.06	79.60	26.75	4.32	86.66	1172.55
SA.8	604.22	225.40	72.28	291.22	9.95	20.91	56.61	1280.60
SA.9	646.28	275.09	23.59	441.12	10.38	29.54	124.11	1550.12
MA.1	796.60	206.78	54.17	150.56	8.84	5.35	120.17	1342.48
MA.2	345.33	70.99	20.05	113.93	5.87	5.41	48.50	610.09
MA.3	281.61	68.57	50.26	78.41	11.91	6.36	87.78	584.91
MA.4	367.91	78.22	55.10	73.52	20.93	26.75	102.27	724.71
MA.5	167.27	48.65	37.22	29.89	3.78	3.77	48.06	338.63
MA.6	155.36	56.22	26.39	47.47	1.22	2.49	49.83	338.98

Table A.6. Crop insurance prices, maximum price options, 1980-92 ($/tonne)

Province.Crop	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
AL.WHEATHQ	130	140	150	150	150	150	150	115	110	160	145	92	98
AL.BARLEY	90	110	120	120	120	120	105	65	60	95	87	66	75
AL.CANOLA	220	230	250	250	260	280	280	210	240	265	260	250	247
AL.FLAX	220	240	260	260	270	280	280	205	200	280	280	248	168
AL.LENTILS	240	360	400	400	360	360	300	300	300	330	400	375	265
AL.FLDPEAS	170	170	170	170	170	170	170	170	170	165	175	170	165
SA.WHEATHQ	130	140	150	150	150	150	150	115	110	170	145	90	110
SA.BARLEY	90	110	120	120	120	120	100	65	60	95	87	65	80
SA.CANOLA	220	230	250	250	260	280	280	210	240	265	240	250	255
SA.FLAX	220	240	260	260	270	280	280	205	200	280	255	250	170
SA.LENTILS	240	360	400	400	360	360	360	360	250	360	400	375	320
SA.FLDPEAS	130	140	160	160	160	170	170	170	160	175	175	195	165
MA.WHEATHQ	130	140	150	150	150	150	150	115	110	170	145	90	111
MA.BARLEY	90	110	120	120	120	120	105	65	65	95	85	65	78
MA.CANOLA	225	230	250	250	260	280	280	210	240	265	260	235	255
MA.FLAX	220	240	260	260	270	280	280	205	200	280	280	215	170
MA.LENTILS	300	300	300	300	300	300	300	300	250	330	400	375	300
MA.FLDPEAS	140	170	195	195	170	170	170	170	160	165	175	190	165

Source: Agriculture Canada.

Table A.7. IMAP prices, 1980-92 ($/tonne)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
WHEATHQ	182.50	213.45	228.27	232.89	238.46	241.70	236.35	232.70	232.74	235.22	241.75	225.55	213.92
BARLEY	127.62	147.92	155.29	157.16	160.10	161.46	157.62	156.07	156.93	158.96	161.68	143.57	137.65
CANOLA	349.16	412.55	433.40	435.71	445.25	452.76	448.93	442.65	442.40	446.40	460.33	440.78	401.36
FLAX	388.39	453.38	476.30	480.00	490.30	488.95	471.54	457.44	460.30	464.20	472.48	436.37	399.13
LENTILS	581.11	672.32	712.87	724.64	730.06	722.60	682.94	657.26	665.41	688.16	724.79	739.59	661.33
FLDPEAS	258.65	302.43	318.19	319.78	324.51	324.88	309.94	299.75	298.32	301.71	306.10	304.08	275.95

Source: Canadian Wheat Board.

Table A.8. Port prices for insured crops ($/tonne)

Year	WHEATHQ	BARLEY	FLAX	CANOLA
1970	61.40	41.79	99.86	122.78
1971	58.64	37.20	101.24	108.94
1972	79.15	67.26	190.06	160.48
1973	168.21	119.06	399.38	279.78
1974	164.39	107.05	375.68	318.90
1975	146.28	104.06	274.12	226.80
1976	117.14	91.50	275.98	288.99
1977	120.30	88.39	225.93	296.19
1978	160.53	91.08	303.72	316.02
1979	196.43	107.47	328.95	309.10
1980	222.12	146.55	377.75	331.16
1981	199.62	131.07	352.12	325.21
1982	192.34	110.00	293.79	307.83
1983	193.98	138.02	364.29	455.40
1984	186.37	131.30	352.35	387.32
1985	160.00	110.00	293.22	303.02
1986	130.00	80.00	210.72	239.86
1987	134.02	74.08	245.92	302.05
1988	197.14	124.23	387.15	337.88
1989	172.11	124.38	373.95	303.67
1990	135.00	90.00	232.15	287.86
1991	136.00	100.00	199.00	274.50
1992	150.00	96.00	265.00	325.00

Source: Agriculture Canada.

Table A.9. Farmgate prices for lentils and field peas, 1980-92 ($/tonne)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
MA.LENTILS	595.25	507.06	385.81	308.65	396.83	473.99	396.83	330.69	315.26	396.83	418.88	312.67	232.73
SA.LENTILS	593.93	440.92	330.69	330.69	407.86	661.39	473.99	264.55	365.97	440.92	438.72	312.38	280.46
AL.LENTILS	640.89	529.00	396.00	400.00	550.00	465.00	465.00	262.00	416.00	444.00	448.00	306.00	272.39
MA.FLDPEAS	238.10	249.86	192.90	219.73	227.08	211.28	189.96	194.01	214.95	187.03	177.84	171.51	172.61
SA.FLDPEAS	174.90	209.07	200.62	176.37	200.62	209.44	194.01	176.37	198.42	180.78	174.17	166.65	175.43
AL.FLDPEAS	187.39	220.09	256.84	253.16	213.00	210.00	196.00	173.00	201.00	180.00	184.00	161.45	173.77

Source: Agriculture Canada.

APPENDIX B

Adjusted EPIC Yields Used in RS-CRAM

Table B.1. Adjusted EPIC yields used in RS-CRAM (tonnes/ha)

	INTL	MDTL	NOTL
AL.1.WHTHQSF	1.64	1.66	1.67
AL.1.WHTHQSB	1.33	1.34	1.35
AL.1.BARSB	2.13	2.19	2.20
AL.1.FLAXSB	1.13	1.14	1.14
AL.1.CANSF	1.29	1.30	1.30
AL.1.LENTSB	0.60	0.61	0.61
AL.1.FLDPSB	1.60	1.59	1.58
AL.2.WHTHQSF	2.18	2.23	2.25
AL.2.WHTHQSB	1.97	1.99	2.00
AL.2.BARSB	2.76	2.89	2.90
AL.2.FLAXSB	1.06	1.06	1.06
AL.2.CANSF	1.52	1.53	1.54
AL.2.CANSB	1.25	1.26	1.26
AL.2.LENTSB	0.70	0.71	0.71
AL.2.FLDPSB	1.60	1.59	1.59
AL.3.WHTHQSF	1.78	1.79	1.80
AL.3.WHTHQSB	1.93	1.94	1.94
AL.3.BARSB	2.27	2.52	2.52
AL.3.FLAXSB	0.79	0.79	0.79
AL.3.CANSF	1.27	1.29	1.29
AL.3.CANSB	1.04	1.06	1.06
AL.3.LENTSB	0.84	0.85	0.85
AL.3.FLDPSB	1.60	1.60	1.59
AL.4.WHTHQSF	1.88	1.88	1.89
AL.4.WHTHQSB	2.21	2.18	2.17
AL.4.BARSB	2.58	2.69	2.68
AL.4.FLAXSB	1.00	1.00	0.99
AL.4.CANSF	1.24	1.25	1.25
AL.4.CANSB	1.36	1.35	1.34
AL.4.LENTSB	1.28	1.28	1.27
AL.4.FLDPSB	1.59	1.59	1.58
AL.5.WHTHQSF	2.50	2.48	2.50
AL.5.WHTHQSB	3.00	2.94	2.94
AL.5.BARSB	2.93	3.10	3.10
AL.5.FLAXSB	1.13	1.13	1.13
AL.5.CANSF	1.34	1.34	1.35
AL.5.CANSB	1.45	1.44	1.44
AL.5.LENTSB	0.99	0.99	0.99
AL.5.FLDPSB	1.61	1.60	1.59
AL.6.WHTHQSF	2.56	2.50	2.49
AL.6.WHTHQSB	2.08	2.05	2.04
AL.6.BARSB	2.69	2.78	2.78
AL.6.FLAXSB	1.03	1.03	1.03
AL.6.CANSF	1.08	1.08	1.09

Table B.1. Continued

	INTL	MDTL	NOTL
AL.6.CANSB	1.42	1.41	1.41
AL.6.LENTSB	1.13	1.14	1.13
AL.6.FLDPSB	1.61	1.60	1.59
AL.7.WHTHQSF	1.86	1.87	1.88
AL.7.WHTHQSB	2.18	2.13	2.12
AL.7.BARSB	2.21	2.29	2.28
AL.7.FLAXSB	0.74	0.74	0.73
AL.7.CANSF	0.98	0.99	0.99
AL.7.CANSB	1.12	1.11	1.10
AL.7.LENTSB	1.13	1.14	1.13
AL.7.FLDPSB	1.44	1.43	1.42
SA.1.WHTHQSF	1.46	1.46	1.47
SA.1.WHTHQSB	1.80	1.78	1.78
SA.1.BARSB	1.95	2.05	2.04
SA.1.FLAXSB	0.93	0.93	0.93
SA.1.CANSF	1.03	1.03	1.03
SA.1.CANSB	1.17	1.17	1.16
SA.1.LENTSF	1.07	1.07	1.07
SA.1.LENTSB	1.11	1.11	1.11
SA.1.FLDPSB	1.29	1.29	1.29
SA.2.WHTHQSF	1.58	1.60	1.61
SA.2.WHTHQSB	1.72	1.70	1.70
SA.2.BARSB	1.97	2.10	2.11
SA.2.FLAXSB	0.93	0.93	0.93
SA.2.CANSF	1.25	1.25	1.25
SA.2.CANSB	0.91	0.91	0.91
SA.2.LENTSF	0.98	0.98	0.99
SA.2.LENTSB	1.11	1.11	1.11
SA.2.FLDPSB	1.31	1.31	1.30
SA.3.WHTHQSF	1.50	1.52	1.53
SA.3.WHTHQSB	1.31	1.31	1.32
SA.3.BARSB	1.71	1.82	1.83
SA.3.FLAXSB	0.78	0.78	0.78
SA.3.CANSF	0.63	0.63	0.64
SA.3.CANSB	0.61	0.61	0.61
SA.3.LENTSF	0.89	0.90	0.90
SA.3.LENTSB	1.11	1.11	1.11
SA.3.FLDPSB	1.27	1.27	1.27
SA.4.WHTHQSF	1.55	1.57	1.59
SA.4.WHTHQSB	1.22	1.24	1.25
SA.4.BARSB	1.69	1.79	1.80
SA.4.FLAXSB	0.95	0.95	0.95
SA.4.CANSF	1.11	1.11	1.11
SA.4.CANSB	1.07	1.07	1.07
SA.4.LENTSF	0.80	0.81	0.81

Table B.1. Continued

	INTL	MDTL	NOTL
SA.4.LENTSB	1.11	1.11	1.11
SA.4.FLDPSB	1.25	1.26	1.26
SA.5.WHTHQSF	1.56	1.56	1.57
SA.5.WHTHQSB	2.13	2.12	2.12
SA.5.BARSB	2.28	2.41	2.41
SA.5.FLAXSB	1.13	1.13	1.13
SA.5.CANSF	1.17	1.17	1.18
SA.5.CANSB	1.36	1.36	1.35
SA.5.LENTSF	1.03	1.03	1.03
SA.5.LENTSB	1.11	1.11	1.11
SA.5.FLDPSB	1.39	1.38	1.37
SA.6.WHTHQSF	1.60	1.61	1.62
SA.6.WHTHQSB	1.78	1.77	1.77
SA.6.BARSB	2.07	2.19	2.19
SA.6.FLAXSB	1.07	1.07	1.07
SA.6.CANSF	1.16	1.16	1.17
SA.6.CANSB	1.21	1.21	1.20
SA.6.LENTSF	0.97	0.97	0.97
SA.6.LENTSB	1.11	1.11	1.11
SA.6.FLDPSB	1.25	1.25	1.24
SA.7.WHTHQSF	1.81	1.82	1.82
SA.7.WHTHQSB	1.87	1.87	1.87
SA.7.BARSB	2.29	2.36	2.36
SA.7.FLAXSB	1.02	1.02	1.02
SA.7.CANSF	1.35	1.35	1.35
SA.7.CANSB	1.30	1.31	1.30
SA.7.LENTSF	0.89	0.89	0.90
SA.7.LENTSB	1.11	1.11	1.11
SA.7.FLDPSB	1.24	1.24	1.24
SA.8.WHTHQSF	2.17	2.16	2.16
SA.8.WHTHQSB	1.53	1.52	1.52
SA.8.BARSB	2.48	2.55	2.54
SA.8.FLAXSB	1.24	1.24	1.24
SA.8.CANSF	1.17	1.17	1.18
SA.8.CANSB	1.34	1.34	1.33
SA.8.LENTSF	1.00	1.00	1.00
SA.8.LENTSB	1.11	1.11	1.11
SA.8.FLDPSB	1.42	1.41	1.40
SA.9.WHTHQSF	1.72	1.72	1.72
SA.9.WHTHQSB	2.13	2.10	2.09
SA.9.BARSB	2.47	2.54	2.53
SA.9.FLAXSB	1.22	1.22	1.22
SA.9.CANSF	1.22	1.22	1.22
SA.9.CANSB	1.42	1.41	1.40
SA.9.LENTSF	0.95	0.95	0.96

Table B.1. Continued

	INTL	MDTL	NOTL
SA.9.LENTSB	1.11	1.11	1.11
SA.9.FLDPSB	1.46	1.44	1.43
MA.1.WHTHQSF	1.71	1.73	1.74
MA.1.WHTHQSB	2.23	2.21	2.21
MA.1.BARSB	2.55	2.69	2.69
MA.1.FLAXSB	0.93	0.93	0.93
MA.1.CANSF	1.18	1.19	1.18
MA.1.CANSB	0.98	0.98	0.98
MA.1.LENTSB	1.06	1.07	1.06
MA.1.FLDPSB	1.38	1.37	1.37
MA.2.WHTHQSF	1.76	1.76	1.77
MA.2.WHTHQSB	2.27	2.25	2.24
MA.2.BARSB	2.47	2.55	2.54
MA.2.FLAXSB	1.00	1.00	0.99
MA.2.CANSF	1.12	1.13	1.12
MA.2.LENTSB	1.03	1.03	1.03
MA.2.FLDPSB	1.44	1.43	1.42
MA.3.WHTHQSF	2.33	2.32	2.31
MA.3.WHTHQSB	1.97	1.97	1.96
MA.3.BARSB	2.72	2.89	2.88
MA.3.FLAXSB	1.02	1.02	1.02
MA.3.CANSF	1.25	1.26	1.26
MA.3.CANSB	1.03	1.04	1.04
MA.3.LENTSB	1.00	0.99	0.99
MA.3.FLDPSB	1.28	1.28	1.27
MA.4.WHTHQSF	2.42	2.39	2.39
MA.4.WHTHQSB	2.06	2.03	2.03
MA.4.BARSB	2.87	3.04	3.04
MA.4.FLAXSB	1.12	1.12	1.12
MA.4.CANSF	1.28	1.29	1.29
MA.4.CANSB	1.06	1.07	1.07
MA.4.LENTSF	1.04	1.04	1.04
MA.4.LENTSB	1.03	1.03	1.02
MA.4.FLDPSB	1.31	1.31	1.30
MA.5.WHTHQSF	2.48	2.45	2.44
MA.5.WHTHQSB	1.75	1.73	1.72
MA.5.BARSB	2.61	2.74	2.74
MA.5.FLAXSB	1.11	1.11	1.11
MA.5.CANSF	1.11	1.12	1.11
MA.5.LENTSB	1.02	1.02	1.02
MA.5.FLDPSB	1.27	1.26	1.25
MA.6.WHTHQSF	2.38	2.35	2.35
MA.6.WHTHQSB	1.67	1.65	1.65
MA.6.BARSB	2.50	2.60	2.60
MA.6.FLAXSB	0.98	0.98	0.97

Table B.1. Continued

	INTL	MDTL	NOTL
MA.6.CANSF	1.01	1.02	1.02
MA.6.LENTSB	1.05	1.04	1.04
MA.6.FLDPSB	1.30	1.29	1.28

APPENDIX C

Baseline Average Activity Costs Used in RS-CRAM

Table C.1. Baseline average activity costs used in RS-CRAM ($/ha)

Region & Activity	INTL	MDTL	NOTL	COMTL
AL.1.SUMFAL	27.96	26.81	25.49	
AL.1.WHTHQSF	97.66	94.65	91.18	
AL.1.WHTHQSB	123.8	122.42	120.14	
AL.1.BARSB	146.18	146.14	144.28	
AL.1.FLAXSB	108.12	106.65	103.75	
AL.1.CANSF	136.22	134.88	132.43	
AL.1.LENTSB	93.84	95.15	94.96	
AL.1.FLDPSB	105.06	104.88	103.79	
AL.1.OTHSF				125.3
AL.1.OTHSB				105.8
AL.2.SUMFAL	30.1	28.88	27.52	
AL.2.WHTHQSF	95.15	92.46	89.22	
AL.2.WHTHQSB	112.99	111.65	109.47	
AL.2.BARSB	129.52	130.91	129.89	
AL.2.FLAXSB	88.41	87.07	84.28	
AL.2.CANSF	130.87	130.03	127.94	
AL.2.CANSB	135.47	135.09	133.21	
AL.2.LENTSB	109.79	110.05	109.24	
AL.2.FLDPSB	135.34	134.5	133.1	
AL.2.OTHSF				128.25
AL.2.OTHSB				100.63
AL.3.SUMFAL	27.66	26.53	25.21	
AL.3.WHTHQSF	97.83	94.79	91.29	
AL.3.WHTHQSB	122.29	120.91	118.64	
AL.3.BARSB	139.75	140.62	139.3	
AL.3.FLAXSB	101.81	100.18	97.18	
AL.3.CANSF	136.82	135.43	132.92	
AL.3.CANSB	147.64	147.23	145.12	
AL.3.LENTSB	102.02	103.26	103.48	
AL.3.FLDPSB	110.49	113.53	113.97	
AL.3.OTHSF				124.98
AL.3.OTHSB				99.48
AL.4.SUMFAL	27.3	26.98	25.39	
AL.4.WHTHQSF	124.43	124.47	122.09	
AL.4.WHTHQSB	132.03	131.83	129.84	
AL.4.BARSB	149.74	148.63	145.86	
AL.4.FLAXSB	104.08	104.62	104.62	
AL.4.CANSF	95.66	95.97	94.6	
AL.4.CANSB	147.01	148.21	147.06	
AL.4.LENTSB	77.86	80.2	80.63	
AL.4.FLDPSB	74.75	75.23	74.44	
AL.4.OTHSF				115.67
AL.4.OTHSB				153.1
AL.5.SUMFAL	47.05	47.2	46.4	

Table C.1. Continued

Region & Activity	INTL	MDTL	NOTL	COMTL
AL.5.WHTHQSF	121.98	122.31	120.82	
AL.5.WHTHQSB	150.66	150.21	148.1	
AL.5.BARSB	178.16	178.17	175.9	
AL.5.FLAXSB	137.49	133.48	127.56	
AL.5.CANSF	157.77	157.08	154.24	
AL.5.CANSB	196.68	198.23	197.1	
AL.5.LENTSB	96.56	97.84	97.79	
AL.5.FLDPSB	115.8	114.91	112.99	
AL.5.OTHSF				135.89
AL.5.OTHSB				148.16
AL.6.SUMFAL	36.81	34.96	32.42	
AL.6.WHTHQSF	158.17	157.04	152.51	
AL.6.WHTHQSB	149.29	149.26	146.69	
AL.6.BARSB	173.32	171.58	167.08	
AL.6.FLAXSB	144.01	140	134.08	
AL.6.CANSF	149.71	151.95	150.35	
AL.6.CANSB	185	186.47	184.67	
AL.6.LENTSB	92.15	93.77	93.97	
AL.6.FLDPSB	85.79	85.01	83.14	
AL.6.OTHSF				123.65
AL.6.OTHSB				148.16
AL.7.SUMFAL	34.32	32.66	30.37	
AL.7.WHTHQSF	101.1	99.5	96.13	
AL.7.WHTHQSB	140.74	138.47	134.36	
AL.7.BARSB	114.12	111.19	106.35	
AL.7.FLAXSB	124.97	126.77	125.66	
AL.7.CANSF	66.84	67.44	66.5	
AL.7.CANSB	64.57	65.13	64.61	
AL.7.LENTSB	97.1	98.53	98.74	
AL.7.FLDPSB	61.61	62.44	61.88	
AL.7.OTHSF				114.27
AL.7.OTHSB				147.75
SA.1.SUMFAL	22.61	22.16	21.76	
SA.1.WHTHQSF	100.42	100.71	100.2	
SA.1.WHTHQSB	174.56	174.7	173.12	
SA.1.BARSB	131.58	131.8	131.02	
SA.1.FLAXSB	128.63	131.57	132.96	
SA.1.CANSF	138.71	138.21	136.74	
SA.1.CANSB	132.85	130.97	128.82	
SA.1.LENTSF	83.35	124.53	126.97	
SA.1.LENTSB	98.69	103.42	105.67	
SA.1.FLDPSB	72.69	73.86	73.66	
SA.1.OTHSF				144.75
SA.1.OTHSB				164.71
SA.2.SUMFAL	19.19	18.7	18.03	

Table C.1. Continued

Region & Activity	INTL	MDTL	MDTL	COMTL
SA.2.WHTHQSF	94.07	94.02	92.66	
SA.2.WHTHQSB	98.42	96.54	93.99	
SA.2.BARSB	123.08	120.17	116.69	
SA.2.FLAXSB	124.34	126.07	126.01	
SA.2.CANSF	124.98	125.46	124.15	
SA.2.CANSB	165.44	166.4	165.17	
SA.2.LENTSF	53.05	78.6	146.59	
SA.2.LENTSB	110.79	116.79	120.13	
SA.2.FLDPSB	65.44	67.14	67.43	
SA.2.OTHSF				141.24
SA.2.OTHSB				164.71
SA.3.SUMFAL	23.27	23.44	23.06	
SA.3.WHTHQSF	109.12	107.9	105.68	
SA.3.WHTHQSB	131.96	132.69	131.7	
SA.3.BARSB	115.76	113.39	110.45	
SA.3.FLAXSB	94.02	94.68	92.39	
SA.3.CANSF	107.27	107.14	105.27	
SA.3.CANSB	165.44	166.4	165.17	
SA.3.LENTSF	47.43	41.38	52.03	
SA.3.LENTSB	82.15	85.35	86.66	
SA.3.FLDPSB	59.33	60.65	60.82	
SA.3.OTHSF				145.98
SA.3.OTHSB				164.71
SA.4.SUMFAL	28.49	29.31	29.47	
SA.4.WHTHQSF	105.29	104.8	102.58	
SA.4.WHTHQSB	160.39	161.65	160.04	
SA.4.BARSB	132.63	130.11	127.44	
SA.4.FLAXSB	121.54	124.21	124.29	
SA.4.CANSF	120.05	118.85	117.74	
SA.4.CANSB	182.49	181.03	178.76	
SA.4.LENTSF	70.64	40.49	49.65	
SA.4.LENTSB	76.71	79.67	80.28	
SA.4.FLDPSB	57.28	58.49	58.62	
SA.4.OTHSF				152.89
SA.4.OTHSB				164.81
SA.5.SUMFAL	27.36	26.83	26.23	
SA.5.WHTHQSF	135.85	136.13	134.14	
SA.5.WHTHQSB	139.7	140.1	138.79	
SA.5.BARSB	141.81	140.55	138.25	
SA.5.FLAXSB	167.15	170.18	169.76	
SA.5.CANSF	129.74	131.48	130.94	
SA.5.CANSB	196.94	198.92	196.75	
SA.5.LENTSF	67.26	69.66	81.36	
SA.5.LENTSB	86.56	90.04	91.2	
SA.5.FLDPSB	72.69	73.86	73.66	

Table C.1. Continued

Region & Activity	INTL	MDTL	NOTL	COMTL
SA.5.OTHSF				149.37
SA.5.OTHSB				164.71
SA.6.SUMFAL	20.75	20.33	19.74	
SA.6.WHTHQSF	95.94	95.66	94.12	
SA.6.WHTHQSB	129.54	130.12	128.56	
SA.6.BARSB	125.05	124.27	121.67	
SA.6.FLAXSB	91.98	94.05	94.49	
SA.6.CANSF	148.96	148.79	144.46	
SA.6.CANSB	165.22	166.18	164.95	
SA.6.LENTSF	53.05	78.6	76.22	
SA.6.LENTSB	67.45	68.7	68.92	
SA.6.FLDPSB	54.58	57.06	58.08	
SA.6.OTHSF				143.49
SA.6.OTHSB				165.75
SA.7.SUMFAL	17.05	16.66	16.23	
SA.7.WHTHQSF	102.85	103.89	103.28	
SA.7.WHTHQSB	127.79	128.14	126.84	
SA.7.BARSB	125.6	125.16	123.55	
SA.7.FLAXSB	114.46	118.89	119.83	
SA.7.CANSF	122.12	122.81	121.78	
SA.7.CANSB	126.48	127.03	125.9	
SA.7.LENTSF	57.44	60.16	50.66	
SA.7.LENTSB	57.19	58.24	58.42	
SA.7.FLDPSB	57.94	57.76	56.96	
SA.7.OTHSF				139.22
SA.7.OTHSB				165.75
SA.8.SUMFAL	21.81	22.21	22.34	
SA.8.WHTHQSF	116.62	119.07	120	
SA.8.WHTHQSB	147.55	149.5	149.08	
SA.8.BARSB	147.02	147.67	146.53	
SA.8.FLAXSB	126.73	131.17	133.5	
SA.8.CANSF	116.29	119.35	120.29	
SA.8.CANSB	169.46	172.62	172.47	
SA.8.LENTSF	148.05	123.09	63.73	
SA.8.LENTSB	73.11	74.75	75.14	
SA.8.FLDPSB	64.58	65.09	64.19	
SA.8.OTHSF				144.75
SA.8.OTHSB				164.71
SA.9.SUMFAL	21.81	22.21	22.34	
SA.9.WHTHQSF	116.62	119.07	120	
SA.9.WHTHQSB	147.55	149.5	149.08	
SA.9.BARSB	147.02	147.67	146.53	
SA.9.FLAXSB	126.73	131.17	133.5	
SA.9.CANSF	116.29	119.35	120.29	
SA.9.CANSB	169.39	172.55	172.4	

Table C.1. Continued

Region & Activity	INTL	MDTL	NOTL	COMTL
SA.9.LENTSF	75.65	81.88	63.51	
SA.9.LENTSB	70.39	72.32	72.83	
SA.9.FLDPSB	68.55	68.3	67.08	
SA.9.OTHSF				144.75
SA.9.OTHSB				164.71
MA.1.SUMFAL	22.61	22.16	21.76	
MA.1.WHTHQSF	100.42	100.71	100.2	
MA.1.WHTHQSB	174.56	174.7	173.12	
MA.1.BARSB	131.48	131.7	130.93	
MA.1.FLAXSB	128.63	131.57	132.96	
MA.1.CANSF	138.61	138.11	136.64	
MA.1.CANSB	132.85	130.97	128.82	
MA.1.LENTSB	86.56	90.04	91.2	
MA.1.FLDPSB	72.69	73.86	73.66	
MA.1.OTHSF				144.7
MA.1.OTHSB				164.71
MA.2.SUMFAL	22.9	22.41	21.98	
MA.2.WHTHQSF	97.03	96.89	96.11	
MA.2.WHTHQSB	185.89	185.31	183.29	
MA.2.BARSB	124.9	124.5	123.35	
MA.2.FLAXSB	119.91	122.38	123.47	
MA.2.CANSF	131.81	130.79	129.02	
MA.2.LENTSB	86.56	90.04	91.2	
MA.2.FLDPSB	72.69	73.86	73.66	
MA.2.OTHSF				146.05
MA.2.OTHSB				164.98
MA.3.SUMFAL	24.47	23.74	23.16	
MA.3.WHTHQSF	112.83	113.05	112.46	
MA.3.WHTHQSB	194.66	194.62	192.82	
MA.3.BARSB	150.07	150.14	149.24	
MA.3.FLAXSB	128.23	131.61	133.24	
MA.3.CANSF	149.12	148.35	146.66	
MA.3.CANSB	147.77	148.63	148.12	
MA.3.LENTSB	86.56	90.04	91.2	
MA.3.FLDPSB	72.69	73.86	73.66	
MA.3.OTHSF				155.1
MA.3.OTHSB				186.15
MA.4.SUMFAL	25.3	24.44	23.78	
MA.4.WHTHQSF	111.56	111.36	110.45	
MA.4.WHTHQSB	197.42	196.65	194.25	
MA.4.BARSB	151.65	151.1	149.73	
MA.4.FLAXSB	111.24	114.13	115.42	
MA.4.CANSF	114.68	113.35	111.21	
MA.4.CANSB	110.61	111.23	110.58	
MA.4.LENTSF	100.32	110.13	81.36	

Table C.1. Continued

Region & Activity	INTL	MDTL	NOTL	COMTL
MA.4.LENTSB	86.56	90.04	91.2	
MA.4.FLDPSB	72.69	73.86	73.66	
MA.4.OTHSF				277.74
MA.4.OTHSB				288.64
MA.5.SUMFAL	26.56	25.52	24.74	
MA.5.WHTHQSF	113.51	112.53	111.08	
MA.5.WHTHQSB	191.41	189.3	185.93	
MA.5.BARSB	136.48	132.67	129.26	
MA.5.FLAXSB	132.21	133.74	134.18	
MA.5.CANSF	151.75	149.42	146.56	
MA.5.LENTSB	86.56	90.04	91.2	
MA.5.FLDPSB	72.69	73.86	73.66	
MA.5.OTHSF				157.01
MA.5.OTHSB				176.7
MA.6.SUMFAL	25.75	24.83	24.12	
MA.6.WHTHQSF	109.21	108.3	106.92	
MA.6.WHTHQSB	178.29	176.33	173.13	
MA.6.BARSB	136.57	134.99	132.94	
MA.6.FLAXSB	126.45	128.25	128.87	
MA.6.CANSF	142.75	140.58	137.86	
MA.6.LENTSB	86.56	90.04	91.2	
MA.6.FLDPSB	72.69	73.86	73.66	
MA.6.OTHSF				151.04
MA.6.OTHSB				166.75

APPENDIX D

Expected Insurance Parameters Used in RS-CRAM

Table D.1. Expected insurance parameters used in RS-CRAM ($ / ha) [a]

	CROPNET	RIP	CI	GPR	PR
AL.1.WHTHQSF.INTL	198.36	15.75	23.85	12.84	11.47
AL.1.WHTHQSF.MDTL	207.40	15.68	24.16	13.04	11.64
AL.1.WHTHQSF.NOTL	212.94	16.46	23.78	13.12	11.71
AL.1.WHTHQSB.INTL	127.18	20.55	18.52	10.44	9.25
AL.1.WHTHQSB.MDTL	130.91	21.34	18.55	10.54	9.33
AL.1.WHTHQSB.NOTL	134.22	21.42	18.62	10.57	9.36
AL.1.BARSB .INTL	70.80	28.15	20.70	8.75	10.94
AL.1.BARSB .MDTL	78.46	29.05	20.41	9.00	11.24
AL.1.BARSB .NOTL	81.20	29.35	20.30	9.03	11.27
AL.1.FLAXSB .INTL	300.48	54.77	21.26	17.32	13.90
AL.1.FLAXSB .MDTL	303.92	55.02	20.89	17.41	13.97
AL.1.FLAXSB .NOTL	308.23	54.96	20.63	17.44	14.00
AL.1.CANSF .INTL	260.44	10.07	27.33	9.29	16.90
AL.1.CANSF .MDTL	264.22	10.35	27.16	9.34	16.98
AL.1.CANSF .NOTL	270.08	10.90	26.43	9.41	17.11
AL.1.LENTSB .INTL	99.59	45.09	28.84	20.73	17.78
AL.1.LENTSB .MDTL	100.82	45.39	28.03	21.00	18.01
AL.1.LENTSB .NOTL	101.58	45.28	28.26	21.08	18.08
AL.1.FLDPSB .INTL	171.73	33.44	11.28	32.17	19.05
AL.1.FLDPSB .MDTL	171.00	32.60	10.79	32.05	18.98
AL.1.FLDPSB .NOTL	170.52	31.69	10.30	31.83	18.85
AL.2.WHTHQSF.INTL	285.28	23.99	29.08	16.94	12.39
AL.2.WHTHQSF.MDTL	298.00	24.30	29.01	17.33	12.67
AL.2.WHTHQSF.NOTL	305.82	24.58	28.89	17.49	12.78
AL.2.WHTHQSB.INTL	217.88	20.08	45.34	15.13	11.08
AL.2.WHTHQSB.MDTL	224.09	19.43	45.14	15.35	11.24
AL.2.WHTHQSB.NOTL	227.27	19.20	45.19	15.38	11.26
AL.2.BARSB .INTL	131.99	21.46	44.76	10.92	12.04
AL.2.BARSB .MDTL	144.07	22.73	47.44	11.47	12.64
AL.2.BARSB .NOTL	146.30	22.46	46.93	11.52	12.69
AL.2.FLAXSB .INTL	273.15	47.38	25.50	15.81	12.12
AL.2.FLAXSB .MDTL	275.33	48.58	25.59	15.87	12.17
AL.2.FLAXSB .NOTL	278.97	48.33	25.48	15.87	12.16
AL.2.CANSF .INTL	317.58	20.02	46.20	10.73	17.55
AL.2.CANSF .MDTL	323.06	20.24	46.97	10.84	17.74
AL.2.CANSF .NOTL	325.88	19.97	47.27	10.85	17.75
AL.2.CANSB .INTL	233.16	16.56	37.97	8.81	14.41
AL.2.CANSB .MDTL	237.44	16.71	38.75	8.92	14.60
AL.2.CANSB .NOTL	240.05	16.80	39.16	8.94	14.62
AL.2.LENTSB .INTL	91.93	67.44	44.52	23.88	20.42
AL.2.LENTSB .MDTL	95.43	67.01	44.19	24.24	20.73
AL.2.LENTSB .NOTL	97.30	67.68	44.35	24.38	20.86
AL.2.FLDPSB .INTL	143.62	32.80	10.62	32.19	18.98
AL.2.FLDPSB .MDTL	143.55	31.99	10.29	32.07	18.91
AL.2.FLDPSB .NOTL	143.46	31.59	9.77	31.87	18.80

Table D.1. Continued

	CROPNET	RIP	CI	GPR	PR
AL.3.WHTHQSF.INTL	208.60	27.90	14.08	13.82	9.44
AL.3.WHTHQSF.MDTL	215.43	28.05	13.67	13.92	9.51
AL.3.WHTHQSF.NOTL	221.46	28.02	13.50	14.00	9.56
AL.3.WHTHQSB.INTL	200.30	23.02	25.69	15.16	10.35
AL.3.WHTHQSB.MDTL	206.03	24.09	24.24	15.27	10.42
AL.3.WHTHQSB.NOTL	208.44	24.28	24.30	15.27	10.42
AL.3.BARSB .INTL	78.07	27.59	23.05	9.14	9.13
AL.3.BARSB .MDTL	105.53	31.23	21.60	10.23	10.16
AL.3.BARSB .NOTL	107.74	31.88	21.42	10.27	10.20
AL.3.FLAXSB .INTL	176.60	43.05	12.90	11.85	5.65
AL.3.FLAXSB .MDTL	179.92	43.87	12.23	11.91	5.67
AL.3.FLAXSB .NOTL	182.36	43.72	12.34	11.90	5.67
AL.3.CANSF .INTL	237.35	22.85	25.21	9.08	14.85
AL.3.CANSF .MDTL	246.07	22.28	26.47	9.25	15.13
AL.3.CANSF .NOTL	247.85	22.35	26.10	9.23	15.09
AL.3.CANSB .INTL	161.32	19.25	20.60	7.49	12.25
AL.3.CANSB .MDTL	167.84	18.63	21.80	7.64	12.49
AL.3.CANSB .NOTL	169.21	18.35	21.52	7.62	12.46
AL.3.LENTSB .INTL	150.36	65.33	33.70	28.96	17.84
AL.3.LENTSB .MDTL	151.67	65.56	33.30	29.19	17.98
AL.3.LENTSB .NOTL	151.74	65.81	33.64	29.29	18.04
AL.3.FLDPSB .INTL	169.98	32.69	10.06	32.23	14.74
AL.3.FLDPSB .MDTL	166.02	31.74	9.68	32.09	14.68
AL.3.FLDPSB .NOTL	164.09	31.24	9.48	31.90	14.59
AL.4.WHTHQSF.INTL	182.88	24.79	17.92	14.58	8.24
AL.4.WHTHQSF.MDTL	183.64	24.83	17.91	14.61	8.25
AL.4.WHTHQSF.NOTL	188.01	25.31	17.27	14.68	8.29
AL.4.WHTHQSB.INTL	241.69	31.92	12.86	17.28	9.70
AL.4.WHTHQSB.MDTL	236.31	32.19	11.61	17.00	9.54
AL.4.WHTHQSB.NOTL	237.10	32.09	11.57	16.95	9.51
AL.4.BARSB .INTL	115.04	34.99	11.10	10.40	10.55
AL.4.BARSB .MDTL	128.81	37.20	10.85	10.85	10.98
AL.4.BARSB .NOTL	131.09	36.89	10.86	10.83	10.97
AL.4.FLAXSB .INTL	255.22	50.96	12.43	14.92	12.46
AL.4.FLAXSB .MDTL	254.40	50.60	12.35	14.89	12.43
AL.4.FLAXSB .NOTL	253.27	49.77	12.41	14.84	12.39
AL.4.CANSF .INTL	277.85	28.43	20.93	8.84	13.38
AL.4.CANSF .MDTL	279.25	28.83	20.77	8.87	13.43
AL.4.CANSF .NOTL	281.84	28.30	20.27	8.88	13.43
AL.4.CANSB .INTL	271.66	26.11	15.68	9.69	14.63
AL.4.CANSB .MDTL	267.29	24.73	14.46	9.61	14.49
AL.4.CANSB .NOTL	266.48	24.68	14.16	9.56	14.43
AL.4.LENTSB .INTL	325.87	119.97	17.95	44.15	25.63
AL.4.LENTSB .MDTL	322.61	120.27	18.36	44.12	25.61
AL.4.LENTSB .NOTL	320.48	120.24	18.61	44.01	25.55

Table D.1. Continued

	CROPNET	RIP	CI	GPR	PR
AL.4.FLDPSB .INTL	202.05	33.83	11.74	32.14	22.88
AL.4.FLDPSB .MDTL	200.58	33.06	11.38	32.03	22.80
AL.4.FLDPSB .NOTL	199.87	32.33	10.90	31.82	22.65
AL.5.WHTHQSF.INTL	273.45	33.46	16.52	19.34	11.73
AL.5.WHTHQSF.MDTL	269.84	32.72	16.34	19.20	11.64
AL.5.WHTHQSF.NOTL	275.50	33.95	15.66	19.35	11.72
AL.5.WHTHQSB.INTL	333.18	50.18	12.01	23.38	14.09
AL.5.WHTHQSB.MDTL	325.04	48.15	11.45	22.97	13.85
AL.5.WHTHQSB.NOTL	327.66	48.12	11.09	22.97	13.84
AL.5.BARSB .INTL	122.34	42.10	10.28	11.83	10.14
AL.5.BARSB .MDTL	142.70	44.87	9.79	12.53	10.70
AL.5.BARSB .NOTL	144.49	44.76	9.71	12.51	10.68
AL.5.FLAXSB .INTL	276.10	60.59	9.16	16.90	12.23
AL.5.FLAXSB .MDTL	278.98	59.90	9.23	16.85	12.19
AL.5.FLAXSB .NOTL	283.77	59.73	9.19	16.81	12.17
AL.5.CANSF .INTL	251.16	26.85	13.73	9.49	14.34
AL.5.CANSF .MDTL	253.32	26.85	13.70	9.49	14.34
AL.5.CANSF .NOTL	259.82	26.77	12.93	9.57	14.46
AL.5.CANSB .INTL	254.22	28.45	10.42	10.36	15.61
AL.5.CANSB .MDTL	251.69	27.64	9.97	10.32	15.54
AL.5.CANSB .NOTL	250.14	27.33	9.73	10.26	15.45
AL.5.LENTSB .INTL	206.09	79.77	23.80	34.02	4.10
AL.5.LENTSB .MDTL	206.23	79.29	24.08	34.18	4.12
AL.5.LENTSB .NOTL	205.93	79.04	24.42	34.18	4.12
AL.5.FLDPSB .INTL	165.14	32.40	9.83	32.24	21.64
AL.5.FLDPSB .MDTL	165.12	31.52	9.36	32.08	21.53
AL.5.FLDPSB .NOTL	165.80	31.10	8.87	31.93	21.42
AL.6.WHTHQSF.INTL	251.74	42.59	9.59	20.16	17.30
AL.6.WHTHQSF.MDTL	243.60	42.02	9.59	19.67	16.90
AL.6.WHTHQSF.NOTL	246.90	41.91	9.35	19.60	16.83
AL.6.WHTHQSB.INTL	179.43	31.47	9.92	16.27	14.02
AL.6.WHTHQSB.MDTL	174.39	31.92	9.17	16.00	13.78
AL.6.WHTHQSB.NOTL	176.34	31.58	9.28	15.97	13.76
AL.6.BARSB .INTL	103.67	36.34	10.32	10.86	13.80
AL.6.BARSB .MDTL	116.87	39.29	9.11	11.26	14.29
AL.6.BARSB .NOTL	121.29	39.22	9.05	11.27	14.29
AL.6.FLAXSB .INTL	228.14	54.01	11.36	15.47	10.72
AL.6.FLAXSB .MDTL	231.87	53.96	11.19	15.46	10.71
AL.6.FLAXSB .NOTL	236.94	53.45	10.78	15.40	10.67
AL.6.CANSF .INTL	175.62	19.88	19.46	7.65	15.49
AL.6.CANSF .MDTL	174.84	19.46	19.07	7.67	15.50
AL.6.CANSF .NOTL	179.86	19.42	18.81	7.74	15.63
AL.6.CANSB .INTL	257.56	29.47	12.40	10.18	20.36
AL.6.CANSB .MDTL	256.09	28.56	11.98	10.18	20.34
AL.6.CANSB .NOTL	253.98	27.85	12.36	10.10	20.19

Table D.1. Continued

	CROPNET	RIP	CI	GPR	PR
AL.6.LENTSB .INTL	261.29	98.80	17.63	39.08	16.77
AL.6.LENTSB .MDTL	259.95	98.40	18.10	39.16	16.81
AL.6.LENTSB .NOTL	258.76	97.90	18.50	39.10	16.78
AL.6.FLDPSB .INTL	194.26	33.84	10.41	32.63	22.69
AL.6.FLDPSB .MDTL	193.30	33.16	10.30	32.45	22.56
AL.6.FLDPSB .NOTL	193.34	32.63	9.79	32.25	22.42
AL.7.WHTHQSF.INTL	208.15	27.72	12.92	14.75	14.90
AL.7.WHTHQSF.MDTL	209.88	27.40	13.21	14.78	14.93
AL.7.WHTHQSF.NOTL	215.56	27.73	12.58	14.87	15.02
AL.7.WHTHQSB.INTL	222.51	37.81	8.17	17.20	17.40
AL.7.WHTHQSB.MDTL	216.70	37.25	8.16	16.81	17.01
AL.7.WHTHQSB.NOTL	219.66	37.15	7.99	16.73	16.93
AL.7.BARSB .INTL	114.52	33.34	5.70	9.02	12.95
AL.7.BARSB .MDTL	125.87	35.80	6.43	9.35	13.43
AL.7.BARSB .NOTL	129.66	35.34	6.41	9.31	13.37
AL.7.FLAXSB .INTL	137.62	40.53	10.07	11.13	12.13
AL.7.FLAXSB .MDTL	134.98	40.29	9.76	11.10	12.09
AL.7.FLAXSB .NOTL	134.40	39.92	9.24	11.03	12.01
AL.7.CANSF .INTL	241.84	20.32	10.64	7.12	15.65
AL.7.CANSF .MDTL	243.92	20.15	9.91	7.15	15.69
AL.7.CANSF .NOTL	244.86	20.37	10.05	7.16	15.70
AL.7.CANSB .INTL	291.62	21.38	7.67	8.13	17.82
AL.7.CANSB .MDTL	287.41	21.33	7.65	8.06	17.69
AL.7.CANSB .NOTL	285.25	20.86	7.79	7.99	17.54
AL.7.LENTSB .INTL	255.50	98.80	17.63	39.08	19.83
AL.7.LENTSB .MDTL	254.35	98.40	18.10	39.16	19.87
AL.7.LENTSB .NOTL	253.15	97.90	18.50	39.10	19.84
AL.7.FLDPSB .INTL	189.38	33.77	9.77	29.37	20.83
AL.7.FLDPSB .MDTL	186.07	33.30	10.16	29.05	20.60
AL.7.FLDPSB .NOTL	185.14	32.68	10.19	28.85	20.47
SA.1.WHTHQSF.INTL	153.24	11.67	14.40	11.17	9.98
SA.1.WHTHQSF.MDTL	152.25	11.76	14.37	11.12	9.93
SA.1.WHTHQSF.NOTL	154.58	11.47	13.90	11.19	9.98
SA.1.WHTHQSB.INTL	137.45	29.35	19.20	14.22	12.66
SA.1.WHTHQSB.MDTL	134.37	28.76	18.47	14.06	12.51
SA.1.WHTHQSB.NOTL	136.51	28.58	18.06	14.06	12.52
SA.1.BARSB .INTL	65.50	26.55	14.59	9.33	12.04
SA.1.BARSB .MDTL	75.97	27.38	16.05	9.85	12.68
SA.1.BARSB .NOTL	76.67	27.23	15.97	9.85	12.68
SA.1.FLAXSB .INTL	202.14	53.68	21.97	18.10	17.91
SA.1.FLAXSB .MDTL	198.92	53.44	21.95	18.08	17.89
SA.1.FLAXSB .NOTL	197.81	53.51	21.75	18.08	17.88
SA.1.CANSF .INTL	169.80	17.53	17.55	10.35	22.44
SA.1.CANSF .MDTL	169.57	17.51	17.63	10.33	22.38
SA.1.CANSF .NOTL	172.97	16.93	16.60	10.38	22.48

Table D.1. Continued

	CROPNET	RIP	CI	GPR	PR
SA.1.CANSB .INTL	219.86	23.55	21.25	12.39	26.75
SA.1.CANSB .MDTL	220.54	23.08	21.02	12.35	26.66
SA.1.CANSB .NOTL	221.25	23.64	20.79	12.30	26.55
SA.1.LENTSF .INTL	247.07	138.47	34.38	33.95	31.54
SA.1.LENTSF .MDTL	205.61	138.35	34.60	33.94	31.53
SA.1.LENTSF .NOTL	203.24	138.21	34.45	33.93	31.51
SA.1.LENTSB .INTL	247.59	138.44	22.82	35.24	32.64
SA.1.LENTSB .MDTL	244.56	138.92	22.12	35.33	32.72
SA.1.LENTSB .NOTL	241.25	138.41	22.47	35.24	32.63
SA.1.FLDPSB .INTL	146.22	47.01	23.57	18.80	19.17
SA.1.FLDPSB .MDTL	145.55	47.00	23.18	18.79	19.16
SA.1.FLDPSB .NOTL	145.33	47.15	22.36	18.72	19.08
SA.2.WHTHQSF.INTL	180.57	13.03	18.25	12.14	10.21
SA.2.WHTHQSF.MDTL	184.51	13.48	18.22	12.31	10.35
SA.2.WHTHQSF.NOTL	187.46	13.69	17.75	12.34	10.36
SA.2.WHTHQSB.INTL	208.37	28.81	20.69	13.63	11.36
SA.2.WHTHQSB.MDTL	206.79	27.87	20.38	13.50	11.26
SA.2.WHTHQSB.NOTL	209.48	27.77	20.40	13.51	11.27
SA.2.BARSB .INTL	72.45	26.76	15.77	9.40	11.58
SA.2.BARSB .MDTL	90.09	28.78	17.75	10.09	12.40
SA.2.BARSB .NOTL	93.98	28.59	17.68	10.09	12.40
SA.2.FLAXSB .INTL	201.68	49.15	24.02	18.38	19.28
SA.2.FLAXSB .MDTL	201.91	49.79	23.83	18.45	19.35
SA.2.FLAXSB .NOTL	201.69	49.41	24.04	18.44	19.35
SA.2.CANSF .INTL	241.95	21.08	22.10	12.66	29.84
SA.2.CANSF .MDTL	242.19	20.15	22.09	12.67	29.85
SA.2.CANSF .NOTL	246.38	20.27	21.37	12.76	30.03
SA.2.CANSB .INTL	102.00	15.02	16.14	9.23	21.74
SA.2.CANSB .MDTL	102.25	14.67	16.42	9.26	21.80
SA.2.CANSB .NOTL	104.92	14.49	15.53	9.29	21.86
SA.2.LENTSF .INTL	245.73	121.65	31.53	31.34	26.36
SA.2.LENTSF .MDTL	221.10	121.95	31.33	31.41	26.41
SA.2.LENTSF .NOTL	153.81	122.16	30.96	31.44	26.44
SA.2.LENTSB .INTL	233.71	138.44	22.82	35.24	29.60
SA.2.LENTSB .MDTL	229.40	138.92	22.12	35.33	29.68
SA.2.LENTSB .NOTL	225.01	138.41	22.47	35.24	29.59
SA.2.FLDPSB .INTL	155.98	47.43	18.54	18.78	19.81
SA.2.FLDPSB .MDTL	154.28	47.36	18.23	18.77	19.80
SA.2.FLDPSB .NOTL	153.09	47.20	17.87	18.68	19.70
SA.3.WHTHQSF.INTL	166.23	21.44	15.50	11.76	10.16
SA.3.WHTHQSF.MDTL	171.64	22.05	15.41	11.93	10.30
SA.3.WHTHQSF.NOTL	176.55	22.52	14.89	12.01	10.37
SA.3.WHTHQSB.INTL	111.40	23.44	22.97	10.52	9.04
SA.3.WHTHQSB.MDTL	110.22	23.16	22.71	10.53	9.05
SA.3.WHTHQSB.NOTL	114.20	23.44	22.14	10.60	9.11

Table D.1. Continued

	CROPNET	RIP	CI	GPR	PR
SA.3.BARSB .INTL	57.61	26.06	15.71	8.36	10.93
SA.3.BARSB .MDTL	72.14	27.80	16.36	8.94	11.65
SA.3.BARSB .NOTL	76.22	27.81	16.28	8.98	11.71
SA.3.FLAXSB .INTL	178.31	41.45	19.95	15.38	16.42
SA.3.FLAXSB .MDTL	179.05	41.65	20.00	15.43	16.47
SA.3.FLAXSB .NOTL	181.06	41.37	20.13	15.41	16.46
SA.3.CANSF .INTL	83.81	11.07	8.02	6.50	14.57
SA.3.CANSF .MDTL	83.94	10.54	8.30	6.50	14.57
SA.3.CANSF .NOTL	86.77	10.73	7.90	6.52	14.61
SA.3.CANSB .INTL	20.09	11.66	10.05	6.45	14.43
SA.3.CANSB .MDTL	18.89	11.71	9.88	6.44	14.42
SA.3.CANSB .NOTL	19.64	11.83	9.82	6.43	14.39
SA.3.LENTSF .INTL	225.76	94.07	35.39	28.77	23.92
SA.3.LENTSF .MDTL	233.58	94.78	35.08	28.96	24.07
SA.3.LENTSF .NOTL	224.77	94.39	34.70	29.10	24.20
SA.3.LENTSB .INTL	263.31	138.44	22.82	35.24	29.36
SA.3.LENTSB .MDTL	261.81	138.92	22.12	35.33	29.44
SA.3.LENTSB .NOTL	259.44	138.41	22.47	35.24	29.36
SA.3.FLDPSB .INTL	156.10	47.06	18.11	18.29	17.36
SA.3.FLDPSB .MDTL	155.36	47.16	18.18	18.33	17.40
SA.3.FLDPSB .NOTL	154.85	46.82	17.74	18.27	17.34
SA.4.WHTHQSF.INTL	174.24	27.15	26.52	12.29	10.75
SA.4.WHTHQSF.MDTL	179.48	26.94	26.30	12.45	10.89
SA.4.WHTHQSF.NOTL	184.67	26.80	25.35	12.55	10.98
SA.4.WHTHQSB.INTL	74.41	25.17	23.99	9.79	8.49
SA.4.WHTHQSB.MDTL	74.48	25.83	23.83	9.88	8.57
SA.4.WHTHQSB.NOTL	79.51	25.99	23.58	9.99	8.66
SA.4.BARSB .INTL	39.25	26.54	23.22	8.22	10.66
SA.4.BARSB .MDTL	53.12	27.58	22.80	8.71	11.25
SA.4.BARSB .NOTL	57.15	27.89	22.91	8.78	11.36
SA.4.FLAXSB .INTL	212.53	49.92	20.68	18.66	20.56
SA.4.FLAXSB .MDTL	211.26	50.12	20.44	18.78	20.70
SA.4.FLAXSB .NOTL	212.01	49.07	20.20	18.83	20.76
SA.4.CANSF .INTL	218.81	19.62	11.82	11.50	27.77
SA.4.CANSF .MDTL	219.52	19.47	11.55	11.47	27.69
SA.4.CANSF .NOTL	221.60	19.23	11.26	11.49	27.74
SA.4.CANSB .INTL	141.88	18.13	20.63	11.28	27.20
SA.4.CANSB .MDTL	143.58	18.22	20.38	11.28	27.22
SA.4.CANSB .NOTL	144.64	17.94	19.97	11.24	27.11
SA.4.LENTSF .INTL	177.09	87.62	43.17	25.56	21.85
SA.4.LENTSF .MDTL	209.07	88.40	42.50	25.77	22.04
SA.4.LENTSF .NOTL	201.53	88.75	41.71	25.92	22.17
SA.4.LENTSB .INTL	267.92	138.44	22.82	35.24	30.27
SA.4.LENTSB .MDTL	266.66	138.92	22.12	35.33	30.35
SA.4.LENTSB .NOTL	264.99	138.41	22.47	35.24	30.27

Table D.1. Continued

	CROPNET	RIP	CI	GPR	PR
SA.4.FLDPSB .INTL	154.26	46.82	17.24	18.00	16.28
SA.4.FLDPSB .MDTL	153.88	46.84	17.30	18.06	16.33
SA.4.FLDPSB .NOTL	153.58	46.59	17.30	18.04	16.31
SA.5.WHTHQSF.INTL	121.62	19.04	19.22	11.99	10.85
SA.5.WHTHQSF.MDTL	121.74	19.24	18.89	11.98	10.84
SA.5.WHTHQSF.NOTL	125.08	19.03	18.49	12.02	10.87
SA.5.WHTHQSB.INTL	225.05	26.79	20.23	16.61	15.00
SA.5.WHTHQSB.MDTL	222.90	26.01	19.34	16.52	14.91
SA.5.WHTHQSB.NOTL	223.66	26.10	19.27	16.52	14.91
SA.5.BARSB .INTL	90.85	28.11	14.69	10.71	12.23
SA.5.BARSB .MDTL	106.90	30.29	17.85	11.31	12.90
SA.5.BARSB .NOTL	108.79	30.50	17.39	11.29	12.87
SA.5.FLAXSB .INTL	233.12	65.23	26.51	21.93	19.96
SA.5.FLAXSB .MDTL	229.81	65.00	26.49	21.91	19.94
SA.5.FLAXSB .NOTL	230.51	65.15	26.39	21.92	19.94
SA.5.CANSF .INTL	215.04	29.32	25.57	11.85	22.68
SA.5.CANSF .MDTL	215.22	29.71	25.10	11.90	22.76
SA.5.CANSF .NOTL	217.44	29.17	25.33	11.95	22.84
SA.5.CANSB .INTL	215.26	31.82	21.36	13.95	26.65
SA.5.CANSB .MDTL	213.76	32.29	20.24	13.98	26.69
SA.5.CANSB .NOTL	212.81	31.91	19.88	13.90	26.55
SA.5.LENTSF .INTL	247.63	131.70	31.35	32.65	25.36
SA.5.LENTSF .MDTL	245.59	131.85	31.27	32.67	25.38
SA.5.LENTSF .NOTL	234.31	131.55	31.00	32.67	25.38
SA.5.LENTSB .INTL	259.24	138.44	22.82	35.24	27.33
SA.5.LENTSB .MDTL	257.45	138.92	22.12	35.33	27.39
SA.5.LENTSB .NOTL	255.23	138.41	22.47	35.24	27.32
SA.5.FLDPSB .INTL	165.92	49.12	18.55	19.66	18.39
SA.5.FLDPSB .MDTL	163.84	48.79	18.22	19.60	18.33
SA.5.FLDPSB .NOTL	162.38	48.58	17.67	19.47	18.22
SA.6.WHTHQSF.INTL	186.91	21.59	13.46	12.38	9.54
SA.6.WHTHQSF.MDTL	190.64	21.88	13.35	12.51	9.64
SA.6.WHTHQSF.NOTL	193.19	22.20	13.45	12.56	9.68
SA.6.WHTHQSB.INTL	189.41	30.43	19.91	14.08	10.85
SA.6.WHTHQSB.MDTL	186.81	30.35	19.40	14.00	10.79
SA.6.WHTHQSB.NOTL	187.94	30.05	19.42	13.99	10.79
SA.6.BARSB .INTL	83.94	31.86	12.26	9.84	10.61
SA.6.BARSB .MDTL	98.12	33.14	13.79	10.45	11.25
SA.6.BARSB .NOTL	101.13	33.31	13.58	10.47	11.26
SA.6.FLAXSB .INTL	286.46	59.43	24.64	20.79	17.38
SA.6.FLAXSB .MDTL	284.67	59.30	24.41	20.78	17.37
SA.6.FLAXSB .NOTL	282.82	59.31	24.59	20.73	17.34
SA.6.CANSF .INTL	202.30	21.33	15.52	11.99	20.88
SA.6.CANSF .MDTL	202.47	21.19	15.30	11.99	20.87
SA.6.CANSF .NOTL	208.25	21.09	15.13	12.03	20.95

Table D.1. Continued

	CROPNET	RIP	CI	GPR	PR
SA.6.CANSB .INTL	203.42	24.16	21.99	12.70	22.06
SA.6.CANSB .MDTL	201.98	23.81	21.82	12.71	22.09
SA.6.CANSB .NOTL	201.52	23.89	21.95	12.67	22.03
SA.6.LENTSF .INTL	242.46	113.81	29.98	30.93	25.22
SA.6.LENTSF .MDTL	217.76	114.14	29.89	31.01	25.28
SA.6.LENTSF .NOTL	221.20	114.30	29.70	31.08	25.34
SA.6.LENTSB .INTL	277.52	138.44	22.82	35.24	28.75
SA.6.LENTSB .MDTL	277.96	138.92	22.12	35.33	28.82
SA.6.LENTSB .NOTL	276.68	138.41	22.47	35.24	28.74
SA.6.FLDPSB .INTL	156.95	45.54	17.20	17.88	15.81
SA.6.FLDPSB .MDTL	154.55	45.44	17.36	17.91	15.83
SA.6.FLDPSB .NOTL	153.20	44.99	17.10	17.85	15.78
SA.7.WHTHQSF.INTL	224.02	32.35	10.93	14.24	9.25
SA.7.WHTHQSF.MDTL	225.55	32.26	11.40	14.37	9.34
SA.7.WHTHQSF.NOTL	226.74	32.07	11.35	14.39	9.35
SA.7.WHTHQSB.INTL	205.09	32.87	25.52	14.92	9.73
SA.7.WHTHQSB.MDTL	203.74	33.04	25.07	14.90	9.72
SA.7.WHTHQSB.NOTL	205.46	33.04	24.69	14.90	9.72
SA.7.BARSB .INTL	106.61	34.53	14.28	10.96	9.70
SA.7.BARSB .MDTL	114.84	35.51	14.65	11.32	10.00
SA.7.BARSB .NOTL	116.53	35.42	14.69	11.32	10.01
SA.7.FLAXSB .INTL	247.57	57.06	23.47	19.89	15.70
SA.7.FLAXSB .MDTL	242.86	56.90	23.28	19.87	15.68
SA.7.FLAXSB .NOTL	240.80	56.96	23.55	19.84	15.66
SA.7.CANSF .INTL	294.97	26.30	14.24	14.19	21.33
SA.7.CANSF .MDTL	293.31	26.38	13.61	14.13	21.24
SA.7.CANSF .NOTL	295.07	25.88	13.74	14.16	21.29
SA.7.CANSB .INTL	268.43	21.53	28.87	13.77	20.76
SA.7.CANSB .MDTL	269.33	21.75	28.35	13.83	20.85
SA.7.CANSB .NOTL	268.04	22.13	28.02	13.75	20.74
SA.7.LENTSF .INTL	214.26	94.19	32.23	28.42	20.45
SA.7.LENTSF .MDTL	213.09	94.75	31.91	28.58	20.57
SA.7.LENTSF .NOTL	224.00	94.37	31.65	28.70	20.65
SA.7.LENTSB .INTL	287.27	138.44	22.82	35.24	25.48
SA.7.LENTSB .MDTL	287.91	138.92	22.12	35.33	25.54
SA.7.LENTSB .NOTL	286.68	138.41	22.47	35.24	25.47
SA.7.FLDPSB .INTL	150.54	46.88	17.90	17.71	15.99
SA.7.FLDPSB .MDTL	151.95	47.01	17.87	17.81	16.08
SA.7.FLDPSB .NOTL	152.75	47.02	18.06	17.83	16.09
SA.8.WHTHQSF.INTL	249.99	31.94	18.97	16.98	11.98
SA.8.WHTHQSF.MDTL	246.33	32.42	17.63	16.90	11.92
SA.8.WHTHQSF.NOTL	244.60	32.36	17.37	16.87	11.89
SA.8.WHTHQSB.INTL	111.13	22.58	13.50	11.99	8.46
SA.8.WHTHQSB.MDTL	107.97	22.81	12.41	11.91	8.40
SA.8.WHTHQSB.NOTL	108.13	22.78	12.31	11.90	8.39
SA.8.BARSB .INTL	104.14	34.21	16.49	11.68	10.72

Table D.1. Continued

	CROPNET	RIP	CI	GPR	PR
SA.8.BARSB .MDTL	111.00	34.63	17.17	11.99	10.99
SA.8.BARSB .NOTL	111.49	34.33	16.76	11.95	10.95
SA.8.FLAXSB .INTL	311.09	69.50	28.29	24.12	16.19
SA.8.FLAXSB .MDTL	305.25	69.13	27.58	24.05	16.14
SA.8.FLAXSB .NOTL	302.36	69.38	27.36	24.00	16.11
SA.8.CANSF .INTL	233.86	24.36	23.76	11.98	16.52
SA.8.CANSF .MDTL	232.00	24.81	23.65	12.01	16.55
SA.8.CANSF .NOTL	233.23	24.00	23.51	12.09	16.66
SA.8.CANSB .INTL	237.52	29.70	18.77	13.88	19.16
SA.8.CANSB .MDTL	234.36	28.86	17.70	13.87	19.14
SA.8.CANSB .NOTL	231.86	28.70	17.21	13.81	19.06
SA.8.LENTSF .INTL	156.63	122.80	30.35	31.77	25.63
SA.8.LENTSF .MDTL	182.30	123.15	30.25	31.84	25.68
SA.8.LENTSF .NOTL	242.15	123.38	30.01	31.86	25.70
SA.8.LENTSB .INTL	271.86	138.44	22.82	35.24	28.40
SA.8.LENTSB .MDTL	271.91	138.92	22.12	35.33	28.47
SA.8.LENTSB .NOTL	270.46	138.41	22.47	35.24	28.39
SA.8.FLDPSB .INTL	175.98	52.19	17.85	20.03	15.57
SA.8.FLDPSB .MDTL	174.72	51.88	17.45	19.98	15.53
SA.8.FLDPSB .NOTL	174.06	51.45	17.05	19.85	15.43
SA.9.WHTHQSF.INTL	170.64	24.28	18.28	13.44	9.25
SA.9.WHTHQSF.MDTL	167.79	24.39	18.25	13.41	9.22
SA.9.WHTHQSF.NOTL	167.67	24.36	18.02	13.44	9.24
SA.9.WHTHQSB.INTL	218.47	34.03	16.57	16.86	11.59
SA.9.WHTHQSB.MDTL	209.85	33.43	16.00	16.56	11.38
SA.9.WHTHQSB.NOTL	209.59	33.37	15.94	16.51	11.35
SA.9.BARSB .INTL	105.67	36.33	12.62	11.82	10.62
SA.9.BARSB .MDTL	112.59	36.27	12.42	12.09	10.85
SA.9.BARSB .NOTL	113.08	36.24	12.42	12.05	10.82
SA.9.FLAXSB .INTL	311.86	67.11	20.46	23.75	17.21
SA.9.FLAXSB .MDTL	306.58	66.72	20.23	23.70	17.17
SA.9.FLAXSB .NOTL	303.69	66.33	19.75	23.63	17.13
SA.9.CANSF .INTL	247.19	26.15	24.12	12.66	16.56
SA.9.CANSF .MDTL	243.40	25.85	23.75	12.61	16.50
SA.9.CANSF .NOTL	244.15	25.74	24.14	12.68	16.59
SA.9.CANSB .INTL	267.41	27.28	15.51	14.91	19.43
SA.9.CANSB .MDTL	261.84	26.90	15.43	14.82	19.32
SA.9.CANSB .NOTL	256.92	27.10	15.97	14.67	19.12
SA.9.LENTSF .INTL	214.80	108.06	28.84	30.37	22.40
SA.9.LENTSF .MDTL	209.84	108.73	28.63	30.48	22.48
SA.9.LENTSF .NOTL	229.12	109.25	28.38	30.55	22.53
SA.9.LENTSB .INTL	274.26	138.44	22.82	35.24	26.05
SA.9.LENTSB .MDTL	274.02	138.92	22.12	35.33	26.11
SA.9.LENTSB .NOTL	272.45	138.41	22.47	35.24	26.04
SA.9.FLDPSB .INTL	182.03	53.13	12.33	20.80	18.05

Table D.1. Continued

	CROPNET	RIP	CI	GPR	PR
SA.9.FLDPSB .MDTL	180.71	52.48	12.01	20.65	17.91
SA.9.FLDPSB .NOTL	179.79	51.35	12.01	20.46	17.75
MA.1.WHTHQSF.INTL	192.12	13.52	21.60	18.86	12.17
MA.1.WHTHQSF.MDTL	195.47	13.58	21.95	19.10	12.32
MA.1.WHTHQSF.NOTL	198.13	13.81	21.54	19.20	12.38
MA.1.WHTHQSB.INTL	199.97	24.89	20.31	24.82	16.02
MA.1.WHTHQSB.MDTL	197.27	24.95	18.90	24.58	15.86
MA.1.WHTHQSB.NOTL	198.45	24.86	18.72	24.55	15.84
MA.1.BARSB .INTL	128.63	31.20	18.13	14.93	13.48
MA.1.BARSB .MDTL	141.73	32.66	21.80	15.82	14.31
MA.1.BARSB .NOTL	142.90	32.72	21.37	15.84	14.33
MA.1.FLAXSB .INTL	201.91	60.69	30.40	29.98	21.99
MA.1.FLAXSB .MDTL	199.54	60.70	30.44	30.02	22.02
MA.1.FLAXSB .NOTL	196.46	60.58	30.38	29.92	21.95
MA.1.CANSF .INTL	219.70	31.78	17.08	17.30	26.21
MA.1.CANSF .MDTL	223.35	32.35	16.11	17.47	26.46
MA.1.CANSF .NOTL	222.88	31.80	15.50	17.38	26.32
MA.1.CANSB .INTL	163.08	26.11	14.18	14.28	21.64
MA.1.CANSB .MDTL	167.62	26.61	13.26	14.42	21.85
MA.1.CANSB .NOTL	169.05	26.30	12.73	14.37	21.77
MA.1.LENTSB .INTL	239.17	147.45	33.52	60.32	33.35
MA.1.LENTSB .MDTL	236.68	148.10	33.68	60.46	33.43
MA.1.LENTSB .NOTL	235.45	147.65	33.38	60.42	33.42
MA.1.FLDPSB .INTL	161.03	30.37	22.94	23.52	13.99
MA.1.FLDPSB .MDTL	159.28	30.51	22.87	23.48	13.97
MA.1.FLDPSB .NOTL	159.07	30.10	22.53	23.42	13.93
MA.2.WHTHQSF.INTL	197.29	21.20	24.72	19.40	16.93
MA.2.WHTHQSF.MDTL	198.64	21.06	24.80	19.48	17.00
MA.2.WHTHQSF.NOTL	200.36	21.05	24.37	19.56	17.07
MA.2.WHTHQSB.INTL	193.33	21.62	24.29	25.22	21.97
MA.2.WHTHQSB.MDTL	190.96	22.02	22.17	24.88	21.66
MA.2.WHTHQSB.NOTL	191.65	22.17	21.73	24.78	21.57
MA.2.BARSB .INTL	126.72	28.41	16.40	14.41	20.27
MA.2.BARSB .MDTL	134.36	30.72	20.03	14.85	20.93
MA.2.BARSB .NOTL	135.19	30.57	19.88	14.83	20.90
MA.2.FLAXSB .INTL	232.16	65.12	32.51	32.00	31.81
MA.2.FLAXSB .MDTL	230.26	65.14	32.55	32.04	31.85
MA.2.FLAXSB .NOTL	227.76	64.97	32.36	31.95	31.76
MA.2.CANSF .INTL	208.15	28.12	18.66	16.30	33.53
MA.2.CANSF .MDTL	213.53	28.20	17.52	16.52	33.96
MA.2.CANSF .NOTL	213.84	27.94	17.06	16.42	33.75
MA.2.LENTSB .INTL	229.63	144.46	35.06	58.13	41.95
MA.2.LENTSB .MDTL	226.22	144.80	34.91	58.13	41.95
MA.2.LENTSB .NOTL	224.85	144.50	34.84	58.07	41.90
MA.2.FLDPSB .INTL	175.63	28.10	19.87	24.44	20.95

Table D.1. Continued

	CROPNET	RIP	CI	GPR	PR
MA.2.FLDPSB .MDTL	172.71	28.53	19.07	24.28	20.81
MA.2.FLDPSB .NOTL	171.00	28.03	18.47	24.09	20.66
MA.3.WHTHQSF.INTL	286.81	30.55	28.44	25.81	20.15
MA.3.WHTHQSF.MDTL	285.77	30.36	26.49	25.75	20.10
MA.3.WHTHQSF.NOTL	285.67	30.61	26.28	25.68	20.04
MA.3.WHTHQSB.INTL	144.27	25.80	24.01	21.87	17.07
MA.3.WHTHQSB.MDTL	143.90	25.92	22.54	21.87	17.07
MA.3.WHTHQSB.NOTL	145.42	25.92	22.25	21.82	17.03
MA.3.BARSB .INTL	127.66	32.85	31.12	15.84	19.25
MA.3.BARSB .MDTL	142.94	35.18	34.32	16.88	20.57
MA.3.BARSB .NOTL	143.27	35.02	34.35	16.86	20.54
MA.3.FLAXSB .INTL	234.75	66.29	33.08	32.84	29.47
MA.3.FLAXSB .MDTL	231.93	66.26	33.08	32.87	29.49
MA.3.FLAXSB .NOTL	229.17	66.24	33.16	32.80	29.43
MA.3.CANSF .INTL	229.91	32.20	24.51	18.16	31.32
MA.3.CANSF .MDTL	236.72	31.70	23.10	18.44	31.79
MA.3.CANSF .NOTL	237.20	31.06	22.85	18.37	31.67
MA.3.CANSB .INTL	164.63	26.44	20.26	14.98	25.83
MA.3.CANSB .MDTL	168.36	26.39	19.04	15.20	26.20
MA.3.CANSB .NOTL	168.14	25.82	18.67	15.14	26.10
MA.3.LENTSB .INTL	218.85	139.38	39.00	55.91	41.56
MA.3.LENTSB .MDTL	214.74	139.71	39.07	55.84	41.51
MA.3.LENTSB .NOTL	213.22	139.73	39.14	55.78	41.47
MA.3.FLDPSB .INTL	143.82	32.62	29.08	21.75	19.00
MA.3.FLDPSB .MDTL	142.74	32.57	28.76	21.75	18.99
MA.3.FLDPSB .NOTL	142.35	32.45	28.56	21.70	18.95
MA.4.WHTHQSF.INTL	310.49	31.01	25.62	27.06	18.12
MA.4.WHTHQSF.MDTL	306.67	30.74	24.38	26.76	17.92
MA.4.WHTHQSF.NOTL	306.75	30.77	24.28	26.68	17.87
MA.4.WHTHQSB.INTL	160.97	26.42	21.72	22.97	15.38
MA.4.WHTHQSB.MDTL	158.69	26.02	20.73	22.73	15.22
MA.4.WHTHQSB.NOTL	160.12	25.95	20.74	22.68	15.19
MA.4.BARSB .INTL	141.57	34.88	29.93	16.82	15.92
MA.4.BARSB .MDTL	159.19	37.40	32.60	17.87	16.94
MA.4.BARSB .NOTL	159.99	37.43	32.70	17.85	16.92
MA.4.FLAXSB .INTL	287.02	72.77	36.48	36.07	24.87
MA.4.FLAXSB .MDTL	284.69	72.79	36.52	36.11	24.90
MA.4.FLAXSB .NOTL	281.71	72.67	36.46	36.01	24.83
MA.4.CANSF .INTL	278.25	33.24	19.17	18.86	32.17
MA.4.CANSF .MDTL	282.47	33.35	18.65	19.00	32.39
MA.4.CANSF .NOTL	282.93	33.38	18.31	18.92	32.25
MA.4.CANSB .INTL	215.30	27.17	16.11	15.64	26.66
MA.4.CANSB .MDTL	216.85	27.33	15.35	15.75	26.84
MA.4.CANSB .NOTL	215.58	27.91	15.37	15.68	26.73
MA.4.LENTSF .INTL	221.08	146.57	37.31	58.60	42.30

Table D.1. Continued

	CROPNET	RIP	CI	GPR	PR
MA.4.LENTSF .MDTL	211.06	146.55	37.40	58.58	42.29
MA.4.LENTSF .NOTL	239.62	146.31	37.45	58.55	42.27
MA.4.LENTSB .INTL	229.04	146.00	38.58	57.98	41.84
MA.4.LENTSB .MDTL	225.42	146.31	38.53	57.98	41.84
MA.4.LENTSB .NOTL	223.98	145.93	38.50	57.91	41.79
MA.4.FLDPSB .INTL	149.63	33.05	28.37	22.32	19.04
MA.4.FLDPSB .MDTL	148.21	32.95	28.13	22.31	19.03
MA.4.FLDPSB .NOTL	147.58	32.66	28.06	22.24	18.98
MA.5.WHTHQSF.INTL	313.16	30.50	21.20	27.74	28.33
MA.5.WHTHQSF.MDTL	310.87	30.09	19.29	27.47	28.04
MA.5.WHTHQSF.NOTL	310.68	30.01	19.04	27.38	27.94
MA.5.WHTHQSB.INTL	109.73	21.46	15.08	19.57	19.99
MA.5.WHTHQSB.MDTL	109.52	21.39	13.56	19.38	19.78
MA.5.WHTHQSB.NOTL	112.21	21.22	13.48	19.34	19.73
MA.5.BARSB .INTL	132.95	31.83	27.70	15.38	29.62
MA.5.BARSB .MDTL	151.10	32.00	28.41	16.13	31.04
MA.5.BARSB .NOTL	153.94	31.87	28.54	16.11	31.00
MA.5.FLAXSB .INTL	263.27	71.87	36.14	35.76	42.45
MA.5.FLAXSB .MDTL	262.30	71.88	36.18	35.80	42.50
MA.5.FLAXSB .NOTL	260.17	71.76	36.12	35.70	42.38
MA.5.CANSF .INTL	185.74	28.05	19.29	16.21	47.70
MA.5.CANSF .MDTL	192.40	28.01	18.10	16.39	48.21
MA.5.CANSF .NOTL	193.82	27.26	17.59	16.25	47.76
MA.5.LENTSB .INTL	228.78	146.29	37.83	57.81	21.82
MA.5.LENTSB .MDTL	224.73	146.69	37.70	57.75	21.80
MA.5.LENTSB .NOTL	223.07	146.46	37.68	57.66	21.76
MA.5.FLDPSB .INTL	146.05	29.95	26.64	21.66	22.77
MA.5.FLDPSB .MDTL	143.88	29.35	25.97	21.54	22.64
MA.5.FLDPSB .NOTL	142.51	28.91	25.67	21.40	22.50
MA.6.WHTHQSF.INTL	296.42	28.25	19.03	26.68	32.76
MA.6.WHTHQSF.MDTL	294.50	28.92	17.54	26.47	32.48
MA.6.WHTHQSF.NOTL	294.13	28.69	17.39	26.37	32.36
MA.6.WHTHQSB.INTL	106.64	19.90	13.23	18.73	22.99
MA.6.WHTHQSB.MDTL	106.58	20.43	12.24	18.60	22.81
MA.6.WHTHQSB.NOTL	108.29	20.06	12.27	18.50	22.70
MA.6.BARSB .INTL	119.79	31.28	26.81	14.75	29.93
MA.6.BARSB .MDTL	132.07	31.15	27.37	15.37	31.16
MA.6.BARSB .NOTL	133.72	31.09	27.29	15.34	31.10
MA.6.FLAXSB .INTL	223.68	64.46	31.22	31.54	42.74
MA.6.FLAXSB .MDTL	222.45	64.35	30.98	31.56	42.76
MA.6.FLAXSB .NOTL	218.72	64.19	31.37	31.44	42.62
MA.6.CANSF .INTL	163.95	26.56	18.65	14.76	40.35
MA.6.CANSF .MDTL	170.45	26.28	17.72	14.97	40.88
MA.6.CANSF .NOTL	171.73	25.98	17.33	14.89	40.67
MA.6.LENTSB .INTL	237.09	152.64	37.81	59.52	23.32

Table D.1. Continued

	CROPNET	RIP	CI	GPR	PR
MA.6.LENTSB .MDTL	233.12	153.03	37.33	59.42	23.28
MA.6.LENTSB .NOTL	230.61	153.05	37.08	59.26	23.22
MA.6.FLDPSB .INTL	150.66	30.98	27.50	22.32	18.22
MA.6.FLDPSB .MDTL	148.42	30.41	26.94	22.19	18.12
MA.6.FLDPSB .NOTL	146.79	29.80	26.41	22.03	17.99

[a] Variable definitions are as follows: CROPNET = expected market revenue less average cost, RIP = expected revenue insurance payment, CI = expected crop Insurance indemnity payment, GPR = expected revenue insurance premium, PR = expected crop insurance premium

APPENDIX E

RS-CRAM Objective Function and Selected Calculations

RS-CRAM Objective Function

The objective function sums consumer and producer surplus, adds government revenues to producers, and subtracts transportation costs.

$$\text{CPS} = \text{D}(\mathbf{q}) + \text{R}(\mathbf{q}) - \text{C}(\mathbf{x}) - \text{EV}(\mathbf{x}) - \text{T}(\mathbf{q})$$

where:

$\mathbf{x}$ = vector of activity levels by region, activity, crop/fallow sequence, and tillage,
$\mathbf{y}$ = vector of expected activity yields
$\mathbf{q}$ = vector of expected production levels for each activity
= $\mathbf{x'y}$

r = region index
nr = non-risk region index
rr = risk region index
c = crop/fallow sequence index
t = tillage practice index
i = year index

D($\mathbf{q}$) = sum of areas under linear market demand curves
= $\mathbf{q}'(\lambda - \tfrac{1}{2}\beta\mathbf{q})$

R($\mathbf{q}$) = expected government payments to producers
= NRG($\mathbf{q}$) + RRG($\mathbf{q}$) + LVG($\mathbf{q}$)

where
NRG($\mathbf{q}$) = non-risk region expected government payments to crop production

$$= \sum_{nr}\sum_{c}\sum_{t} X_{nr,c} \cdot G_{nr,c}$$

where G is the government payments rate per hectare

RRG($\mathbf{q}$) = risk region expected government payments to crop production

$$\text{either} = \sum_{rr}\sum_{c}\sum_{t} X_{rr,c,t}\ (CI_{rr,c,t} - PR_{rr,c,t}) \qquad (\textit{baseline})$$

$$\text{or} = \sum_{rr}\sum_{t}\sum_{t} X_{rr,c,t}(RIP_{rr,c,t} - GPR_{rr,c,t} - PR_{rr,c,t}) \qquad (\text{GRIP})$$

where P = 10 year moving average market price
CI = crop insurance indemnity payment per hectare
PR = crop insurance premium per hectare
RIP = revenue insurance payment per hectare
GPR = revenue insurance premium per hectare

LVG(**q**) = expected government payments to livestock production

C(**x**) = input cost function, including and PMP coefficients for land
= $(\mathbf{c} + \alpha)'\mathbf{x} + \frac{1}{2}\mathbf{x}'\gamma\,\mathbf{x}$

EV(**x**) = EV risk aversion adjustment
= $\frac{1}{2}\phi\ \mathbf{x}'\Omega\mathbf{x}$

T(**q**) = transport costs

D(**q**) comprises consumer surplus plus total consumer expenditures. Total consumer expenditures less transportation costs, T(**q**), gives producer market revenues. Producer market revenues plus government payments gives total producer revenue. Finally, total producer revenue less producer costs C(**x**) and opportunity costs associated with risk EV(**x**) gives total producer surplus. Thus, for the baseline scenario with only crop insurance, the sum of consumer and producer surplus is:

$$\begin{aligned}\mathrm{CPS} = {} & \mathbf{q}'(\lambda - \tfrac{1}{2}\boldsymbol{\beta} q) + \sum_{nr}\sum_{c}\sum_{t} X_{nr,c} \cdot G_{nr,c} \\ & + \sum_{rr}\sum_{c}\sum_{t} X_{rr,c,t}(CI_{rr,c,t} - PR_{rr,c,t}) \\ & + LVG(\mathbf{q}) - (\mathbf{c}'x + \alpha' x + \tfrac{1}{2}\mathbf{x}'\gamma x) - \tfrac{1}{2}\boldsymbol{\phi} x'\Omega x - T(\mathbf{q})\end{aligned}$$

and for the GRIP scenario with crop and revenue insurance

$$\begin{aligned}\mathrm{CPS} = {} & \mathbf{q}'(\lambda - \tfrac{1}{2}\beta q) + \sum_{nr}\sum_{c}\sum_{t} X_{nr,c} \cdot G_{nr,c} \\ & + \sum_{rr}\sum_{c}\sum_{t} X_{rr,c,t}(RIP_{rr,c,t} - GPR_{rr,c,t} - PR_{rr,c,t}) \\ & + LVG(\mathbf{q}) - (\mathbf{c}'x + \alpha' x + \tfrac{1}{2}\mathbf{x}'\gamma x) - \tfrac{1}{2}\phi\mathbf{x}'\Omega x - T(q)\end{aligned}$$

Expected Net Per Hectare Crop Returns

CNR = crop net returns per hectare
Y = current yield
P = 10 year moving average price
INSP = insurance price from maximum price option
IMAP = indexed moving average price
CSTHA = production cost per hectare
CI = crop insurance indemnity payment
LTAY = long-term average yield
PR = crop insurance premium
PRPCT = premium percentage
CL = coverage level
RIP = revenue insurance payment
GPR = revenue insurance premium

Baseline: Crop insurance only

$$\begin{aligned}
CNR_{\pi,c,t,i} &= Y_{\pi,c,t,i}P_{\pi,c,i} + CI_{\pi,c,t,i} - PR_{\pi,c,t,i} - CSTHA_{\pi,c,t,i} \\
CI_{\pi,c,t,i} &= \max\{0, (CL_{c}LTAY_{\pi,c,t,i} - Y_{\pi,c,t,i})INSP_{\pi,c,i}\} \\
PR_{\pi,c,t,i} &= CL_{\pi,c}PRPCT_{\pi,i}LTAY_{\pi,c,t,i}INSP_{\pi,c,i}
\end{aligned}$$

GRIP: Crop and revenue insurance

$$\begin{aligned}
CNR_{\pi,c,t,i} &= Y_{\pi,c,t,i}P_{\pi,c,i} + RIP_{\pi,c,t,i} - GPR_{\pi,c,t,i} - PR_{\pi,c,t,i} - CSTHA_{\pi,c,t,i} \\
RIP_{\pi,c,t,i} &= \max\{0, (CL_{c}LTAY_{\pi,c,t,i}IMAP_{\pi,c,i} - Y_{\pi,c,t,i}P_{\pi,c,i}\} \\
GPR_{\pi,c,t,i} &= CL_{\pi,c}PRPCT_{\pi,i}LTAY_{\pi,c,t,i}IMAP_{\pi,c,i}
\end{aligned}$$

Variance-covariance matrix calculations

The variance-covariance matrix Ω is computed using detrended time series of per hectare net activity returns. First, the time series of net returns for each activity is computed according to the above formulas. Second, a linear trend is calculated for each activity. Times series of deviations of net returns from these trends are then computed. Variances and covariances are finally computed for these detrended series.

Let

$CNR_{j,i}$ = expected net returns to crop activity/tillage combination j in year i for a given production region and policy over the sample period 1980-92 (n=13)

$DCNR_{j,i}$ = $CNR_{j,i} - b_0 - b_1 * i$ where b_0 and b_1 are OLS coefficients

$V_{j,k}$ = covariance of net returns to crop activity/tillage combinations j and k within a given production region and policy

$$V_{j,k} = \frac{1}{n-1}\left[\sum_{i=1}^{n} DCNR_{j,i} DCNR_{k,i}\right]$$

Risk Parameter Estimation

The coefficient of absolute risk aversion, ϕ, is estimated following the method of House (1989). A variance-covariance matrix (**V**) of detrended observed net returns is computed from historical data covering 1982-88 in the same manner described above. A different data set is used for estimating ϕ because a full set of historical data is not available at the level of disaggregation used in the model itself. The coefficient is

$$\phi = -T / (\mathbf{x'Vx})^{1/2}$$

where T is the standard normal percentile for a parameter b and **x** is a vector of mean observed crop areas over the same period. The parameter b corresponds to producers' willingness to accept a loss. It is assumed here that producers are willing to accept the probability that a loss will occur approximately one year in 7, resulting in a b value of 0.85.

The coefficient is estimated for producers in the three Prairie provinces only and does not account for production of lentils or field peas, which are minor crops and the omission of which should not significantly bias the estimation. The estimated value is $\phi = 7.231921E-7$. It is difficult to validate this estimate becuase it is a measure of *absolute* risk aversion and thus depends on the income level of producers in the particular data set. Multiplying ϕ by the net crop income for wheat, barley, flax, and canola from the baseline solution, however, yields a rough estimate of the Arrow-Pratt coefficient of *relative* risk aversion which can be compared to other estimates of relative risk aversion. For RS-CRAM, this estimate is 2.966. House (1989) uses the same methodology for U.S. producers and obtains an estimate of 3.41, but uses a b value of 0.80 rather than 0.85. As House also notes, the range of estimates used in other studies varies widely, from 0.08 to 7.0, depending on methodology and sample.

APPENDIX F

Endogenous Crop Prices Generated by RS-CRAM

Table F.1. Endogenous crop prices generated by RS-CRAM ($/tonne)

	WHEATHQ	WHEATHQ2	WHEATHQ3	WHEATHQ4	BARLEY	FLAX	CANOLA	LENTILS	FLDPEAS
AL.1	197.43	178.44	172.95	142.82	104.24	366.35	316.77	312.26	161.26
AL.2	198.02	179.03	173.54	143.41	104.83	366.92	317.36	312.85	161.85
AL.3	198.17	179.18	173.69	143.56	104.98	367.09	317.51	313.00	162.00
AL.4	198.02	179.03	173.54	143.41	104.83	366.94	317.36	312.85	161.85
AL.5	197.87	178.88	173.39	143.26	104.68	366.84	317.21	312.70	161.70
AL.6	198.17	179.18	173.69	143.56	104.98	367.07	317.51	313.00	162.00
AL.7	197.43	178.44	172.95	142.82	104.24	366.35	316.79	312.26	161.26
SA.1	199.18	180.19	174.70	157.42	106.13	365.34	312.34	313.00	162.00
SA.2	198.89	179.90	174.41	157.13	105.84	365.05	312.37	311.39	160.39
SA.3	198.44	179.45	173.96	156.68	105.38	364.60	313.24	312.26	161.26
SA.4	196.81	177.96	172.47	155.05	103.86	363.05	313.98	311.51	160.51
SA.5	198.74	179.75	174.26	156.98	105.72	364.90	311.90	312.56	161.56
SA.6	197.99	179.00	173.51	156.23	104.95	364.17	313.84	311.81	160.81
SA.7	197.55	178.56	173.07	155.79	104.50	363.71	313.39	311.37	160.37
SA.8	197.99	179.00	173.51	156.23	104.94	364.15	313.05	311.81	160.81
SA.9	197.70	178.71	173.22	155.94	104.65	363.86	313.54	311.52	160.52
MA.1	198.65	179.66	174.17	156.89	104.99	366.33	314.30	312.10	161.10
MA.2	198.21	179.22	173.73	156.45	104.54	365.97	314.99	313.00	162.00
MA.3	199.25	180.26	174.77	157.49	105.58	366.94	313.84	312.70	161.70
MA.4	199.25	180.26	174.77	157.49	105.57	366.93	313.37	312.70	161.70
MA.5	199.55	180.56	175.07	157.79	105.88	367.23	313.37	313.00	162.00
MA.6	199.10	180.11	174.62	157.34	105.43	366.78	312.46	312.55	161.55

APPENDIX G

Detailed Erosion Results

Table G.1. Wind erosion results for Alberta

Region	Baseline	GRIP	GRIPNR	GRIPHR	INDCROP	TILL
Percentage Shifts in Mean Wind Erosion Per Hectare						
	(tons/ha)			(percent change)		
1	3.557	-1.259	-1.132	-1.225	0.129	-22.530
2	3.277	-1.070	-0.670	-1.866	2.288	-24.460
3	0.856	-3.130	-3.111	-3.808	18.609	-40.815
4	0.324	-1.476	-1.301	-2.528	9.883	-47.614
5	0.258	-2.419	-2.508	-3.446	12.725	-47.162
6	0.283	-1.318	-1.019	-1.488	0.051	-40.714
7	0.070	-0.719	-0.559	-0.814	-1.215	-50.146
AL	1.363	-1.359	-1.112	-1.852	3.388	-27.225
Mean Wind Erosion (tons per hectare)						
1	3.557	3.512	3.517	3.513	3.561	2.755
2	3.277	3.242	3.255	3.216	3.352	2.475
3	0.856	0.829	0.830	0.824	1.016	0.507
4	0.324	0.319	0.320	0.316	0.356	0.170
5	0.258	0.252	0.251	0.249	0.291	0.136
6	0.283	0.279	0.280	0.279	0.283	0.168
7	0.070	0.069	0.069	0.069	0.069	0.035
AL	1.363	1.345	1.348	1.338	1.409	0.992
Minimum Wind Erosion (tons per hectare)						
1	0.077	0.076	0.076	0.076	0.077	0.051
2	0.116	0.115	0.116	0.115	0.123	0.072
3	0.001	0.001	0.001	0.001	0.001	0.005
4	0.012	0.012	0.012	0.012	0.013	0.004
5	0.000	0.000	0.000	0.000	0.000	0.001
6	0.000	0.000	0.000	0.000	0.000	0.001
7	0.004	0.004	0.004	0.004	0.003	0.001
AL	0.000	0.000	0.000	0.000	0.000	0.001
Maximum Wind Erosion (tons per hectare)						
1	20.937	20.672	20.699	20.677	20.904	17.361
2	19.222	19.016	19.087	18.866	19.521	15.610
3	4.247	4.100	4.100	4.074	5.084	2.844
4	2.628	2.581	2.587	2.551	2.924	1.610
5	1.538	1.500	1.498	1.484	1.737	0.892
6	1.422	1.403	1.407	1.400	1.418	0.917
7	2.720	2.672	2.677	2.653	2.551	1.626
AL	20.937	20.672	20.699	20.677	20.904	17.361

Table G.2. Water erosion results for Alberta

Region	Baseline	GRIP	GRIPNR	GRIPHR	INDCROP	TILL
Percentage Shifts in Mean Water Erosion Per Hectare						
	(tons/ha)			(percent change)		
1	3.557	-1.259	-1.132	-1.225	0.129	-22.530
2	3.277	-1.070	-0.670	-1.866	2.288	-24.460
3	0.856	-3.130	-3.111	-3.808	18.609	-40.815
4	0.324	-1.476	-1.301	-2.528	9.883	-47.614
5	0.258	-2.419	-2.508	-3.446	12.725	-47.162
6	0.283	-1.318	-1.019	-1.488	0.051	-40.714
7	0.070	-0.719	-0.559	-0.814	-1.215	-50.146
AL	1.431	-2.248	-2.120	-2.871	8.399	-25.935
Mean Water Erosion (tons per hectare)						
1	3.557	3.512	3.517	3.513	3.561	2.755
2	3.277	3.242	3.255	3.216	3.352	2.47548
3	0.856	0.829	0.830	0.824	1.016	0.50674
4	0.324	0.319	0.320	0.316	0.356	0.16987
5	0.258	0.252	0.251	0.249	0.291	0.13624
6	0.283	0.279	0.280	0.279	0.283	0.1677
7	0.070	0.069	0.069	0.069	0.069	0.03483
AL	1.431	1.398	1.400	1.390	1.551	1.060
Minimum Water Erosion (tons per hectare)						
1	0.077	0.076	0.076	0.076	0.077	0.051
2	0.116	0.115	0.116	0.115	0.123	0.072
3	0.001	0.001	0.001	0.001	0.001	0.005
4	0.012	0.012	0.012	0.012	0.013	0.004
5	0.000	0.000	0.000	0.000	0.000	0.001
6	0.000	0.000	0.000	0.000	0.000	0.001
7	0.004	0.004	0.004	0.004	0.003	0.001
AL	0.001	0.001	0.001	0.001	0.001	0.000
Maximum Water Erosion (tons per hectare)						
1	26.432	26.114	26.126	26.116	26.387	22.555
2	23.052	22.804	22.897	22.617	23.560	19.373
3	45.165	44.044	44.038	43.863	50.094	38.299
4	17.037	16.670	16.723	16.432	19.451	13.768
5	19.047	18.371	18.360	18.113	22.544	15.984
6	21.844	21.433	21.502	21.364	22.083	18.555
7	2.627	2.573	2.578	2.555	2.467	1.790
AL	45.165	44.044	44.038	43.863	50.094	38.299

Table G.3. Wind erosion results for Saskatchewan

Region	Baseline	GRIP	GRIPNR	GRIPHR	INDCROP	TILL
Percentage Shifts in Mean Wind Erosion Per Hectare						
	(tons/ha)			(percent change)		
1	4.104	-1.571	-1.778	-2.153	-1.488	-27.554
2	5.125	1.419	0.502	-1.240	-0.559	-20.134
3	17.144	-0.452	-0.451	-0.651	-0.652	-15.034
4	9.929	-0.041	-0.041	-0.345	-0.387	-15.096
5	1.100	-1.342	-0.780	-1.229	4.430	-38.760
6	3.214	-1.323	-1.274	-2.573	2.226	-22.232
7	3.363	-0.772	-0.773	-1.357	0.925	-16.553
8	0.625	-0.661	-0.453	-1.273	-3.637	-46.081
9	0.993	-1.107	-1.153	-1.573	5.364	-41.269
SA	5.732	-0.445	-0.513	-0.988	-0.130	-18.261
Mean Wind Erosion (tons per hectare)						
1	4.104	4.039	4.031	4.016	4.043	2.973
2	5.125	5.197	5.150	5.061	5.096	4.093
3	17.144	17.067	17.067	17.033	17.033	14.567
4	9.929	9.925	9.925	9.895	9.891	8.430
5	1.100	1.085	1.091	1.086	1.148	0.673
6	3.214	3.172	3.173	3.132	3.286	2.500
7	3.363	3.337	3.337	3.317	3.394	2.806
8	0.625	0.621	0.622	0.617	0.602	0.337
9	0.993	0.983	0.982	0.978	1.047	0.584
SA	5.732	5.707	5.703	5.676	5.725	4.686
Minimum Wind Erosion (tons per hectare)						
1	0.370	0.372	0.372	0.372	0.367	0.204
2	0.011	0.011	0.011	0.011	0.011	0.004
3	0.188	0.187	0.187	0.187	0.188	0.147
4	0.260	0.261	0.261	0.260	0.259	0.189
5	0.008	0.008	0.008	0.008	0.008	0.005
6	0.149	0.149	0.148	0.148	0.157	0.102
7	0.028	0.028	0.027	0.028	0.029	0.017
8	0.009	0.008	0.008	0.008	0.008	0.005
9	0.044	0.044	0.044	0.044	0.043	0.016
SA	0.008	0.008	0.008	0.008	0.008	0.004
Maximum Wind Erosion (tons per hectare)						
1	15.124	14.822	14.789	14.720	14.869	11.731
2	23.438	23.763	23.552	23.122	23.300	19.678
3	52.832	52.559	52.559	52.454	52.472	46.303
4	51.370	51.334	51.334	51.183	51.163	45.156
5	6.032	5.917	5.961	5.903	6.261	4.129
6	37.947	37.330	37.377	36.760	38.635	32.315
7	29.438	29.218	29.219	29.023	29.615	25.533
8	6.544	6.466	6.495	6.414	6.202	4.413
9	7.519	7.368	7.367	7.289	8.405	5.213
SA	52.832	52.559	52.559	52.454	52.472	46.303

Table G.4. Water erosion results for Saskatchewan

Region	Baseline	GRIP	GRIPNR	GRIPHR	INDCROP	TILL
Percentage Shifts in Mean Water Erosion Per Hectare						
	(tons/ha)			(percent change)		
1	1.023	-1.907	-2.113	-2.561	-1.250	-21.299
2	1.001	1.342	0.408	-1.380	-0.497	-16.806
3	1.822	-0.511	-0.510	-0.706	-0.711	-11.831
4	1.982	-0.026	-0.026	-0.360	-0.344	-10.785
5	0.930	-2.201	-1.425	-2.687	4.864	-23.712
6	0.817	-1.650	-1.592	-3.144	2.016	-14.776
7	1.545	-0.821	-0.818	-1.388	0.898	-11.256
8	0.910	-1.145	-0.707	-1.929	-3.649	-24.257
9	1.275	-2.340	-2.338	-3.445	13.627	-19.484
SA	1.260	-0.967	-0.937	-1.721	1.622	-15.726
Mean Water Erosion (tons per hectare)						
1	1.023	1.003	1.001	0.996	1.010	0.805
2	1.001	1.015	1.005	0.988	0.996	0.833
3	1.822	1.812	1.812	1.809	1.809	1.606
4	1.982	1.982	1.982	1.975	1.975	1.768
5	0.930	0.909	0.917	0.905	0.975	0.709
6	0.817	0.804	0.804	0.791	0.834	0.696
7	1.545	1.533	1.533	1.524	1.559	1.371
8	0.910	0.900	0.904	0.893	0.877	0.689
9	1.275	1.245	1.245	1.231	1.449	1.027
SA	1.260	1.248	1.248	1.238	1.280	1.062
Minimum Water Erosion (tons per hectare)						
1	0.016	0.016	0.016	0.016	0.016	0.006
2	0.002	0.002	0.002	0.002	0.002	0.001
3	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000
5	0.012	0.012	0.012	0.012	0.012	0.004
6	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000
SA	0.000	0.000	0.000	0.000	0.000	0.000
Maximum Water Erosion (tons per hectare)						
1	32.082	31.438	31.377	31.220	31.708	28.770
2	64.226	64.837	64.340	63.292	64.014	59.602
3	33.336	33.159	33.159	33.097	33.130	30.787
4	42.756	42.739	42.739	42.597	42.611	39.911
5	54.090	52.936	53.340	52.658	57.537	48.632
6	21.115	20.747	20.759	20.434	21.569	19.212
7	26.561	26.333	26.332	26.186	26.820	24.576
8	8.992	8.889	8.929	8.820	8.697	7.545
9	26.294	25.668	25.668	25.373	29.979	23.219
SA	64.226	64.837	64.340	63.292	64.014	59.602

Table G.5. Wind erosion results for Manitoba

Region	Baseline	GRIP	GRIPNR	GRIPHR	INDCROP	TILL
Percentage Shifts in Mean Wind Erosion Per Hectare						
	(tons/ha)	(percent change)				
1	2.336	-0.684	-0.793	-1.208	3.391	-39.401
2	2.889	-0.409	-0.469	-0.788	0.115	-44.673
3	1.848	-0.436	-0.481	-0.645	-2.492	-41.266
4	1.437	-0.730	-0.627	-0.915	-1.700	-43.382
5	2.565	-0.870	-0.870	-0.875	-1.586	-34.989
6	1.004	-0.657	-0.657	-0.613	-2.860	-41.983
MA	2.128	-0.637	-0.685	-0.958	0.534	-40.445
Mean Wind Erosion (tons per hectare)						
1	2.336	2.320	2.318	2.308	2.415	1.416
2	2.889	2.877	2.875	2.866	2.892	1.598
3	1.848	1.840	1.839	1.836	1.802	1.085
4	1.437	1.426	1.428	1.424	1.412	0.813
5	2.565	2.543	2.543	2.543	2.524	1.668
6	1.004	0.997	0.997	0.997	0.975	0.582
MA	2.128	2.114	2.113	2.108	2.139	1.267
Minimum Wind Erosion (tons per hectare)						
1	0.203	0.201	0.201	0.201	0.202	0.067
2	0.011	0.011	0.011	0.011	0.010	0.004
3	0.217	0.216	0.216	0.215	0.217	0.080
4	0.228	0.227	0.227	0.227	0.228	0.081
5	0.002	0.002	0.002	0.002	0.003	0.000
6	0.224	0.223	0.223	0.223	0.203	0.096
MA	0.002	0.002	0.002	0.002	0.003	0.000
Maximum Wind Erosion (tons per hectare)						
1	17.563	17.429	17.424	17.289	18.935	12.654
2	12.269	12.205	12.208	12.139	12.862	7.929
3	6.495	6.457	6.457	6.446	6.338	4.295
4	6.910	6.873	6.881	6.860	6.800	4.558
5	12.407	12.296	12.296	12.298	12.293	8.840
6	6.208	6.172	6.172	6.173	6.191	4.216
MA	17.563	17.429	17.424	17.289	18.935	12.654

Table G.6. Water erosion results for Manitoba

Region	Baseline	GRIP	GRIPNR	GRIPHR	INDCROP	TILL
Percentage Shifts in Mean Water Erosion Per Hectare						
	(tons/ha)		(percent change)			
1	1.12965	-0.386	-0.547	-0.949	10.851	-27.759
2	5.947	-0.362	-0.246	-1.234	4.788	-20.900
3	0.805	0.348	0.258	0.252	1.317	-29.487
4	1.296	0.318	0.431	0.395	1.289	-28.935
5	0.807	-0.457	-0.457	-0.362	6.704	-33.429
6	0.786	-0.599	-0.599	-0.645	8.075	-34.154
MA	1.704	-0.252	-0.227	-0.794	5.808	-25.312
Mean Water Erosion (tons per hectare)						
1	1.130	1.125	1.123	1.119	1.252	0.816
2	5.947	5.925	5.932	5.873	6.231	4.704
3	0.805	0.808	0.807	0.807	0.816	0.568
4	1.296	1.300	1.301	1.301	1.312	0.921
5	0.807	0.803	0.803	0.804	0.861	0.537
6	0.786	0.781	0.781	0.781	0.850	0.518
MA	1.704	1.699	1.700	1.690	1.803	1.272
Minimum Water Erosion (tons per hectare)						
1	0.019	0.019	0.019	0.018	0.023	0.005
2	0.010	0.010	0.010	0.009	0.012	0.002
3	0.007	0.007	0.007	0.007	0.008	0.002
4	0.022	0.022	0.022	0.022	0.023	0.007
5	0.021	0.021	0.021	0.021	0.025	0.006
6	0.177	0.176	0.176	0.175	0.199	0.092
MA	0.007	0.007	0.007	0.007	0.008	0.002
Maximum Water Erosion (tons per hectare)						
1	36.356	36.296	36.210	36.082	40.765	30.665
2	44.606	44.446	44.497	44.057	46.461	36.583
3	6.816	6.867	6.857	6.861	6.932	5.446
4	6.991	7.052	7.062	7.065	7.154	5.569
5	31.265	31.362	31.362	31.435	35.510	26.765
6	1.192	1.185	1.185	1.185	1.265	0.810
MA	44.606	44.446	44.497	44.057	46.461	36.583

APPENDIX H

Model Execution

CARD executes RS-CRAM using the General Algebraic Modelling System version 2.25 (GAMS) described in Brooke et. al. (1988) and the Minos 5.1 nonlinear optimization algorithm (Murtagh and Saunders, 1987). Results presented in this report were produced on a DECStation 5000 operating under Ultrix 4.3a, a Unix type operating system. Results produced on other platforms, such as DOS on a personal computer, may differ slightly.

The GAMS script files for calibration are executed in the standard way, using SAVE and RESTART files. The steps are as follows:

1. Solve phase1.gms and save the results for phase2 in work files p1.* by executing the following UNIX command:

   ```
   gams phase1 -s p1
   ```

   where p1 is the name of the SAVE files that will be read into phase2.gms.
2. Then run phase2.gms using phase1 results and save the results in p2.* by executing the following UNIX command:

   ```
   gams phase2 -r p1 -s p2
   ```

   where p2 is the name of the SAVE files that will be read into phase3.gms.
3. Finally, run phase3 using the phase2 results and save the final PMP model's results in p3.* by executing the following UNIX command:

   ```
   gams phase3 -r p2 -s p3
   ```

4. A policy scenario may be run by reading the phase3 SAVE files into the sceanrio GAMS script file. To run the GRIP scenario, for example, use the UNIX command

   ```
   gams grip -r p3 -s g1
   ```

Report writing routines are generally run following execution of policy runs using the RESTART files from the policy scenario. Several baseline results are saved at the end of phase3.gms, where documentation is provided, to facilitate scenario comparisons.

Execution of economic and environmental linkage is achieved in the following two steps:

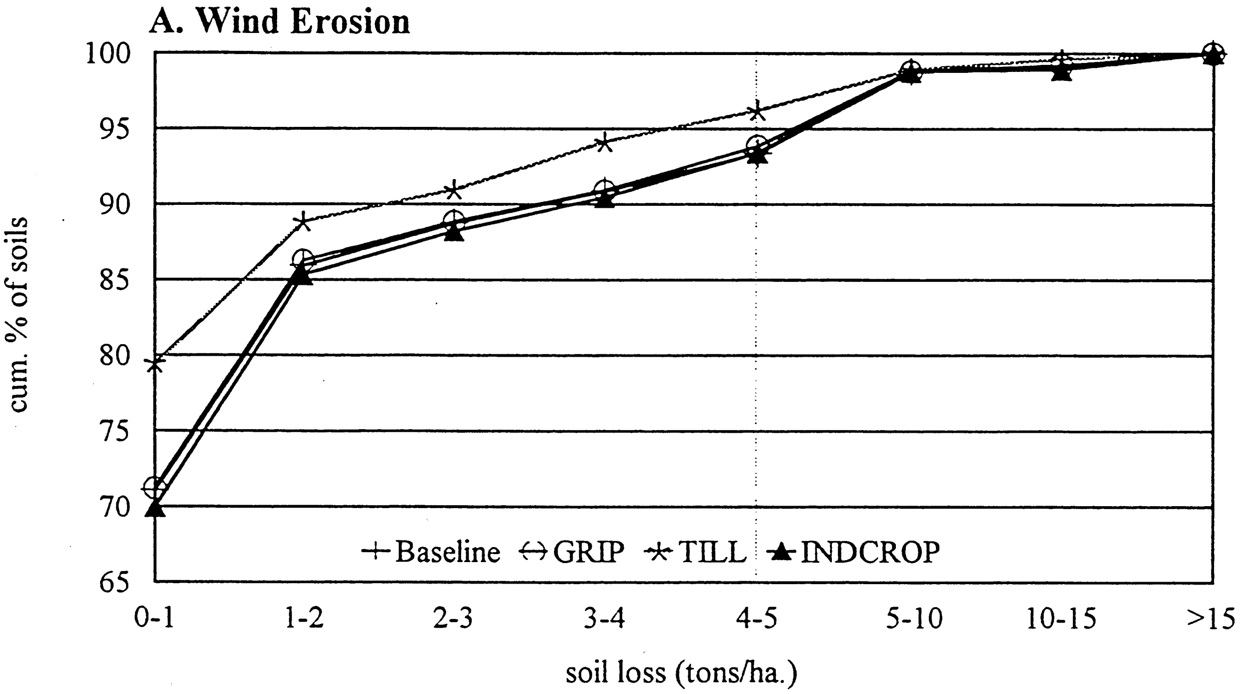
1. Run phase4.gms using the command

   ```
   gams phase4 -r p3 -ps 9999
   ```

   Phase4.gms will read activity levels from the phase3 or scenario RESTART files and compute the ratio of each activity levels to the total. The example given is for obtaining erosion baseline estimates from phase3.gms. The method is identical for other policy scenarios. Edit the listing file phase4.lst to remove the header and footer text and save it as "dist.dat" under the directory in which results for the particular scenario are stored. This step should be performed in each of the policy directories including the baseline.
2. Execute the SAS code file aleros.sas, saeros.sas, and maeros.sas to compute the policy specific spatial distributions and also the percentage shifts in soil erosion (wind and water) in each province. These SAS files may be edited to produce erosion results at various levels of aggregation and detail, as discussed in section III.E.

APPENDIX I.

Cumulative frequency distributions of soil loss, selected examples



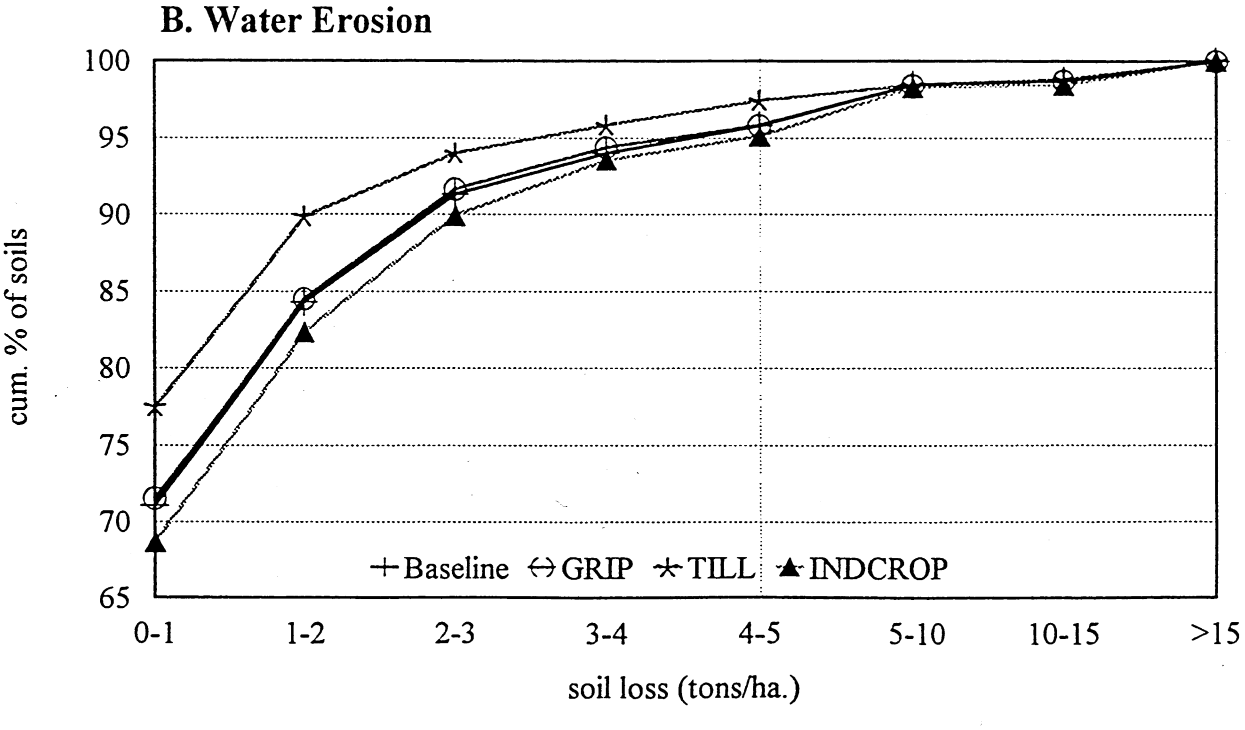
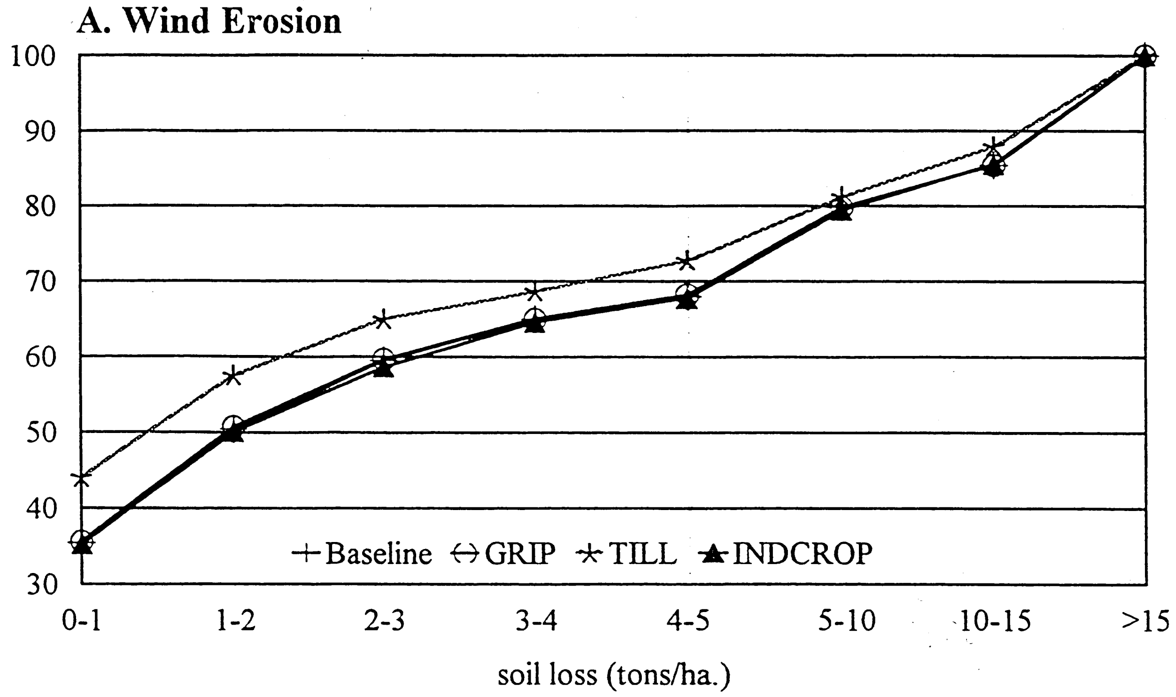


Figure I.1.. Cumulative Frequency Distribution of (A) Wind Erosion and (B) Water Erosion in Alberta Under Alternative Scenarios


A. Wind Erosion

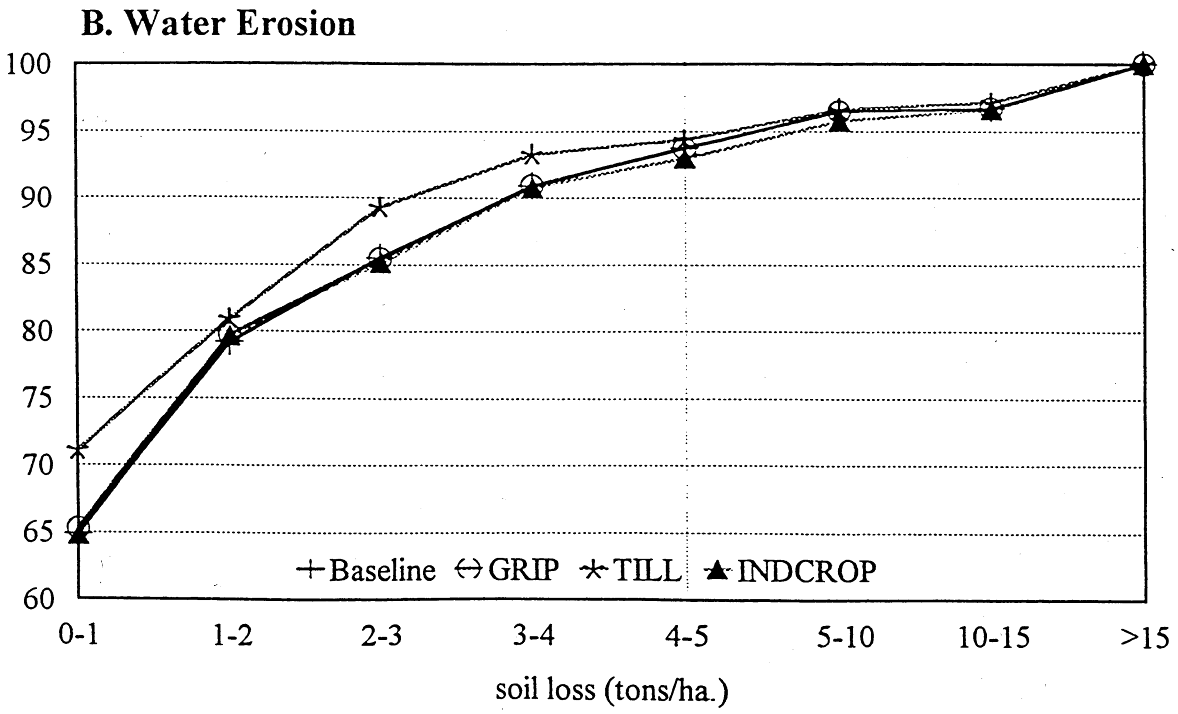
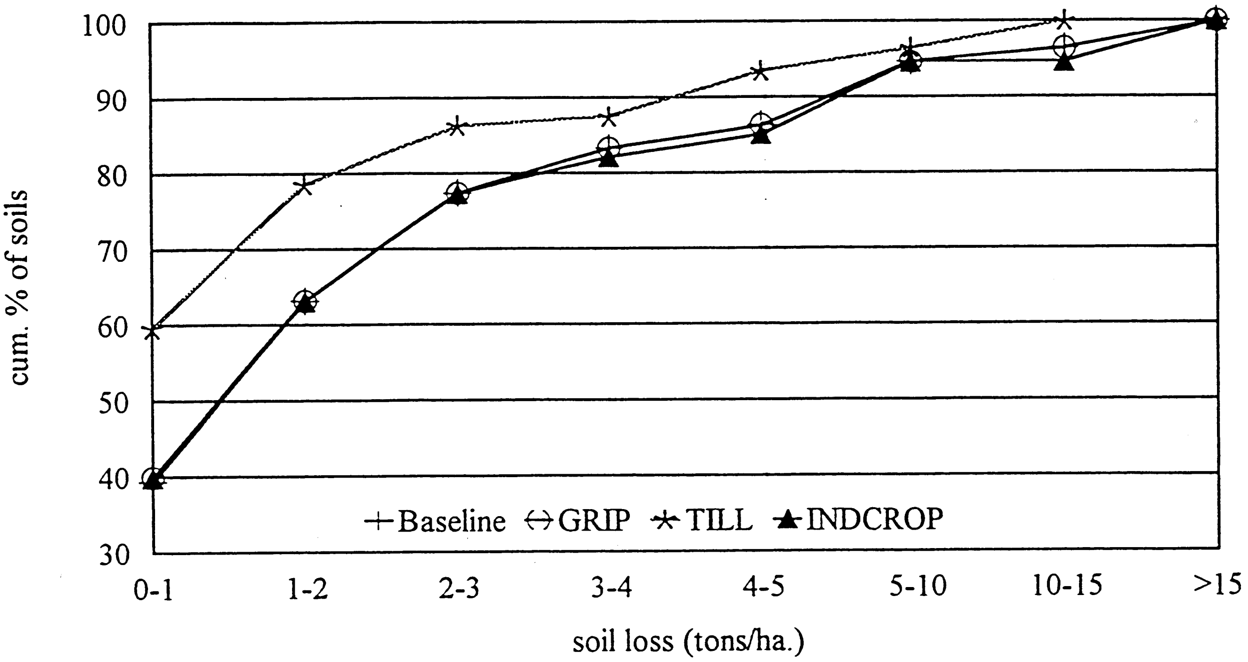

B. Water Erosion

Figure I.2. Cumulative Frequency Distribution of (A) Wind Erosion and (B) Water Erosion in Saskatchewan Under Alternative Scenarios

A. Wind Erosion



B. Water Erosion

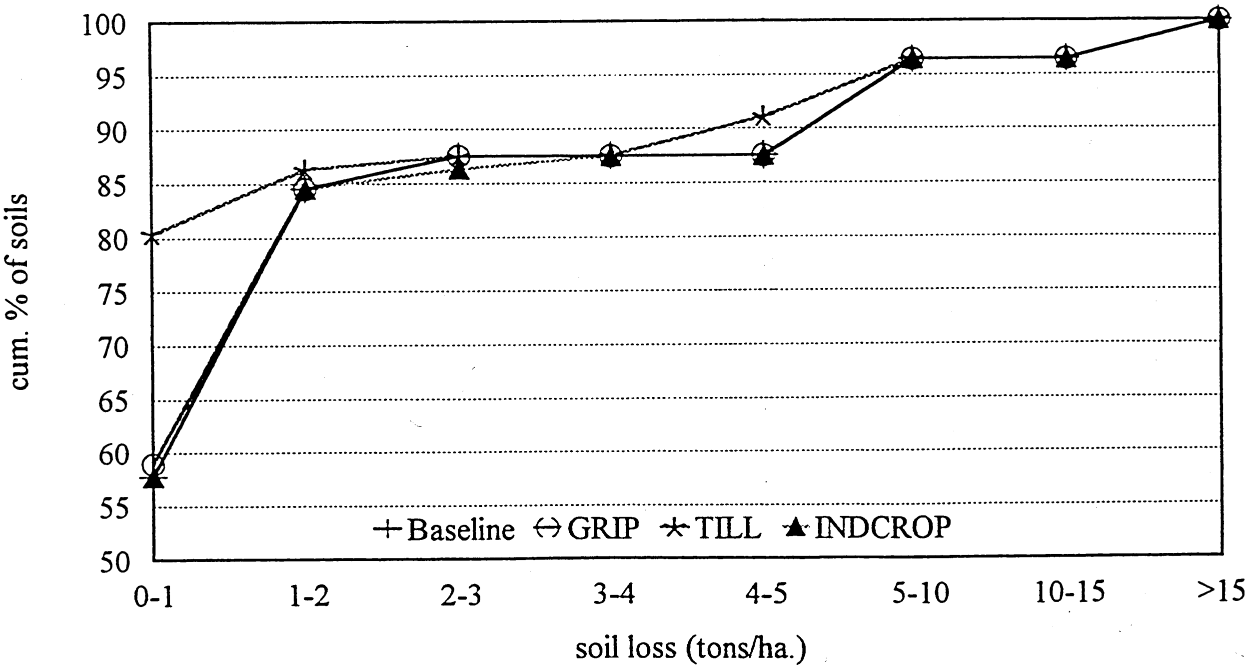


Figure I.3. Cumulative Frequency Distribution of (A) Wind Erosion and (B) Water Erosion in Manitoba Under Alternative Scenarios

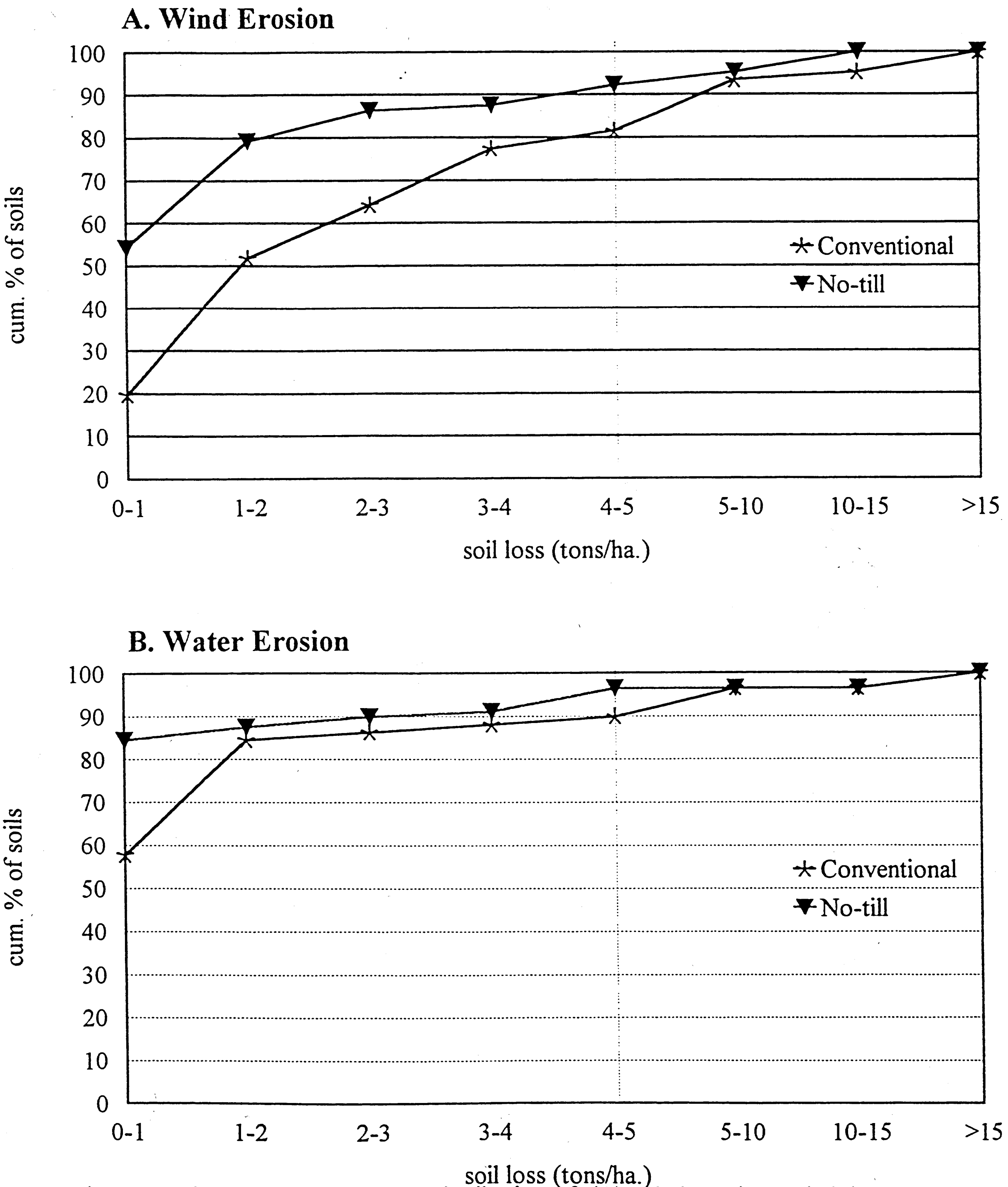


Figure I.4. Cumulative Frequency Distribution of (A) Wind Erosion and (B) Water Erosion for Wheat on Stubble in Manitoba Under the Baseline with Conventional and No-till Practices