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ABSTRACT

Public concern over the potential effects of energy price increases on the U.S. food and fiber system has been dramatically justified in the Trans Pecos region of Texas where a 450 percent increase in the price of natural gas was followed by the idling of thousands of irrigated acres and the departure of many of the farmers.

This study was conducted to provide the answers to two questions: (1) Can an irrigated farm survive in the Trans Pecos? and (2) If it survives, how profitable will it be? Coyanosa, one of the irrigated areas of the Trans Pecos, was selected as a study area, and the St. Lawrence area of the Edwards Plateau was selected to provide comparative estimates of survival and profitability.

A modified MOTAD linear programming-simulation model was developed to generate estimates of survival and profitability by recursive simulation of multiple time periods, as follows: (1) development of a farm plan, (2) generation of stochastic prices and yields, (3) simulation and evaluation of the farm plan in operation, and (4) update of the planning situation to reflect adjustments in expected prices, expected yields, and credit restrictions. The model then returns to step 1 for simulation of the next time period.

The model was applied to the Coyanosa and St. Lawrence regions under alternative future scenarios for inflation rates, energy prices, crop prices, and interest rates. The Coyanosa model was also applied under most likely scenario conditions to analyze the effects of alternative levels of risk-aversion and alternative tenure situations. Each

application included 20 simulations of a 10 year planning horizon to develop a distribution of outcome.

The Coyanosa farm survived about 8 years under the optimistic scenario and 5 years under all other scenarios. The most likely rate of survival was 20-30 percent with a range of 10 percent to 65 percent for other scenarios. The average life and rate of survival was higher for the St. Lawrence farm under all scenarios.

The internal rate of return on equity capital for the Coyanosa farm was 36.8 percent under the optimistic scenario and negative under all other scenarios. The rate of return for St. Lawrence was not significantly different for the optimistic scenario; however, it was higher than Coyanosa for all other scenarios.

The level of risk-aversion described by the baseline model appears to be relatively high compared to other studies, but there are indications that it may be relatively low for the St. Lawrence area. Both rate of return and survival increased in response to decreased levels of risk-aversion; however, the latter result may be related to the specification of the risk restraint.

Land purchase provided higher estimates of survival and profitability than rental or combined rental and purchase. These results seem to relate to the finding that traditional crop share rental arrangements are unsatisfactory for the Coyanosa area.

It was concluded from this study that (1) survival and profitability of irrigated crop production in the Coyanosa area will depend greatly upon future levels of inflation, energy prices, crop prices, and interest rates, (2) survival and profitability for Coyanosa will most likely be lower than St. Lawrence, and (3) land purchase provides greater potential survival and profitability than traditional crop share rental arrangements. These conclusions were limited by need for additional research regarding the effects of beginning equity levels and consideration of risk in farm planning. Conclusions were also limited by the data and assumptions utilized in the study.

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INTRODUCTION

The OPEC oil embargo of 1973 and the natural gas curtailments during the severe winter of 1976-1977 served to focus concern on the energy supply-demand situation in the United States (Federal Energy Administration; VanArsdall and Devlin). While many alternative solutions to the 'energy crisis' and the 'natural gas shortage' have been proposed, all include one or more of the following major objectives: (1) an increase in natural gas supplies, (2) a decrease in natural gas demand, and/or (3) development of alternative energy sources (Texas Governor's Energy Advisory Council). These proposals differ in pricing mechanisms, degree of governmental involvement, and other aspects; but it seems certain that energy users, particularly natural gas users, can expect higher prices for energy over the next 5 to 10 year period.

There is a pressing need for analysis of the potential effects of increasing energy prices on different sectors of the economy. This need is particularly critical in the case of agriculture, since farmers are price-takers and cannot 'pass through' higher energy costs.

While higher energy prices and/or reduced energy supplies will have significant impacts on agriculture as a whole, the impacts will not be distributed equally between regions and enterprises. Irrigated crop production is relatively more energy intensive than dryland production; therefore, producers in irrigated regions will be more severely affected. Higher energy prices will tend to reduce production and

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Citations in this study follow the style and format of the American Journal of Agricultural Economics.

increase crop prices. Since demand for farm products is generally inelastic, total farm income will be increased. But irrigated regions will incur the majority of the increased costs and only a portion of the increased income resulting in a shift of comparative advantage to dryland farming regions (Dvoskin and Heady).

The Trans Pecos Region of Texas has already experienced severe price increases for natural gas and substantial adjustments in irrigated farming. This region, with irrigated acreage totaling less than five percent of that in the High Plains, received national attention in 1975 as the price of natural gas dramatically increased over 450 percent from $.40 to $1.85 per thousand cubic feet (MCF). This translates into a 60 percent increase in pumping costs or a 10-15 percent increase in the cost of producing cotton (Condra, Lindsey, Neeb, and Philley). Many farms have been abandoned and other farmers are near default on land and/or operating loan payments. Lenders are also reluctant to foreclose or make new loans because the collateral value of land has been severely reduced under the depressed land market conditions (Newsweek, American Cotton Grower, Lynch, Odle). Land prices have fallen from $500 per acre in the 1960's (Sindt) to $200 per acre in 1972 (Schmedemann) and finally to current levels of $100-200 per acre (Lynch).

Cost and return budget projections indicate that the Trans Pecos region can compete with many other irrigated regions in the production of cotton and other crops if improved management practices are adopted (Condra 1978). However, these changes generally require the committment of resources, and herein lies the basic problem. The future of irrigated crop production is uncertain in many regions, but there is even greater uncertainty in the Trans Pecos. This uncertainty leads to reluctance of new farmers to move in, investors to buy land, and lenders to furnish capital. More information is badly needed concerning the future of irrigated crop production in the Trans Pecos.

Farmers, investors, and lenders need the answers to two basic questions: (1) Can an irrigated farm survive in the Trans Pecos? and (2) If an irrigated farm does survive, how profitable will it be? The answers to these questions are of critical importance to the Trans Pecos, but they also have important implications for other irrigated regions facing energy price increases. Thus policy makers also need the answers to these questions as they consider energy and farm program legislation.

Therefore the Trans Pecos, unlike other irrigated regions, provides the best opportunity in the United States to analyze directly the impacts of a dramatic energy price increase. Furthermore and more importantly, the Trans Pecos offers an opportunity to analyze alternatives which may lead to the survival of irrigation in this and other irrigated regions.

Objectives

The overall objective of this study was to investigate the future economic implications of irrigated crop production in the Trans Pecos. Specific objectives of this study were:

1. To develop a computerized model to plan, simulate, and evaluate a farm's organizational activities, incorporating capital, risk, and time considerations.

2. To estimate the profitability and rate of survival for an irrigated farm in the Trans Pecos under alternative future crop and energy price scenarios.

3. To compare the estimated profitability and rate of survival for an irrigated farm in the Trans Pecos with similar estimates from another irrigated area.

4. To test the sensitivity of the results to changes in the assumptions regarding tenure situation and risk-aversion behavior of the farmer.

The Study Area

The Trans Pecos is a vast region of over 18 million acres in far west Texas with elevations ranging from 2500' to 8750' above sea level. Annual rainfall over most of the area is less than 12' (Godfrey, Carter, and McKee), so all crop production is under irrigation. There are 14 irrigated areas; but over 70% of the irrigated acreage is located in the Pecos Valley, which is comprised of 10 of these areas located in Pecos, Reeves, and Ward Counties. The other areas are the Wild Horse and Lobo Valleys in Culberson County, the Dell Valley in Hudspeth County, and the Presidio Valley in Presidio County (Longnecker and Lyerly; Texas Water Development Board). Most of the irrigation is from ground water sources and natural gas powers over 60 percent of the pumping plants (Texas Crop & Livestock Reporting Service 1976).

Development of large-scale irrigation with ground water in the Trans Pecos began in the 1940's and reached a peak in the mid-1960's. Total irrigated acreage reached 290,000 acres in 1964 and declined by about 37 percent to 184,000 acres in 1974. This dramatic reduction in irrigated acres in the decade between 1964 and 1974 has been attributed to a number of factors including: (1) declining cotton yields, (2) increased production costs, and (3) changes in the government farm program. The decline in cotton yields has been partially explained by climatic changes and the advent of mechanized harvesting. As yields declined, farmers increased irrigation and fertilizer levels in an effort to regain previous high yields (Sindt); which, in turn, increased the insect pest problem resulting in even greater yield reductions (Pate, Hefner, and Neeb). Production costs increased because of (1) increased insect pest control costs; (2) increased input costs, i.e., inflation; (3) increased pumping costs (associated with declining well yields and increased pumping lifts); and (4) reduced crop yields without corresponding reductions in fixed and variable production inputs (Sindt).

Cotton, the primary cash crop, accounted for 43 percent of the irrigated acreage in 1964. As the profitability of cotton production decreased, cotton acreage declined in relatively the same proportions as total irrigated acreage. Sorghum and small grains remained marginally profitable, but the net returns from these crops were not sufficient to maintain the typical farm unit (Sindt). Vegetables also remained profitable (Extension Economists-Management), but their replacement of cotton as a primary crop was limited because of their relatively high market risk. Vegetable production has traditionally required a substantial degree of financial stability on the part of the producer, a condition unrepresentative of most producers in the Trans Pecos (Sindt).

The dramatic increase in the price of natural gas in 1975-76 led to even greater reductions in irrigated acreage (Texas Crop & Livestock Reporting Service 1976). Many producers have moved, gone bankrupt, or simply left their land idle (Newsweek). While the increase in the price of natural gas in 1975-1976 was not responsible for the decline in irrigated acreage in the decade preceding 1974, it has contributed significantly to the situation which exists today in the Trans Pecos.

The Trans Pecos region is characterized by significant variation in soil types, ground water quality, pumping depths, and annual rainfall. Therefore, to minimize aggregation errors this study was limited to one area, the Coyanosa area in the Pecos Valley (Figure 1). Development of irrigation in the Coyanosa area began in 1948 and reached a peak in the early 1960's, with approximately 40,000 acres under irrigation and over 300 wells lifting water from the Pecos aquifer. The water quality varies but generally total dissolved solids are less than 2000 ppm (Texas Water Development Board). The typical well in this area is drilled 500-1000 feet deep with a lift of 350-400 feet (Kent).

The soils of the Coyanosa area are silty clay loams and clay loams, which are well suited to crop production under irrigation (Soil Conservation Service). The growing season ranges from 215 to 230 days and annual rainfall is about 14 inches (Hildreth and Orton; Griffiths and Orton).

Review of Literature

The following review of literature was developed to address two major points. The first section includes studies dealing with the

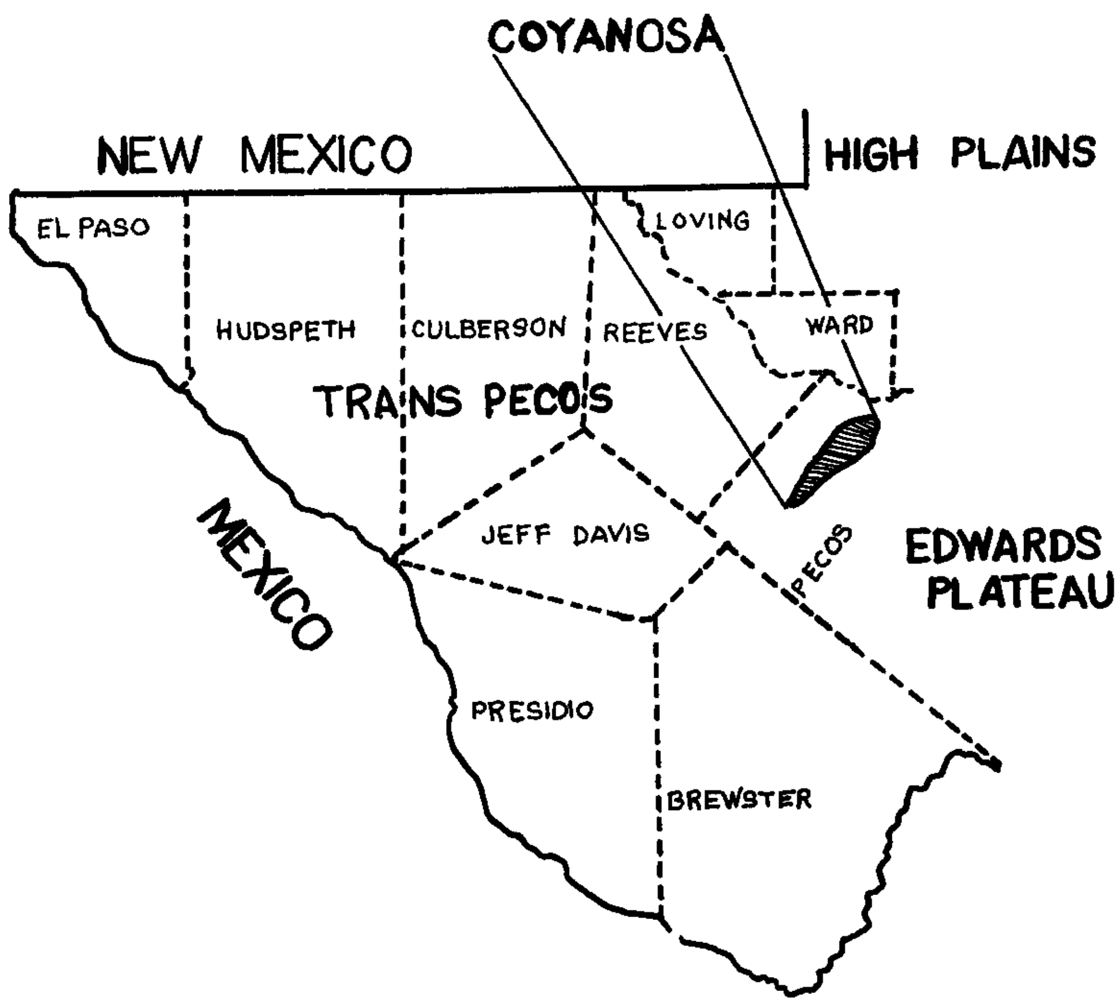

Figure 1. The Study Area

impact of increasing energy prices on agriculture. The second section includes studies which represent applications of various quantitative techniques which are especially relevant to this research effort.

Impact of Increasing Energy Prices

The prospect of increasing energy prices has raised many questions regarding potential impacts on the economy as a whole, the food and fiber system, and the consumer. Penn and Irwin estimate that in the shortrun a 10 percent reduction in natural gas usage would decrease employment and GNP by 7.5 percent and 6.8 percent respectively. These results include a projected 5.4 percent reduction in output from the agriculture, forestry, and fisheries sector. Another study (Moriak) estimates that a 20 percent annual increase in energy costs would result in sharply higher crop prices, substantially higher livestock prices, and one-third reduction in net farm income. Thus, it becomes apparent that the potential impact of energy prices and energy legislation on the U.S. economy and the food and fiber system is significant.

The magnitude of the impact of increasing energy prices on irrigated agriculture will be significantly affected by the level of exports. Dvoskin and Heady estimate that doubling of energy prices by 1985 with exports at 1972-1973 levels would result in a 22 percent reduction in U.S. irrigated acreage. In a more recent study, based on export levels somewhat higher than 1975 levels, Dvoskin, Heady and English project a reduction of less than two percent in irrigated acreage with doubled energy prices. These same results show a four percent shift of irrigated acres from the South Central Region to the Great Plains

Region. This acreage represents a shift from irrigated to dryland cotton in the South Central Region. Based on these results, it appears that irrigated crop production is more vulnerable than dryland production to energy price increases and/or supply reductions, and that the South Central Region (Texas, Oklahoma, et al.) is more vulnerable than other irrigated regions.

Irrigation is vital to Texas Agriculture with over 60 percent of the total crop value produced under irrigation (Knutson, et al.). In 1974, 8.8 million acres were irrigated with 13.1 million acre-feet of water, over 78 percent of which was pumped from ground water sources (Texas Water Development Board). According to Coble and LePori, some 39 percent of total energy used in agriculture was to power irrigation wells and about 76 percent of the irrigation pumping fuel used in 1973 was natural gas. The fact that ground water is the primary irrigation source and that natural gas is the primary pumping fuel explains why Texas irrigated crop production is so vulnerable to increases in energy prices and/or reductions in energy supplies.

The High Plains is one of the most important irrigated regions in Texas in terms of acreage, crop output, and cash receipts. This region has over 6 million irrigated acres (Texas Crop and Livestock Reporting Service 1976) or about 68 percent of the irrigated acreage in the state. In 1974, 68 percent of the ground water pumped for irrigation in Texas was used on the High Plains (Texas Water Development Board). This irrigation water was pumped with over 80,000 pump motors, 59 percent of which were fueled with natural gas (Texas Crop & Livestock Reporting Service 1976). Understandably a major portion of the effort to identify the probable effects of energy price increases and energy supply reductions on irrigated agriculture in Texas has centered on the High Plains.

A 10 percent reduction in the supply of irrigation fuel available (i.e., rationing) to the High Plains could result in a similar decline in irrigated acreage and a three percent decrease in producer net returns (Casey, Lacewell, and Jones). However, the effect of natural gas price increases in the High Plains will be directly related to crop price levels. Assuming 1971-1974 average crop price levels, regional irrigated acreage would likely begin to decline with natural gas price increases over $2.00/MCF. However, the region can sustain much higher natural gas prices if crop price levels are in the 1975-1976 range (Condra and Lacewell; Lacewell, Condra and Fish). These results include the effects of an energy price increase on regional net farm income but largely ignore implications for the individual producer relative to net income or economic viability. Thus, the point must be made that regional results may not be particularly meaningful for a specific farm because individual situations and cash requirements to meet fixed obligations differ greatly. Likewise, failure to consider the effects of energy price increases on net farm income and financial position of the individual farm may obscure the long run effect of energy price increases at the regional level (Lacewell, Condra, and Fish). More recent analyses confirm that 'break-even energy prices' vary greatly depending upon tenure situation, management level, and other factors associated with the individual farm (Hardin and Lacewell; Shipley and Goss).

It is interesting to note that, while all this attention has centered on the potential impacts of energy price increases in the 'major' irrigation areas, many of these impacts have become a reality in the Trans Pecos region of Texas. The cost of pumping water increased from \$2.12 to \$3.40 per acre-inch due to the 450 percent increase in the price of natural gas. This translates into increased per acre costs of \$56 for cotton, \$36 for grain sorghum, \$31 for wheat, and \$92 for alfalfa (Condra 1975).

The increasing cost of energy has stimulated (1) the adoption of more efficient irrigation pumping and distribution systems, (2) the search for crops requiring less water, and (3) the development of improved management production systems for traditional crops in the area. Efforts to improve the efficiency of irrigation systems have included re-engineering of existing furrow irrigation systems and changing to other types of irrigation systems; i.e., sprinkler and drip. Many crops are being evaluated because of their lower water requirements (e.g., guayule, jojoba, and tall wheat grass), but there are insufficient data at this time to adequately assess the economic feasibility of these crops. However, a great deal of progress has been made in the development of an improved management production system for upland cotton. The ECONOCOT system is designed around the principle of applying only that level of irrigation water and/or other inputs (e.g., fertilizer) which yields the greatest potential profits---not the greatest potential yield. Demonstrations of this system have resulted in reductions in costs of production of upland cotton from 70¢ to 50¢ per pound of lint (Condra, Lindsey, Neeb, and Philley).

Quantitative Techniques

Sindt developed representative farm and regional linear programming (LP) models for the Pecos Valley (Reeves County) in 1972. A profit-maximizing model was used to generate optimum production strategies under alternative levels of crop prices. Lacewell, et al. also used representative farm and regional LP models to analyze long run adjustments of Texas High Plains farms to changes in the prices of natural gas and crops. The normative characteristics of LP were modified in this study through the use of flexibility restraints. Neither of these studies explicitly consider the effects of cash flows or risk-aversion on farm adjustments.

Multiperiod linear programming (MLP) was used by Martin and Plaxico to analyze the investment activities of a farm in the Rolling Plains of Texas; however, alternative enterprise organizations were not considered. Boehlje and White incorporated enterprise selection into an MLP model for study of corn-hog farms in Indiana under conditions of known prices and production levels. Johnson also included risk in an MLP model by generating stochastic yields for each year of a fifteen year period.

Quadratic programming (QP), which was proposed by Markowitz for portfolio analysis, was utilized by Adams, et al. to estimate the effects of energy cost increases on field crop and vegetable production in California. Whitson, et al. used a multiperiod QP model (MQP) for analysis of alternative ranch organizations. This study focused on the trade-off between risk and return for different horizontal and vertical growth strategies of a model ranch in the Rolling Plains of Texas.

Recursive programming (RP), a technique developed by Day, was applied in analyzing alternative policy effects on farms in northern Germany (Heidhues). This model, unlike most LP models, provided for investment-disinvestment activities and a functional relationship between sequential periods. This approach differs from MLP and MQP in that annual solutions are generated sequentially rather than simultaneously. Mapp and Dobbins used RP to investigate the implications of rising energy costs for irrigated farms in the Oklahoma Panhandle, including consideration of the effects of changes in pumping costs associated with exhaustion of ground water supplies of the Ogallala aquifer.

The previous methods which have been discussed are basically normative techniques. Computer simulation (CS) is a non-normative technique which has also been used to study these types of problems. Patrick and Eisgruber developed a CS model of a farm operation which included the selection of a farm plan based on the goals of the family, price expectations, and a consumption function. Hinman and Hutton also used CS to estimate the returns and risks associated with expanding dairy farms in Pennsylvania with different levels of equity. This model included stochastic prices and yields for consideration of risk.

Martin, Lard, and Al-Bandar used MLP, RP, and CS in a farm growth model for the Texas High Plains. A similar approach was used by Chien and Bradford in modelling a Kentucky beef farm. Both of these models modified the previous dynamic-certainty characteristics of MLP, but neither accounted for the farmer's consideration of risk in planning enterprise combinations. However, Chien and Bradford did include behavioral restraints to account for personal preference, lumpiness of inputs, and uncertainty.

Hazell's modified LP model for minimization of total absolute deviations (MOTAD) was used by Schurle and Erven to analyze the addition of tomato and cucumber enterprises to a traditional farm plan. Shumway and Gebremeskel also used the MOTAD model to study cow-calf operations in East Texas and the impact of risk-averse behavior on fertilizer demand for tame forages.

Chen and Baker have proposed the use of a marginal risk constraint (MRC) in LP as an alternative to MOTAD or QP for consideration of risk in farm planning. Separable programming has also been used to study similar problems (Thomas, et al.).

While this review has briefly presented some applications of quantitative techniques to problems which are similar to the problem in this study, many examples of each approach have not been included, nor have advantages and disadvantages associated with each technique been discussed. The following section, dealing with development of the model, will include relevant discussion of these techniques. This review has served to show, however, that a variety of approaches have been taken to similar problems.

THE MODEL

A General Description

This model generates estimates of the potential survival and profitability of a farm by simulating its planning and operation under conditions of stochastic prices and yields. Multiple time periods are simulated recursively to consider the effects of outcomes in one time period upon another and the effects of timing of both favorable and unfavorable outcomes. The dynamic nature of the model also allows the analysis of cash flows, lumpiness of input purchases, and other variables as they affect the survival and profitability of the farm.

There are four basic steps in the simulation process of this model. This process is initiated by providing the current, or beginning, farm situation and proceeds, as follows: (1) an optimal farm enterprise plan is developed, based on the restraints specified in the beginning situation and expected crop prices and yields; (2) simulated ('actual') prices and yields are generated; (3) the operation of the farm is simulated (using 'actual' prices and yields), including evaluation of the financial outcome of the farm plan (developed in step 1), payment of fixed obligations, determination of year-end financial position, and replacement of machinery; and (4) the planning situation is updated to reflect adjustments in expected prices and yields, changes in resource availabilities, and credit restrictions. The process then returns to step 1 for recursive simulation of the planning and evaluation of the next year's farm operation. This simulation process is carried out by four sub-models: (1) planning, (2) price-yield, (3) financial-accounting, and (4) update. The following sections will discuss the characteristics, functions, and theoretical considerations associated with the development of each sub-model.

The Planning Sub-model

Theoretical Development

Many economic studies in the area of farm planning and adjustment have assumed that the farmer either should or does select a farm plan to maximize expected net returns. However, there is sufficient evidence that this assumption often does not describe actual behavior (Lin, Dean, and Moore; Freund, R.J.), nor does it necessarily serve as a suitable foundation for deriving farm plans which will meet the objective of the farmer (Schurle and Erven; Whitson). In fact, Lin, Dean, and Moore point out that employment of the profit maximization hypothesis has "generally provided results inconsistent with observed or plausible behavior." For this reason, the explicit consideration of risk was included in the planning sub-model.

Markowitz's theory of portfolio selection proposed the inclusion of both expected income (E) and variance (V) of income in the evaluation of investment alternatives. By minimizing variance of income for each given level of income, he developed an efficient E-V frontier (Figure 2). The frontier is efficient in that the investor must accept greater income variance (V) or risk in order to select a plan with higher expected income (E). The assumption underlying E-V analysis is that

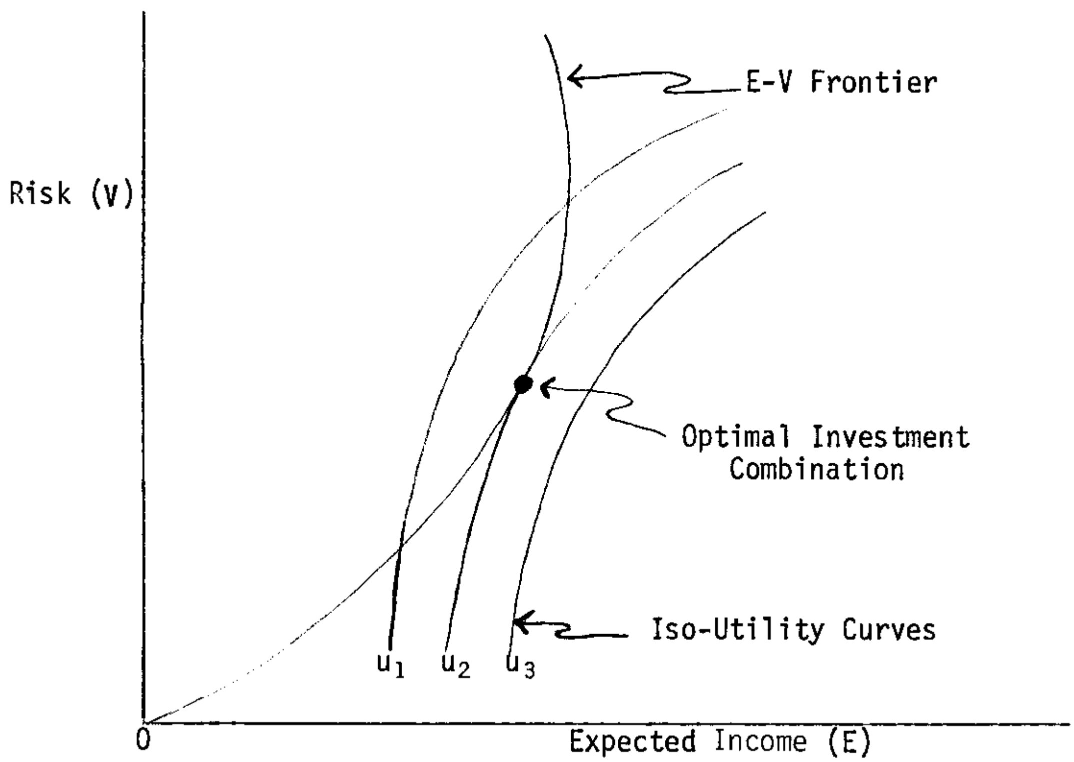

Figure 2. Selection of an Optimal Investment Combination from the Efficient E-V Frontier.

most investors are risk-averters, thus an investment combination with a given level of income (E) and risk (V) will provide greater utility to the investor than another combination with the same level of income (E) and greater risk (V). The selection of the optimal investment combination is shown in Figure 2 using iso-utility curves (u_1, u_2, and u_3) developed for different combinations of (E) and (V).

Selection of a technique. Developemnt of an E-V frontier requires the use of a nonlinear programming technique since the objective function (V) which is minimized is nonlinear. Quadratic programming (QP) is one nonlinear technique which has been used in farm planning and adjustment studies (e.g., Freund R.J.; Whitson; Barry and Willman) by considering different combinations of farm production and marketing activities as investment alternatives. Using this technique, an efficient E-V frontier can be generated for alternative farm plans. However, QP is less efficient in terms of computational time and more restrictive in problem size than linear programming (LP). These comparative disadvantages have stimulated the development of several linear alternatives for approximization of the E-V frontier (e.g., Chen and Baker; Hazell).

Hazell's MOTAD (Minimization of Total Absolute Deviations) was selected as the basic technique for development of the planning sub-model because it provides the advantages of LP and more flexibility than the other linear alternatives. The MOTAD model uses the mean absolute deviation of returns (A) as a measure of risk, rather than the variance of returns (V). By minimizing the mean absolute deviation of returns this model generates an efficient E-A frontier which is an approximation of the E-V frontier. It has been noted that there is a loss in reliability associated with the use of (A) rather than (V) in the generation of efficient E-V farm plans (Hazell); but Thomson and Hazell used a Monte Carlo technique to show that the loss in utility exceeded 10 percent only in cases of high correlation and/or large samples.

Selection of a utility function. Once the efficient E-V frontier of farm plans has been identified, two major approaches have been used to select the optimum plan. The selection of the optimum plan as shown in Figure 2 represents the use of a Bernoullian utility function. This approach is based on the development of iso-utility curves for different levels of expected income and risk. The point of tangency between the E-V frontier and the iso-utility curve represents the farm plan which will maximize utility for the farmer with respect to expected income and risk (Lin, Dean, and Moore). The second approach is based on the assumption that most farmers have multiple goals which can be ranked in importance (Smith and Capstick). It includes the development of a lexicographic utility function, in which a plan is selected to maximize a lesser goal subject to a satisfactory level of achievement for one or more other goals which are ranked as more important by the farmer. Examples of this approach are the maximization of expected net returns subject to a required level of 'certain' income (e.g., Whitson) and the maximization of expected net returns subject to a maximum acceptable level of income variation (e.g., Shumway and Gebremeskel).

Empirical tests have not clearly established either the Bernoullian or the lexicographic approach to be superior in predicting actual behavior. However, it has been shown that either will provide a better estimate of actual behavior than the profit maximization utility function (Lin, Dean, and Moore; Lin and Chang). The lexicographic approach has the advantages over the Bernoullian function of (1) approximating the actual decision-making process of the farmer, (2) being more easily derived, and (3) being more easily adapted for use by large numbers of farmers (Whitson).

The lexicographic utility approach was selected for this model to increase the usefulness of the results for large numbers of farmers and to allow the sensitivity testing of the survival estimates for changes in the assumed level of risk-aversion. The planning sub-model employs this approach to simulate the planning process of a farmer who attempts to select a plan which will maximize expected net returns, but only if he has some degree of certainty that the actual net returns from this plan will be sufficient to meet his fixed obligations (e.g., family living, land payments, etc.).

The Modified MOTAD Model

The planning sub-model simulates the development of a farm plan by selecting a set of crop activities to maximize expected net returns, subject to the available resources and given level of risk-aversion. A simplified structure of the model is shown in Table 1, which represents a matrix for the following linear programming problem:

(1) Maximize $Z = C'X$

Subject to

(2) $AX \lesseqgtr B$

(3) $EX + ID \geq 0$

Table 1. A Simplified Structure of the Planning Sub-model[a]

Item	Standard LP Activities			MOTAD Activities (Deviations)	Resource Availabilities (RHS)
	Crop Production	Crop Sales	Input Purchases		
Objective Function	-c	+c	-c		
Standard LP Restraints:					
Owned Resources	+a				$\leq$ B
Purchased Resources	+a		-1		$\leq$ 0
Yield Transfer	-a	+1			$\leq$ 0
MOTAD Restraints:					
Deviations	±e			+1.0	$\geq$ 0
Risk	-c	+c	-c	-r	$\geq$ F

[a]Where

a = input-output coefficients
B = level of resources available
c = input-output prices
F = level of fixed obligations
e = historical deviations in returns (actual less expected)
r = a coefficient chosen to describe the level of risk-aversion

(4) $$C'X - r(ID) \geq F$$

(5) $$X, D \geq 0$$

Where

A = a matrix of technical coefficients for farm enterprise activities
B = a vector of resource levels
C = a vector of prices or costs
D = a vector of activity levels for MOTAD (risk) activities
E = a matrix of historical annual deviations[1] in returns for each farm production activity
F = a specified level of fixed obligations
I = an identity matrix which serves as the technical coefficient matrix for the MOTAD (risk) activities
r = a coefficient chosen to describe the level of risk-aversion
X = a vector of activity levels for farm enterprise activities
Z = net returns above specified costs

It is evident that equations (1) and (2) are characteristic of a standard LP problem. An enterprise combination is selected which maximizes net returns in equation (1) subject to a set of resource restraints in equation (2). The empirical model includes multiple crop production, crop sales, and input purchases activities, as well as, multiple restraints for owned resources, purchased resources, and yield transfers.

Equations (3) and (4) utilize the MOTAD approach to incorporate a lexicographic utility function in the model. This formulation differs from Hazell's model in that expected net returns are maximized subject to the risk restraint. Thus, risk consideration does not explicitly enter the objective function. The procedure used here is similar to

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[1]An mxn matrix, where m = the number of years' historical deviations and n = the number of production activities.

the formulations in other applications (Shumway and Gebremeskel; Brink and McCarl). Specifically, equation (3) requires that expected net returns (C'X) less a function (r) of previous over-estimates of returns (D) must be greater than or equal to the level of fixed obligations (F). From equation (4) it can be seen that (D) is a vector of annual negative deviations (actual less expected) in returns for a given farm plan and (ID) equals the total negative deviation. The risk-aversion coefficient (r) is a measure of the degree to which the farmer desires to avoid risk. When (r = 0), the risk-aversion criterion is inoperable and the farmer will select the plan which maximizes expected net returns. As (r) increases, the model will select less risky plans with lower expected net returns. Equation (5) simply restrains all enterprise and activity levels (X and D) to non-negative values.

Hazell's original formulation of the MOTAD model includes the assumption that the total negative deviation equals one-half the total absolute deviation. This assumption is logical because mean returns are used for expected returns and annual deviations for activities are calculated as deviations from the respective means. This is important because it allows the selection of (r) to reflect probabilistic estimates for alternative levels of returns.

However, there are two components in this model which result in the inequality of total negative and positive deviations. First, this model uses a procedure for developing expected prices and yields (to be discussed in the next section) which differs from the use of average prices and yields. Secondly, this model extends the MOTAD approach to a recursive application with stochastic prices and yields, so the expected prices and yields used for calculation of deviations will change each year. These two factors insure that an equality of total negative and positive deviations is quite unlikely and the validity of probabilistic statements regarding the variance of net returns is questionable (Hazell; Brink and McCarl).

Two alternative approaches for overcoming this problem were considered but rejected for the following reasons. First, mean prices and yields could have been used as estimates of expected prices and yields. This alternative would have improved the statistical efficiency of the model if deviations of returns were recalculated prior to each year of the recursive simulation process. This alternative was rejected because it would have required the unreasonable assumption that the farmer's expectations and perceptions of risk for year (t-1) are functions of the outcomes in year (t). A second alternative which was considered was the use of total absolute deviations of returns as a measure of risk, rather than total negative deviations. This alternative was not used because it would tend to penalize a crop for which the farmer consistently underestimates returns as heavily as one for which the farmer consistently overestimates returns. It is highly unlikely that the farmer attaches as much disutility to an underestimation of returns as he does to an overestimation of returns.

This model was designed to simulate the planning process, thus a high degree of importance was attached to the logic of the underlying assumptions. In this case some statistical efficiency was given up to achieve, in the author's opinion, a more logical and realistic simulation of the planning process. Certainly this trade-off would have been more serious had the model been designed to generate E-A frontiers. However, in its present application, this risk constraint should serve adequately to simulate the incorporation of risk into the planning process. In fact, there is a possibility that the actual planning process may have an even lower degree of accuracy and statistical efficiency than the simulation.

The Price-Yield Sub-model

This sub-model develops expected prices and yields for use in the planning sub-model and stochastic ('actual') prices and yields for use in the financial-accounting sub-model. Deviations of actual returns from expected returns are also calculated for use in the modified-MOTAD model (planning sub-model).

Expected Prices and Yields

An adaptive expectations model was selected for the development of expected prices and yields because this approach has been shown to provide a reasonable description of the process utilized by farmers to develop price and yield expectations (Fisher and Tanner). The basic model[2] was proposed by Nerlove and applied by Chien and Bradford in

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[2] $Z^*_{t+1} = a(Z_t) + (1-a)(Z^*_t)$

Where

a = the coefficient of expectations

Z = the actual price or yield

Z^* = the estimated price or yield

Can be expanded, as follows:

$$Z^*_{t+1} = a(Z_t) + a(1-a)(Z_{t-1}) + a(1-a)^2(Z_{t-2}) + \dots\dots\dots$$

their sequential model of the farm firm growth process. The price expectations model was also augmented with an exponential smoothing trend model to overcome the tendency of the Nerlove model to lag a continuing trend (Brown and Meyer; Chien and Bradford). The model is represented mathematically as follows:

(6) $$X_{t+1} = a(Z_t) + (1-a)(Z^*_t)$$

(7) $$T_{t+1} = g(X_{t+1} - X_t) + (1-g)(T_t)$$

(8) $$Z^*_{t+1} = X_{t+1} + T_{t+1}$$

Where

a = the coefficient of expectations ($0<a<1.0$)
g = the trend smoothing constant ($0<g<1.0$)
X = the estimate of price or yield without trend
T = the estimate of price or yield trend
Z = the actual price or yield
Z^*= the estimate of price or yield with trend

This model is based on the hypothesis "that farmers revise the price they expect in proportion to the error they have made in prediction," thus the expected price is a geometrically weighted average of past prices (Nerlove). In equation (6) the estimate (without trend) for year (t+1) is calculated as a weighted average of the actual value in year (t) and the estimate (with trend) in year (t). In equation (7) the estimated trend is calculated as a weighted average of the previous trend estimate in year (t) and the difference between the untrended estimates for years (t) and (t+1). The estimate without trend and the trend estimate are summed in equation (8) to yield the expected price. The coefficient of expectation (a) is chosen to represent the farmer's actual behavior. This choice may be made based on previous studies, expert opinion (e.g., Chien and Bradford), or the number of years of history normally used by the farmer in developing his expectations[3]. This adaptive expectations model was also used for development of yield expectations without the trend component.

'Actual' Prices and Yields

Random prices and yields are drawn from a triangular distribution to represent the actual outcomes for these variables in the financial-accounting sub-model. The triangular distribution was chosen because it allows the use of producer and/or expert subjective estimates, it does not require a symmetrical distribution, and it has provided satisfactory performance in other investment analyses (e.g., Cassidy, Rodgers, and McCarthy; Sprow; Taylor and North; Richardson and Mapp). Frequently, as was the case in this study, sufficient data are not available to develop statistical probability distributions for an individual farm. Also, probability distributions developed from historical data may not be relevant for a future period. Three subjective estimates (the minimum, most likely, and maximum values) are required for the triangular distribution. These estimates may be developed from historical data; but in the case of individual farm yields, subjective estimates from farmers themselves may be more meaningful. These parameters define a triangular probability density function, as shown in Figure 3. The farmer is asked to estimate the (a) lowest, (b) most likely, and (c) highest annual yield over a given period of years; e.g. ten years.

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[3]Hillier and Liebermann show that the use of a smoothing constant, or coefficient of expectations, (a) is equivalent, in terms of variance, to use of a moving average with (2-a)/(a) observations.

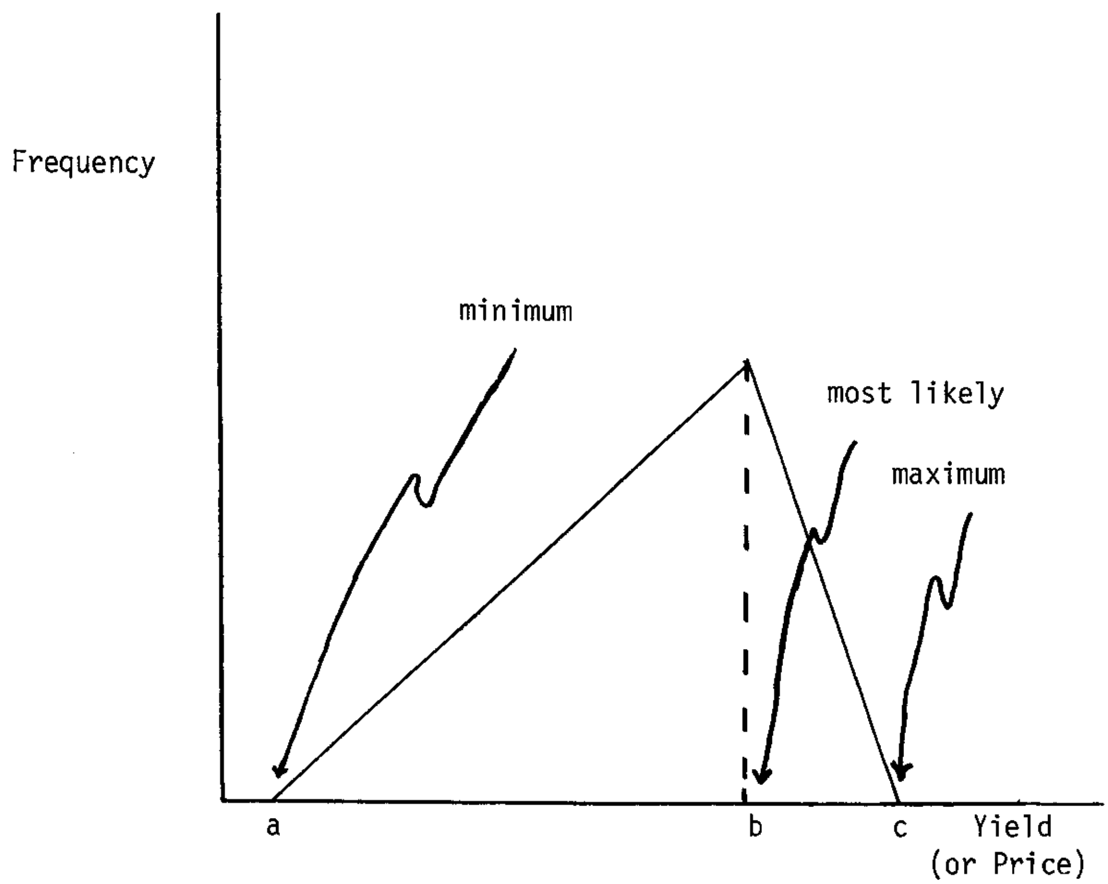

Figure 3. Probability Density Function for a Triangular Yield (or Price) Distribution.

The same approach can be used for prices using expert estimates from marketing specialists, historical relationships, etc. Once the parameters of the probability density function are identified, a random number is drawn from a uniform distribution (0-1). This random number represents a cumulative probability associated with a unique value of (x)[4]. Use of this procedure permits the generation of a series of independent, stochastic prices and yields to represent the risk faced by the farmer in terms of 'actual' versus expected prices and yields.

The procedures outlined above are standard in the generation of stochastic values for variables in simulation models (Naylor, Balintfy, Burdick, and Chu). However, this procedure was modified in the price-yield sub-model to allow correlation of the stochastic values which are generated[5]. This modification was made based upon a procedure which has been developed for correlation of normally distributed values (Anderson, T. W.; Clements, Mapp, and Eidman; Naylor, Balintfy, Burdick, and Chu). The steps in this modified procedure are as follows: (1) generate random normal deviates with mean equal to zero and variance equal to one; (2) correlate random normal deviates, using procedures outlined by Moonan for normally distributed values; (3) convert correlated random normal deviates to cumulative probabilities, which are distributed uniformly between zero and one; and (4) evaluate the cumulative

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[4]Following procedures in Cassidy, Rodgers, and McCarthy:
$x = a + \{F(x)(c-a)(b-a)\}^{\frac{1}{2}}, \; a \leq x \leq b$
$x = c - \{1-F(x)(c-a)(c-b)\}^{\frac{1}{2}}, \; b \leq x \leq c$

[5]This is an empirical procedure which may be subject to error depending upon the distributions which are specified. However, if the correlation between the variables being simulated is reasonably constant throughout the entire range of values for all distributions, the error is not expected to be large (Freund, R.).

probabilities in terms of the specified triangular distributions (Richardson and Condra).

Provisions are made for trends in prices and/or yields by specifying triangular distribution parameters as percentages of a given base. Thus a trend can be included in the simulation process by simply applying a trend to the base without changing the triangular parameters.

The Financial-Accounting Sub-model

The simulation process for the financial operation of the farm is a five step process. This process includes (1) implementing the farm plan, (2) replacing machinery, (3) paying fixed obligations, (4) developing financial statements, and (5) evaluating credit capacity. The farm plan which is developed in the farm planning sub-model is implemented by borrowing investment and operating capital, purchasing inputs, and selling outputs. 'Actual' prices and yields from the price-yield sub-model are used for implementation of the plan.

The machinery complement is depreciated on a straight-line basis over an assumed life. As each piece of equipment is fully depreciated, it is replaced at current (based on trend) replacement cost; and investment credit, depreciation recapture, and capital gains are taken into account. Machinery replacement also includes the borrowing of capital with a specified down-payment requirement.

Fixed obligations include property taxes and insurance, full-time labor, income tax, loan principal and interest payments, and family living expenses. Property taxes and insurance are calculated as a specified percentage of new cost. Full-time labor is specified in the beginning farm situation. Income tax is calculated for the current year and treated as a liability. Payment of income tax of a given year refers to the previous year's liability. Amortization of loan principal and interest payments for land and machinery loans is approximated to provide equal annual payments (principal and interest) for a given loan. Family living expenses are specified exogenously in the farm situation at a fixed yearly level and inflated annually.

Annual financial statements include an income statement, a balance sheet, and a cash flow statement. Market values are used for machinery in the balance sheet to provide a more accurate assessment of the current financial position. However, land is included at cost with no provision for appreciation in land value.

Credit capacity of the farm is evaluated based on the current financial position, the previous year's financial position, and operating loan repayment performance. This procedure (Figure 4) simulates the role of a lender in analyzing the credit worthiness of the farm. If there is not sufficient cash to fully repay the operating loan after the fixed obligations are met, the operating loan carryover for the previous year is examined. Credit is extended if the operating loan carryover has decreased from the previous year. However, if the operating loan carryover has increased, the process moves to an evaluation of changes in net worth. Credit will be extended if net worth has increased from the previous year by more than the increase in operating loan carryover. Essentially this procedure is based on the premise that operating capital will continue to be extended as long as the farmer 'pays out' no more than one consecutive year, and/or the financial condition of the farm is improving. While these decision rules were

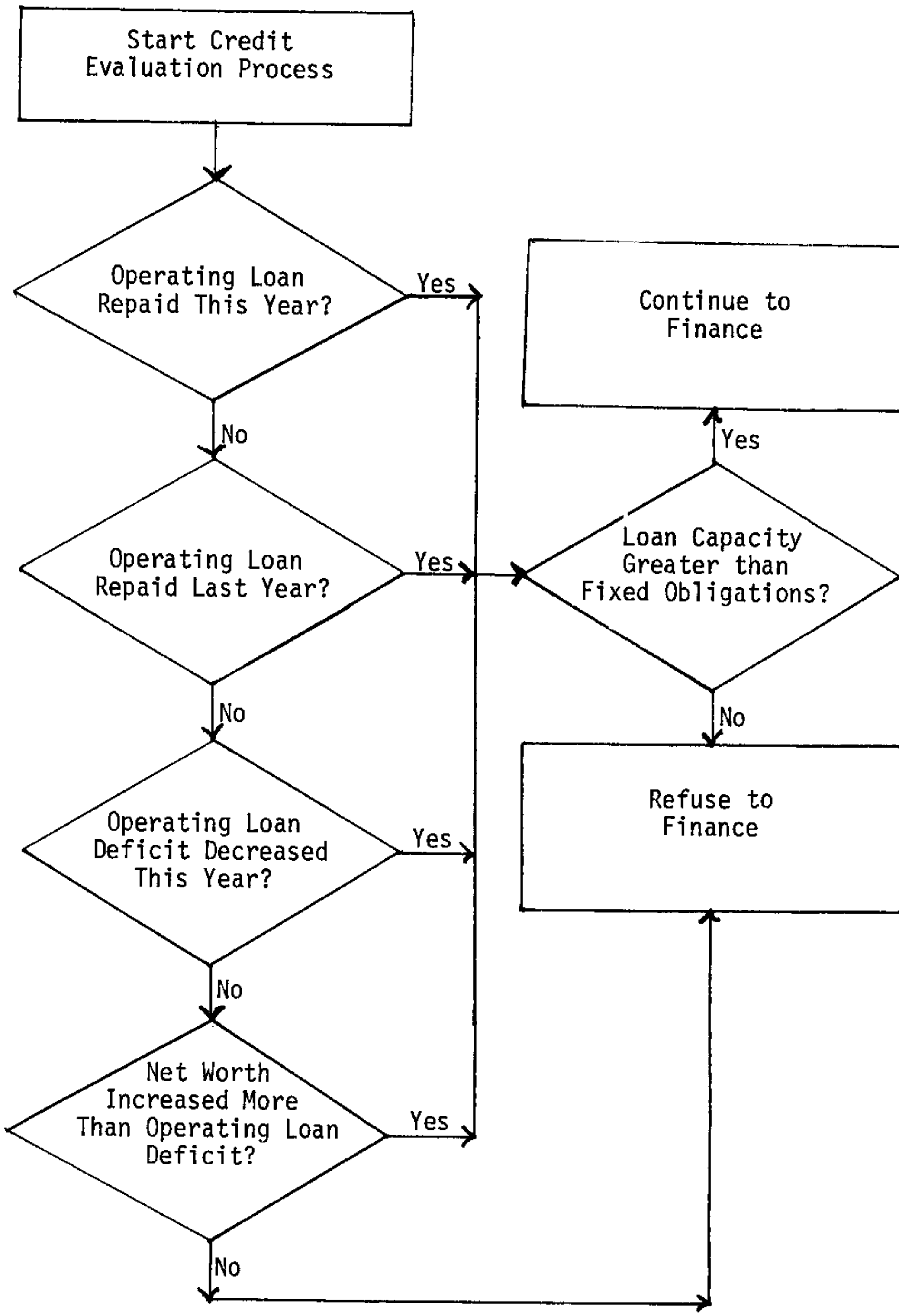

Figure 4. A Flow Chart of the Credit Evaluation Process

developed through interviews with agricultural lenders in the area (Russell; Stewart); it should be noted that one very important factor, personal evaluation of the farmer by the lender, is beyond the scope of this simulation.

Operating credit is extended to the farm by calculating the maximum permissible operating loan based on an exogenously specified maximum debt-equity ratio. This calculation includes operating, machinery, and land debt with the operating loan as a residual borrower, i.e., the debt-equity ratio including maximum permissible operating loan must not exceed a specified parameter. Cash on hand and operating capital requirements are compared to the maximum permissible loan to determine the level of borrowing by the farmer for operations. It should be noted that the maximum permissible operating loan is a constraint in the planning sub-model, but the required operating loan is determined after the plan is developed with an associated level of required operating capital. The farm is considered insolvent if (1) the required conditions for extension of operating credit are not met, or (2) the maximum permissible operating loan is not sufficient to cover fixed obligations.

The Update Sub-model

This sub-model annually updates (1) expected prices and yields, (2) 'actual' prices and yields, (3) annual deviations in actual returns, and (4) price trends. Expected prices and yields are updated in the planning sub-model to reflect changes in the farmer's expectations. This price update includes adjustments in resource prices for specified trends. The annual deviations (MOTAD elements) in enterprise returns are added to the planning model for the current year and deleted for the earliest year. 'Actual' prices and yields, including trend adjustments, are changed in the financial-accounting sub-model for use in simulating the farm operation. In this manner, the update sub-model provides a link between each annual simulation, allowing recursive operation of the model.

PROCEDURES

The procedures in this study are divided into four categories representing steps in the analysis. The categories are (1) specification of alternative scenarios for inflation, crop and energy prices, and interest rates; (2) St. Lawrence area model specification for comparison with the Coyanosa model results; (3) modification of the St. Lawrence model for Coyanosa; and (4) application of the models to provide comparative estimates of risk and profitability for the two regions which were analyzed.

The St. Lawrence-Midkiff area, located in portions of Glasscock, Reagan, Upton, and Midland Counties, was selected for comparison with the Coyanosa area for a number of reasons. First, although St. Lawrence is located in the Edwards Plateau Region, not the Trans Pecos, the two areas have similar soils and climate. Secondly, the farmers in the St. Lawrence-Midkiff area are well known for their expertise in managing limited water supplies. And thirdly, many farmers in this area have indicated an interest in expanding or relocating their operations to the Coyanosa area, hence indicating excellent producer cooperation for this study.

The Trans Pecos region, as discussed earlier, has suffered a dramatic decline in irrigation. The availability of capital for irrigated crop production is severely restricted. Also the number of producers still in operation is greatly reduced and their financial reserves are generally limited. Therefore this discussion of the future of irrigation in the region centers around new farmers, new technology, and new capital. A comparative analytical approach was chosen which compares the risk and profitability of a healthy, growing St. Lawrence area with the distressed Coyanosa area of the Trans Pecos; however, the results are applicable for any farmer, given the availability of capital and adoption of new technology.

Alternative Scenarios

As a basis for the analysis, five alternative scenarios for inflation rates, energy prices, crop prices, and interest rates were developed. These scenarios are shown in Table 2. The BASE, MOD1, and MOD2 scenarios represent realistic situations based on the current situation. However, to establish boundaries, or brackets, LOW and HIGH scenarios were developed. The LOW scenario represents the 'worst' situation that the farmer may face with low crop prices and relatively high energy costs, and the HIGH scenario represents the 'best' situation which the farmer may face with high crop prices and relatively low energy costs. These scenarios are assumed situations which may face the producer, and no attempt has been made to assess the probabilities of occurrence.

Inflation

The rates of inflation for the scenarios range from 4 percent in the LOW scenario to 10 percent in the HIGH scenario, with 7 percent specified for the BASE. While these rates are somewhat higher than those used in most studies (e.g., Quance, Plato, and Smith; Yeh; Davison and Ericksen), they do not seem unrealistic considering the current and historical rates of inflation. During the most recent 10

Table 2. Alternative Scenarios for Inflation, Energy Prices, Crop Prices, and Interest Rates, 1978-1987

Item	Scenario				
	BASE	LOW	MOD1	MOD2	HIGH
	%				
Rate of Inflation	7.0	4.0	10.0	7.0	10.0
Rate of Increase in Energy Prices[a]	10.0	10.0	10.0	7.0	10.0
Rate of Increase in Crop Prices[a]:					
Cotton	7.5	3.4	7.5	7.5	12.0
Sorghum	7.5	3.4	7.5	7.5	11.8
Wheat	7.5	4.0	7.5	7.5	13.6
Short-term Interest Rate	9.0	6.0	12.0	9.0	12.0

[a]nominal, i.e. including inflation

Sources:
1. Christian, R. Caprock Electric Cooperative. Personal Communication. March 3, 1978.
2. Dvoskin, D., E.O. Heady, and B.C. English. Energy Use in U.S. Agriculture: An Evaluation of National and Regional Impacts from Alternative Energy Policies. The Center for Agricultural and Rural Development, Iowa State Univ. CARD rpt. 78, Mar. 1978.
3. Federal Reserve Bank of St. Louis. "National Economic Trends." June 5, 1978.
4. Fox, A. USDA-ESCS. Personal Communication. Apr.-Aug. 1978.
5. Stevens, J. Community Public Service Co. Personal Communication. March 17, 1978.
6. Tidwell, M. Rio Grande Electric Cooperative, Inc. Personal Communication. March 8, 1978.
7. U.S. Department of Agriculture. "Regional Planning Series of Food and Agriculture Projections to 1985 and 2000." USDA-ERS-NEAD Working Paper, 1978.

year period (1968-77) the consumer price index increased at an annual rate of 6.4 percent, while the implicit price deflator and wholesale price index increased at rates of 6.2 and 7.4 percent, respectively (Federal Reserve Bank of St. Louis, May 1978). During the first quarter of 1978, consumer prices increased at an annual rate of 9.0 percent and wholesale prices increased at an annual rate of 12.6 percent (Federal Reserve Bank of St. Louis, June 1978). The rate of inflation has not been less than 4.0 percent annually for any 10 year period since 1964, and the rate has increased steadily for each successive period, i.e., 1964-73, 1965-74, etc.

Energy Prices

The future levels and relationships between individual fuel prices will depend on a number of factors, including national energy policy, foreign policy, and advances in technology. Therefore, rates of price increase for individual fuels and energy-based inputs were not specified. Instead, the scenario rates were applied to all energy-based inputs. The rate of nominal, i.e., including inflation, energy price increase is 10 percent for all scenarios (except MOD2), but the rate of increase in real (nominal less inflation) energy price ranges from zero in the HIGH scenario to 6 percent in the LOW scenario. The BASE scenario uses a 3 percent annual increase in real energy prices. This translates into a 35 percent increase over a ten year period which compares to a 'most likely' estimate of 27 percent used by the U.S. Department of Agriculture in their studies (e.g., VanArsdall and Starbird). The HIGH scenario (no real increase in energy prices) is the most favorable situation which can be projected at this time, and the LOW scenario rate (6 percent annual increase or 79 percent over ten years) is comparable to rates used in other studies (e.g., Adams, King, and Johnston; Dvoskin, Heady, and English). The MOD2 scenario also represents the assumption that there will be no real increase in energy price. This modification has been included to allow analysis of a more favorable energy price situation with baseline assumptions for other variables.

Future price increases for electricity may vary significantly between individual utility companies (Baughman and Cooper, et al.), however, the rates which have been used in this study are generally consistent with projections provided by utility companies serving the study area (Christian; Stevens; Tidwell).

Crop Prices

The BASE 1978 crop prices for Texas were assumed to be the midpoint between the loan and target price for each crop, based on projections of Extension marketing specialists that crop prices received by Texas producers (including deficiency payments) may not be as high as the farm program target prices.

The rates of increase for crop prices shown in Table 2 represent a combination of inflation, supply-demand, and energy effects. For example, in the LOW scenario the various effects for grain sorghum were specified as +4.0 percent for inflation, -1.6 percent for supply-demand, and +1.0 percent for energy price increases. Combining these effects provides +3.4 percent as the estimated rate of annual increase in nominal (including inflation) crop prices. The following discussion deals with the derivation of these individual effects.

Inflation effects. The inflation effect was specified as the rate of inflation for all crops in all scenarios, except MOD1. This means that there will be no real change in crop prices due to inflation. This procedure is based on the assumption that real crop prices for the BASE scenario are at equilibrium, thus any changes in real crop prices will stimulate a supply-demand effect. However, the MOD1 scenario was developed to represent a situation in which crop prices (target and loan) lag inflation. This scenario is justified as a 'likely' situation because of normal delays which occur in the legislative process of raising loan and target prices.

Supply-Demand effects. The basic supply and demand attributes of the NIRAP regional planning series (Quance, Plato, and Smith; U.S. Department of Agriculture; Fox) were modified for incorporation into the scenarios for the study. Annual percentage deviations from the NIRAP baseline real crop prices were used as supply-demand effects for the LOW and HIGH scenarios. In the LOW scenario (low demand-high supplies) these effects were a 1.0 percent decrease per year for wheat and a 1.6 percent decrease per year for cotton and grain sorghum. In the HIGH scenario (high demand-low supplies) these effects were a 3.6 percent increase for wheat, a 2.0 percent increase for cotton, and a 1.8 percent increase for grain sorghum.

Energy price effects. The effects of energy price increases were incorporated in the BASE scenario by assuming that a 3 percent annual increase in real energy prices would increase U.S. crop production costs by 0.5 percent. Under the current farm program this would result in a corresponding increase in the target price (Johnson and Ericksen). This figure is somewhat higher than the estimates made by VanArsdall and Devlin on a national basis, but it is lower than estimates of the increase in production costs for an energy-intensive irrigated area (Condra 1978).

The LOW scenario includes a 1.0 percent annual increase in real crop prices, corresponding to the 6.0 percent annual increase in real energy prices. In a study by Dvoskin, Heady, and English, crop shadow prices were increased by approximately this rate for a doubling of real energy prices over a 10 year period.

The HIGH scenario does not include an energy price effect on crop prices because the rates of inflation and energy price increases are both 10 percent annually. Thus, this scenario includes no real increase in energy prices.

Interest Rates

Short and intermediate term interest rates for the BASE scenario were assumed to be 9 percent annually. Since a 7 percent rate of inflation was assumed for the BASE scenario, this yielded a real rate of interest (i.e., nominal interest rate less inflation rate) of 2 percent. This assumed real interest rate was held constant across all scenarios. Long term interest rates were fixed at 8 percent at the beginning of the period and held constant for all scenarios. This assumption does not have great significance since new long term borrowings were not made during the simulation.

The St. Lawrence Model

The St. Lawrence Cotton Grower's Association cooperated in this project by providing assistance in development of a model farm for St. Lawrence and adjustment of this farm to represent a St. Lawrence farmer purchasing land in Coyanosa. Thirteen individual interviews were conducted with members of the Board of Directors and other farmers selected by the Board, representing typical producers in the St. Lawrence area. A model farm and projected crop budgets (Condra 1978) for the St. Lawrence-Midkiff area were developed from these interviews and presented to the Board of Directors for validation of acreages, machinery complement, yields, etc. An additional meeting was held with the Board to provide final verification and agreement on the estimates.

Farm Characteristics

The model farm for the St. Lawrence area, based on producer interviews, includes 960 acres with the farmer purchasing 320 acres and renting 640 acres. Rental arrangements are such that the landlord receives one-fourth of the cotton crop less ginning and one-third of the grain crop less harvest.

There are 20 irrigation wells equipped with 7.5 horsepower electric submersible pumps. These wells each yield 60 gallons per minute, lifting water from 300 feet. All wells are linked together with underground lines to provide more efficient distribution of the water. The landlord owns the 13 pumps and the underground lines which are located on the rented property, but the farmer is responsible for repairs.

The general cropping pattern is two-thirds cotton and one-third grain which allows a rotation every third year. This cropping pattern is also associated with the limited irrigation supplies, which are sufficient to irrigate only two-thirds of the acreage in summer crops.

The farmer provides the management and his own labor. In addition, he has one man employed on a full-time basis. Seasonal labor is hired for hoeing and cotton harvest.

Projected costs and returns crop budgets, including inputs, machinery operations, and yields, correspond to the Extension Edwards Plateau II crop budgets for the St. Lawrence-Midkiff area (Condra 1978).

The Basic Model (STL1)

Planning sub-model. The LP matrix for the planning sub-model is shown in Appendix A. Crop production activities include cotton, wheat, grain sorghum, and set-aside with dryland and multiple irrigation levels for each crop. Separate activities are specified for crop production on owned and rented land. Selling activities for all three crops, and purchasing activities for electricity, diesel, other energy inputs, and seasonal labor are also provided. The risk activities operate within the framework of the modified-MOTAD model described earlier.

The objective function values represent non-specified variable costs for production activities, receipts for selling activities, and expenditures for specified purchasing activities. The risk activities have zero values in the objective function and affect the objective function value only indirectly through the risk restraint. The objective function in this model is maximized, resulting in the maximization of net returns above variable costs (subject to the restraints included in the model).

The input coefficients for each crop production and set-aside activity were developed from Extension crop budgets for the St. Lawrence-Midkiff area of the Edwards Plateau II region (Condra 1978). Most of these coefficients appear in the matrix as variable costs; however, discussion of relevant input levels and assumed input prices has been provided in this section. The reader should refer to the source budgets for details concerning other input levels, assumed input prices, and machinery operations.

The levels of resources available for crop production are shown in Table 3. Only 90 percent of the 960 total acres in the farm is available for cultivation based on the assumption that the remaining 10 percent is taken up in roads, turnrows, homesteads, etc. Each acre of crop production requires one acre of land, either rented or owned.

The model assumes that the farmer will participate in the farm program provisions as specified in the Food and Agriculture Act of 1977 (Johnson and Ericksen); however, the recent uncertainty surrounding the exact provisions and the effective time periods led to the adoption of several simplifying assumptions. A 10 percent set-aside for cotton and grain sorghum and a 20 percent set-aside for wheat was assumed. Also set-aside, disaster, and prevented planting payments were not included. Deficiency payments were assumed to be included in the price received for the crop. These assumptions were held constant across scenarios, therefore the provisions may be too restrictive in the case of the HIGH

Table 3. Resources Available for Crop Production, St. Lawrence Model

Item	Units	Period				
		Nov.-Dec.	Jan.-Apr.	May-Aug.	Sep.-Oct.	Annual
Land[a]						
Owned	Acres					288
Rented	"					576
Normal Crop Acreage						
Owned	Acres					224
Rented	"					449
Irrigation Water						
Owned	Ac-In	1,210	2,420	2,420	1,210	7,260
Rented	"	2,247	4,494	4,494	2,247	13,482
Labor						
Family	Hours	500	1,000	1,000	500	3,000
Full-Time[b]	"	333	667	667	333	2,000
Tractors	Hours	666	1,334	1,334	666	4,000

[a]Cultivated land available. Does not include roads, turnrows, homestead, etc.
[b]Hired by the month or year

scenario and not restrictive enough in the case of the LOW scenario.

The normal crop acreage (NCA) available under the farm program, based on assumed 1977 plantings, is shown in Table 3. Cotton is normally grown in the St. Lawrence area in a skip-row (2 in - 1 out) pattern to more effectively utilize rainfall and the limited irrigation water. With this practice, one acre of land is the equivalent of two-thirds of an acre of planted cotton. Other crops are normally planted in a solid pattern. It was assumed that the farmer had two-thirds of the farm in skip-row cotton and one-third in solid grain sorghum in 1977.

Cropping patterns were limited in the model to reflect traditional practices in the area. Cotton acreage was limited to two-thirds of the total acreage to simulate the normal cropping rotation for weed control and efficient use of limited water supplies. Although this proportion varies somewhat from year to year, depending upon crop prices, the restraint is expected to accurately reflect practices in the area over time. The model also assumes that the proportion of acreage planted to cotton cannot be greater for owned land than for rented land. This restraint reflects the reluctance of a landlord to allow the renter to plant grain crops, which have tended to return less rent than cotton in the past.

The 20 irrigation wells (7 owned and 13 rented) are assumed to be available to pump water 27 days per month, 24 hours per day. This leaves approximately 10 percent of the time each month for repairs, etc. The availability of irrigation water under these conditions, by critical irrigation periods in the crop production cycle is shown in Table 3. Assumed levels of pumping required in the production of each crop alternative are shown in Appendix B, Table 1 (preplant = 12" and postplant = 6") represent averages derived from producer interviews. It is recognized that there is a large degree of variability in application rates among crops and within the season for a given producer, as well as variability among producers. Therefore, this model, which represents an average situation, does not adequately account for variation in application rates.

Labor availability is divided into family labor and full-time hired labor in Table 3. Family labor refers to the farmer and is based on 60 hours per week during each period. This is time available for general overseeing of the farm, machinery operation, and irrigation. It does not include management practices such as keeping records, planning, reading, and participating in farm organizations. Full-time labor availability is based on 40 hours per week during each period. Seasonal labor may be hired by the hour through a purchasing activity.

The labor requirements for each crop production activity include machinery operation, irrigation, miscellaneous activities, and cotton harvest. However, hoe-labor for cotton was not included as a labor requirement. Instead it was assumed that hoeing would be contracted, and this item was included in non-specified variable costs.

For farming operations the model farm includes two 125 horsepower tractors. Tractor hours available in each period (Table 3) are based on 80 percent of labor hours to represent additional time required for maintenance, travel, etc. Specific equipment requirements and restraints are not included in the model, since the assumption is made that these requirements can be met in a timely manner if both the labor and tractor are available.

Purchasing activities are included for all energy and energy related inputs. Electricity requirements per acre for irrigation are based on a 300 foot lift with 60 percent pump efficiency (Condra 1978). The assumed electric rate for 1978 is \$.03 per kilowatt-hour (KWH) based on current rates in the area (Christian). This results in a cost of \$1.42 per acre-inch of water for electricity. Fuel costs are based on 1978 prices of \$.45 per gallon for diesel and \$.55 per gallon for gasoline. Herbicide, fertilizer, insecticide, and desiccant cost requirements are combined under the category of other energy requirements.

All other variable costs (except interest, ginning, and custom harvest costs) which are not specified in a purchasing activity are included in the objective function value for each crop production activity. These costs represent seed, repairs (machinery and irrigation), insect scouting, and hoeing. In the case of wheat, livestock grazing income has been credited against these other variable costs.

Historical gross return deviations are included in the MOTAD portion of the matrix for a three year period (1976-1977 for the 1978 beginning matrix), based on the assumption that the farmer's expectations are not significantly affected by favorable or unfavorable outcomes over three years in the past. The actual development of the deviations used in the 1978 matrix is discussed in the section on the price-yield sub-model.

The risk-aversion coefficient (r) for the basic St. Lawrence model was assumed to be 1.419.[6] Thus the model develops a plan to maximize

[6]This value was originally selected to represent a specified level of probability that net returns above variable costs would exceed the level of fixed obligations. However, further investigations have shown

expected net returns above variable costs, subject to the following restraint:

(9) $$C'X - 1.419D \geq F$$

Where

C'X = the value of the objective function
1.419 = the assumed risk-aversion coefficient (r)
D = the total negative deviation for the previous 3 year period
F = the level of fixed obligations

This simulates the farmer's desire to maximize net cash profits subject to some degree of certainty that profits will be great enough to cover all fixed obligations.

If the planning sub-model cannot achieve a farm plan which will meet the risk criterion, the level of fixed obligations (F) is arbitrarily reduced to zero. The risk criterion is still operable, but consideration is now given to some degree of certainty that net returns above variable costs will not be negative. In the event that a farm plan still cannot be developed, the risk restraint is eliminated completely; and the farm plan is derived as a straight LP, profit maximizing solution.

Price-yield sub-model. As stated earlier, 1978 base crop prices for Texas were specified as the mid-point between the loan and target price for each crop.[7] St. Lawrence base crop prices for 1978 (Table 4)

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that characteristics of the model are such that no probabilistic statements can be made. Comparison of this risk-aversion coefficient to values from other studies (e.g., Brink and McCarl) indicate that this model describes a very risk-averse farmer.

[7]These prices are $.50 per pound for cotton, $2.83 per bushel for wheat, and $3.73 per hundredweight for grain sorghum (Johnson and Ericksen).

Table 4. Base and Expected 1978 Crop Prices, St. Lawrence Model

Crop	Units	Base Price 1978	Expected Price 1978
Cotton	¢/lb.	47.5	46.6
Wheat	$/bu.	2.46	2.34
Grain Sorghum	$/cwt.	3.21	3.11

were then developed by adjusting these state prices through the use of historical percentage factors.[8] These factors were developed to account for the normal difference between state and St. Lawrence prices and to reduce prices by those yield-determined expenses which are shared by the renter and landlord. The latter adjustment was made to facilitate the handling of crop-share rental agreements in the model.

Stochastic crop prices for simulation of the St. Lawrence farm operation were generated using the triangular distributions shown in Appendix B, Table 2. Two alternative distributions were developed for each crop price. Farm Program 1 represents a situation in which price fluctuations are limited by the loan price as a floor and the target price as a ceiling (Johnson and Ericksen). Farm Program 2 represents a less restrictive program in which prices fluctuate as widely as the extremes of the period from 1968 to 1977 (Texas Crop and Livestock Reporting Service 1968-77b). Farm Program 1 was assumed for the BASE, MOD1, and MOD2 scenarios; and Farm Program 2 was assumed for the LOW and HIGH scenarios.

The simulated prices were correlated using a correlation matrix (Appendix B, Table 3) developed from the de-trended historical price series for the state (Texas Crop and Livestock Reporting Service 1968-77b).

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[8]Historical percentage factors which were developed for the St. Lawrence area are 95 percent for cotton, 86 percent for grain sorghum, and 87 percent for wheat. Cotton prices were net of excess of ginning costs over seed credit. Grain prices were net of harvest costs.

Expected prices for use in the planning sub-model were generated with a price-expectations model. The coefficients of expectations[9] were chosen to be equivalent to a three-year moving average based on the assumption that the farmer forms his expectations with major consideration of only the previous three years' outcomes. Trend smoothing coefficients[10] were selected to minimize the standard error of the estimate for a historical price series (Texas Crop and Livestock Reporting Service 1968-77b), given the specified coefficient of expectations. Expected crop prices for 1978 (Table 4) were developed by using this historical series as input for the expectations model.

Historical yield series for crops in the St. Lawrence area were not available for individual producers because most of the farmers who participated in this study have been farming for only a few years. Therefore, long-term expected yields for each crop alternative were derived from the producer interviews and group meetings. Consensus estimates of the highest and lowest expected yields for a ten year period were also developed. Using these estimates, the county average yield series

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[9]From Hillier and Liebermann, the coefficient of expectations which is equivalent, in terms of variance, to a three year moving average was calculated as follows:

$(2-a)/(a)$ = Number of years, where (a) equals the coefficient of expectations

Therefore

$$(2-a)/(a) = 3$$
$$2-a = 3a$$
$$4a = 2$$
$$a = .5$$

[10]Trend smoothing constants for the St. Lawrence price-expectations model were .70 for cotton and .60 for wheat and grain sorghum.

(Texas Crop and Livestock Reporting Service 1968-1977a) was converted to a simulated individual farm yield series.[11]

The base crop yields shown in Table 5 represent an expected ten year average, as identified by producers in the St. Lawrence area. Stochastic crop yields for the simulated farming operation were generated, using these base yields and the triangular distributions shown in Appendix B, Table 4. The maximum and minimum parameters of these distributions relate the highest and lowest expected yields for these producers during a ten year period.

The correlation matrix used to generate stochastic crop yields is shown in Appendix B, Table 5. A positive relationship between the various crop yields was expected, a priori; hence, negative coefficients which were not statistically significant were assumed to be zero. Perfect correlation was also assumed between irrigation levels for a given crop.

The coefficient of yield expectations was specified in the same manner as the coefficient of price expectations, but trend smoothing constants were not used. The simulated individual yield series was then used as input for the yield expectations model to develop the expected 1978 crop yields (Table 5) for use in the planning sub-model.

The historical expected price and yield series were used to calculate the annual deviations in returns for inclusion in the initial 1978

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[11]This was done by (1) transforming the county yield series to standard normal deviates and (2) using a composite individual mean and standard deviation to develop a new series based on county deviations from mean. This procedure was used by Lin, Dean, and Moore to provide a series with adjusted means and standard deviation.

Table 5. Base and Expected 1978 Crop Yields, St. Lawrence Model

Crop	Irrigation Level	Units	Base Yield 1978	Expected Yield 1978
Cotton				
	Dryland	lbs./ac.[a]	110	107
	PP+0	"	250	247
	PP+1	"	400	395
	PP+2	"	550	543
	PP+3	"	650	642
Wheat				
	Dryland	bu./ac.	15	18
	PP+0	"	25	25
	PP+1	"	35	35
	PP+2	"	44	44
	PP+3	"	50	50
	PP+4	"	53	53
Grain Sorghum				
	Dryland	cwt./ac.	10	11
	PP+0	"	21	23
	PP+1	"	35	38
	PP+2	"	45	49

[a]Land acres as opposed to planted acres.

LP matrix. After each simulation, the earliest set of deviations is deleted and a new set is added.

Financial-accounting sub-model. The beginning balance sheet for the St. Lawrence model (Table 6) was developed from interviews with producers and lenders (Russell; Stewart). The farmer is assumed to own 25 percent equity in 320 acres of land at $325 per acre (including wells and underground lines, but excluding pumps). The machinery complement, which is shown in Appendix B, Table 6, has a book value of $113,558 and is composed of both new and used machinery. The machinery loan amount was calculated by assuming that the farmer purchased all equipment new and has made payments during the entire period of ownership. The beginning cash balance was then specified to provide sufficient net worth to borrow required operating capital.

After the farm plan has been implemented, net returns above variable costs are calculated by: (1) calculating returns based on 'actual' prices and yields, and (2) deducting variable costs of production. Fixed obligations are deducted to determine the ending cash balance. Fixed obligations include: (1) property taxes and insurance, (2) full-time labor, (3) loan principal and interest payments, (4) income tax, and (5) family living expenses.

Property taxes and insurance are calculated at one percent of total machinery and land value. Full-time labor expenses consist of one man's salary at $8000 per year. This represents an hourly wage for 40 hours per week, a house, utilities, and payment of social security taxes.

A 25 percent down-payment is assumed for machinery and land loans, and principal payments are based on a repayment period of 5 years for

Table 6. Beginning Balance Sheet, St. Lawrence Model, January 1, 1978

Assets:	
Cash	$ 7,600
Land	104,000
Machinery	113,558
Total Assets	$225,158
Liabilities:	
Operating Loans	$ -0-
Land Mortgage	78,000
Machinery Loans	46,511
Income Tax Due	-0-
Total Liabilities	$124,511
Net Worth	$100,647

machinery and 20 years for land. Interest is calculated on the average balance over the term of the loan. This assumption, while contrary to some land mortgages, was required to simplify calculations. The interest rate used for land mortgages is 8 percent in all cases, but the interest rate for machinery and operating loans varies as specified in the particular scenario selected.

Straight-line depreciation for machinery is calculated, using the assumed life in Appendix B, Table 6 and salvage value from the Extension budgets (Condra 1978). When a piece of machinery is fully depreciated, it is automatically replaced. Then depreciation recapture, first year's depreciation, and investment credit are calculated. The depreciation procedure does not allow for the extension of the useful life if annual hours of usage are less than the assumed levels in the source budgets.

Non-farm investment is allowed at 6 percent annually if cash on hand exceeds that required to operate. This feature was incorporated in the model because growth, in terms of additional rented or owned acreage, is not allowed.

Income tax is calculated at the end of each year's simulated operation and added to the liabilities for payment in the next year. However, the simulation is begun with no income tax liability. Four exemptions are assumed and the calculation is based on 1977 regulations (U.S. Department of Treasury).

Family living expenses are withdrawn as a fixed amount ($15,000 per year in 1978). This figure corresponds to a young farmer who is establishing a viable farm and building his equity. It is assumed that family living expenses rise with inflation, but do not fluctuate with profits or net worth. This assumption may tend to understate consumption expenditures as net worth increases. Management charges are not explicitly assessed in this model since family living expenses pay for both management and family labor.

After all obligations are paid to the extent of available cash, the credit position of the farm is evaluated to establish the maximum operating loan available for the next year. If the farm fails to repay the operating loan for two consecutive years, and the operating loan 'carry-over' balance is greater than the previous year; the change in net worth is examined. If the increase in operating loan 'carry-over' is greater than the increase in net worth, the farm is considered to be insolvent. Essentially, this means that operating credit will be extended as long as the credit position of the farm is improving. If the evaluation process finds the farm worthy of operating credit in the next year, the maximum level of this loan is calculated as three times net worth less liabilities. This formula simulates the requirement that the farmer maintain a 25 percent equity in operating capital, represented by his net worth. The operating cash restraint provided to the planning sub-model for the next year is the sum of the cash on hand and the maximum operating loan.

Update sub-model. The update sub-model operates based on the various inflation rates specified in the selected scenario. The general inflation rate is used to update labor costs, family living expenses, replacement costs for machinery, and non-energy input prices. All energy-related input prices are inflated with the energy inflation rate. The annual deviations in the planning sub-model LP matrix are updated, along with operating cash and expected crop prices/yields. Base prices for triangular distributions in the price-yield sub-model are also updated based on the trend rates for crop prices.

The Coyanosa Model

The Coyanosa model was developed by modifying the St. Lawrence model (STL1) to reflect differences between the two areas in water resources, climate, and management practices. Modifications in management practices were limited to those deemed necessary by Experiment Station and Extension Service personnel to deal with salinity, pest problems, and soil fertility in the Coyanosa area. This approach was taken based on the assumption that a St. Lawrence farmer (relocating to Coyanosa) would make only those changes in his production system which were immediately necessary. Other modifications which might become necessary and/or desirable cannot be identified at this time.

The Basic Model (COY1)

The LP matrix of the planning sub-model is shown in Appendix C. Crop production activities for an additional irrigation level were added for cotton and grain sorghum because the spring and summer rainfall in the Coyanosa area is about 2 inches less than in the St. Lawrence area (Griffiths and Orton). Dryland alternatives were also deleted for the same reason.

Levels of resources which are assumed to be available are shown in Table 7. Note that both land and normal crop acreage are identical to

Table 7. Resources Available for Crop Production, Coyanosa Model (COY1)

Item	Units	Period				
		Nov.-Dec.	Jan.-Apr.	May-Aug.	Sep.-Oct.	Annual
Land[a]						
Owned	Acres					288
Rented	"					576
Normal Crop Acreage						
Owned	Acres					224
Rented	"					449
Irrigation Water						
Owned	Ac-In.	2,017	4,033	4,033	2,017	12,100
Rented	"	3,745	7,490	7,490	3,745	22,470
Labor						
Family	Hours	500	1,000	1,000	500	3,000
Full-Time[b]	"	333	667	667	333	2,000
Tractors	Hours	666	1,334	1,334	666	4,000

[a]Cultivated land available. Does not include roads, turnrows, homestead, etc.
[b]Hired by the month or year.

the St. Lawrence model. This avoids distortion of the comparison between the St. Lawrence and Coyanosa models with effects of the present farm program.

The Coyanosa model farm is assumed to have 10 irrigation wells (4 owned and 6 rented), lifting water from 400 feet. These wells are equipped with 30 horsepower electric submersible pumps which deliver 200 gallons per minute each. This equipment was chosen because it is more compatible with the management practices of the St. Lawrence area than larger pumps powered with natural gas, which are typical of the Coyanosa area. These smaller electric wells have higher fuel costs than natural gas units, however, these higher costs are largely offset by reduces maintenance and fixed costs (New). The irrigation water available represents a 20 percent increase over the levels indicated for the St. Lawrence farm; but, the Coyanosa area does not have a dryland alternative.

Electricity requirements per acre for irrigation in the Coyanosa model are based on a 400 foot lift and 70 percent pump efficiency. The lift is greater than the St. Lawrence area, but a higher pump efficiency was assumed for the Coyanosa area. The St. Lawrence ground water resources are such, that even the small pumps that are used may exceed the capacity of the ground water supplies, resulting in less efficient operation. This is not the case in the Coyanosa area for the equipment used in this study. The cost of electricity for pumping, \$2.17 per acre-inch based on \$.04 per kilowatt-hour (Stevens; Tidwell), and the pumpage requirements in Appendix D, Table 1 were used to develop the electric cost coefficients in the LP matrix.

Other energy-related input coefficients in the Coyanosa model were increased to reflect Extension budget (Condra 1978) values for fertilizer, herbicide, and insecticide. St. Lawrence producers indicate that there is an increasing trend in that area to use fertilizer and herbicides, and that they would likely follow these recommendations in the Coyanosa area. However, there is great reluctance to use insecticide in the St. Lawrence area, particularly on cotton. Thus, the increased insecticide costs in the Coyanosa model probably reflect more difference between the two areas than actually exists.

Other variable costs were also increased to reflect the higher irrigation repairs associated with the greater lift at Coyanosa (Condra 1978).

Base and expected crop prices for 1978 (Table 8) were developed using the procedures described for the St. Lawrence model.[12] Triangular distributions and the correlation matrix for crop prices are the same as these parameters in the St. Lawrence model.

Base crop yields (Table 9) for the Coyanosa area were derived from ECONOCOT result demonstration data (Condra, Lindsey, Neeb, and Philley), research data from the Pecos Station (Moore and Murphey), and Extension budgets (Condra 1978). Production functions developed in other areas (Grimes; Shipley) were also used to specify relationships between irrigation levels. The expected 1978 yields were developed using the yield expectation model described for St. Lawrence (Table 9). The maximum and

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[12]Historical net percentages which were developed for the Coyanosa area are 112 percent for cotton, 94 percent for grain sorghum, and 87 percent for wheat.

Table 8. Base and Expected 1978 Crop Prices, Coyanosa Model

Crop	Units	Base Price 1978	Expected Price 1978
Cotton	¢/lbs.	56.0	52.8
Wheat	$/bu.	2.46	2.43
Grain Sorghum	$/cwt.	3.51	3.53

Table 9. Base and Expected 1978 Crop Yields, Coyanosa Model

Crop	Irrigation Level	Units	Base Yield 1978	Expected Yield 1978
Cotton				
	PP+0	lbs./ac.	250	250
	PP+1	"	500	501
	PP+2	"	615	616
	PP+3	"	690	691
	PP+4	"	720	721
Wheat				
	PP+0	bu./ac.	16	18
	PP+1	"	29	33
	PP+2	"	39	44
	PP+3	"	47	53
	PP+4	"	52	59
Grain Sorghum				
	PP+0	cwt./ac.	5	6
	PP+1	"	21	24
	PP+2	"	32	37
	PP+3	"	42	48

minimum parameters of the triangular yield distributions and the correlation matrix of crop yields were also not altered for the Coyanosa model.

The beginning balance sheet for the basic Coyanosa model (COY1) is shown in Table 10. Beginning cash was specified to equate net worth to that of the St. Lawrence model. The Coyanosa farmer is assumed to own 25 percent equity in 320 acres of land purchased at $200 per acre, including pumps (Seawright). This price includes renovation of existing well casing to include gravel-pack (Kent). The machinery and equipment complement (Appendix D, Table 2) differs from the St. Lawrence complement in terms of irrigation pumps and additional surface irrigation pipe.

Alternative Levels of Risk-Aversion

Two models were developed to test the sensitivity of model results to changes in the risk-aversion assumption. These models are identical to the basic model (COY1) except for the risk-aversion coefficient (r). The risk-aversion coefficient (r) was arbitrarily increased to 2.991[13] in the more risk-averse model, representing an extremely high level of risk-aversion. In the less risk-averse model (COY3) the risk restraint was removed to provide a standard LP solution or profit-maximizing farm plan with no consideration of risk.

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[13]As in the case of the basic model, this coefficient was chosen to represent a specified level of probability that net returns above variable costs would exceed fixed obligations. However, characteristics of the model will not allow such probabilistic statements.

Table 10. Beginning Balance Sheet, Coyanosa Model (COY1), January 1, 1978

Assets:	
Cash	$ 16,748
Land	64,000
Machinery	116,249
Total Assets	$196,997
Liabilities:	
Operating Loans	$ -0-
Land Mortgage	48,000
Machinery Loans	48,350
Income Tax Due	-0-
Total Liabilities	$ 96,350
Net Worth	$100,647

Alternative Tenure Situations

A model (COY4) was developed to represent a situation in which the farmer is renting 960 acres and purchasing no land. The beginning balance sheet (Appendix D, Table 3) differs from the basic model (COY1) in that land assets and liabilities are zero. Owned pumps were also deducted from the machinery complement assets and liabilities. This model was developed specifically to estimate the projected rates of survival and profitability for a farmer with all rented land and to identify the possible need for development of modified crop-share rental agreements for the Coyanosa area.

A model (COY5) was also developed to represent a situation in which the farmer is purchasing 960 acres and renting no land. Modifications in the beginning balance sheet (Appendix D, Table 3) include increased assets, liabilities, and equity in land and irrigation pumps. This model was developed to estimate the rates of survival and return for a farmer with all purchased land and to analyze the potential profitability of land investment in the Coyanosa area.

Application of the Models

Selected applications of the St. Lawrence and Coyanosa models are shown in Table 11. The code for each model represents the farm model and the scenario; e.g., STL1BASE is the basic St. Lawrence model (STL1) applied under conditions of the BASE scenario.

All of the STL1 and COY1 applications, except COY1MOD2, were made to compare the two areas in terms of risk and profitability.

Table 11. Selected Applications of the St. Lawrence and Coyanosa Models with Alternative Scenarios for Inflation, Energy Prices, Crop Prices, and Interest Rates

Model	Scenario[a]				
	BASE	LOW	MOD1	MOD2	HIGH
STL1	STL1BASE	STL1LOW	STL1MOD1		STL1HIGH
COY1	COY1BASE	COY1LOW	COY1MOD1	COY1MOD2	COY1HIGH
COY2	COY2BASE				
COY3	COY3BASE				
COY4	COY4BASE				
COY5	COY5BASE				

[a]Scenario attributes are presented in Table 2.

The COY1MOD2 application is based on the assumption that the price of electricity in the Coyanosa area may not increase faster than the rate of inflation (see the earlier discussion of scenario attributes). This situation is quite possible because the price of electricity in the Coyanosa area has already risen to a level one-third higher than the St. Lawrence area. Thus the extreme increases in energy prices may already have occurred in the Coyanosa area.

Additional applications were made to test the sensitivity of model results to alternative levels of risk-aversion (COY2BASE and COY3BASE) and to alternative tenure situations (COY4BASE and COY5BASE).

The simulations were limited to a 10 year period because development of meaningful scenarios for a longer period was beyond the scope of this study and extension of the period would greatly increase computational costs. For each application, the given situation was simulated 20 times to develop probability distributions for estimates of risk and profitabiltiy.

RESULTS

Results are presented in this section for the farm simulations which were outlined earlier in Table 11. These results include (1) a comparison of the basic St. Lawrence (STL1) and Coyanosa (COY1) models under alternative future scenarios, (2) a comparison of the basic Coyanosa model with more risk-averse (COY2) and less risk-averse (COY3) models, and (3) a comparison of the basic Coyanosa model with renter-only (COY4) and purchaser-only (COY5) models.

Examples of the computer output from the simulation model are shown in Appendix E. Each report summarizes the simulation of one year's operation. As stated earlier, each situation, i.e., a given scenario for one location for a ten year period, was simulated 20 times to develop a distribution of outcomes for probability analysis. The 20 simulations were then summarized with a separate computer program. An example of the output from the overall summary program is shown in Appendix F.

Alternative Future Scenarios

Five alternative future scenarios for the ten year period (1978-87) were considered in this analysis. These scenarios represent an array of outlooks for inflation, energy prices, crop prices, and interest rates from very pessimistic (LOW) to very optimistic (HIGH). The most likely scenario (Base) was also modified to reflect higher inflation (MOD1) and lower energy prices (MOD2). For additional details of these scenarios, refer to Table 2.

Effects on Farm Plans

Coyanosa. Average cropping patterns for the basic Coyanosa model (COY1) under alternative future scenarios are shown in Table 12. The averages which are shown are mean values for 20 simulations of a 10 year period. There was considerable variation which is not reflected in these statistics, i.e., among simulations and years; and the variation among scenarios was not uniform.

Considering only the most likely (COY1BASE), pessimistic (COY1LOW), and optimistic (COY1HIGH) cases, cotton was the primary crop, ranging from 405.1 acres (73 percent) for COY1LOW to 573.3 acres (84 percent) for COY1HIGH. Wheat was the next most important crop with acreage ranging from 90.0 acres (16 percent) for COY1LOW to 103.7 acres (17 percent) for COY1BASE. Grain sorghum comprised only 8.4 acres (less than 1 percent) for COY1HIGH at the minimum to 61.6 acres (11 percent) for COY1LOW at the maximum. Total crop acreage varied from a low of 556.7 acres (COY1LOW) to 684.9 acres (COY1HIGH). Total crop acreage, cotton acreage, and wheat acreage generally increased in response to higher overall levels of crop prices. However, grain sorghum acreage decreased in response to increases in the overall level of crop prices.

If higher inflation rates are assumed to be most likely (COY1MOD1), the relationships identified for the previous comparison are still relatively consistent. However, if somewhat lower energy prices are assumed to be most likely (COY1MOD2), only the acreage in cotton increases in direct response to a higher overall level of crop prices. There is no consistent scenario effect on wheat, grain sorghum, and total crop acreage. These results suggest that the competitive positions of

Table 12. Cropping Patterns for Alternative Scenarios, Coyanosa Model (COY1)[a], 1978-87.

Item	Units	Scenario[b]				
		BASE	LOW	MOD1	MOD2	HIGH
Cotton Acreage:						
Mean	Acres[e]	460.3	405.1	477.5	451.7	573.3
Trend[c]	Percent	5.6	-14.2	4.3	-1.0	-0-
Wheat Acreage:						
Mean	Acres[e]	103.7	90.0	88.1	183.9	103.2
Trend[c]	Percent	-20.5	-8.9	-20.0	-0-	-13.6
Grain Sorghum Acreage:						
Mean	Acres[e]	41.4	61.6	43.0	76.7	8.4
Trend[c]	Percent	21.7	0.8	-10.8	-4.1	30.0
Total Crop Acreage[d]:						
Mean	Acres[e]	605.4	556.7	608.6	712.3	684.9
Trend[c]	Percent	0.5	-11.6	0.1	-0.4	-1.8
Dryland Acreage[d]:						
Mean	Acres[e]	-0-	-0-	-0-	-0-	-0-
Trend[c]	Percent	-0-	-0-	-0-	-0-	-0-
Irrigated Acreage[d]:						
Mean	Acres[e]	605.4	556.7	608.6	712.3	684.9
Trend[c]	Percent	0.5	-11.6	0.1	-0.4	-1.8

[a]COY1 is the basic Coyanosa model as described in the text.
[b]Scenario attributes are presented in Table 2.
[c]Trend estimated as continuous rate of change.
[d]Does not include set-aside acreage.
[e]Land acres, not planted acres.

absolute levels of crop prices, but also to the relationship between input price and crop price increases.

Comparing trends in crop acreage within scenarios, total crop acreage was relatively stable in all applications except COY1LOW where it decreased 11.6 percent annually. Wheat and grain sorghum maintained or increased their share of crop acreage in this situation, whereas cotton and grain sorghum maintained or increased their shares under the COY1BASE and COY1HIGH situations. Only cotton increased its share under COY1MOD1 and only wheat increased its share under COY1MOD2

St. Lawrence. Table 13 displays average cropping patterns for the basic St. Lawrence model (STL1) under alternative future scenarios. Considering only the most likely (STL1BASE), pessimistic (STL1LOW), and optimistic (STL1HIGH) cases, cotton acreage was lower for St. Lawrence than for Coyanosa, both in absolute terms and in terms of percentage of total crop acreage. It ranged from 389.3 acres (55 percent) for STL1LOW to 450.4 acres (61 percent) for STL1BASE. Wheat was relatively more important in the St. Lawrence results with a low of 257.4 acres (35 percent) for STL1HIGH and a high of 289.9 acres for STL1LOW. Grain sorghum acreage ranged from 25.1 acres (4 percent) for STL1LOW to 36.6 acres (5 percent) for STL1HIGH. Total crop acreage was higher for the St. Lawrence model than for the Coyanosa model, ranging from 608.1 acres (STL1LOW) to 674.6 acres (STL1HIGH). Total crop acreage and grain sorghum acreage increased in response to increased overall crop price levels, but there was no consistent scenario effect on cotton and wheat acreage.

Table 13. Cropping Patterns for Alternative Scenarios, St. Lawrence Model (STL1)[a], 1978-87.

Item	Units	Scenario[b]			
		BASE	LOW	MOD1	HIGH
Cotton Acreage:					
Mean	Acres	450.4	389.3	427.1	433.4
Trend[c]	Percent	-1.0	-2.0	-1.8	-1.1
Wheat Acreage:					
Mean	Acres	257.7	289.9	287.3	257.4
Trend[c]	Percent	-1.0	0.6	0.7	-0.7
Grain Sorghum Acreage:					
Mean	Acres	28.5	25.1	10.3	36.6
Trend[c]	Percent	38.3	-3.4	14.1	13.5
Total Crop Acreage[d]:					
Mean	Acres	736.6	704.4	724.7	727.4
Trend[c]	Percent	-0.2	-0.8	-0.5	-0.4
Dryland Acreage[d]:					
Mean	Acres	70.1	96.2	66.0	52.8
Trend[c]	Percent	11.9	25.1	13.3	9.9
Irrigated Acreage[d]:					
Mean	Acres	666.5	608.1	657.7	674.6
Trend[c]	Percent	-1.0	-3.2	-1.4	-0.9

[a] STL1 is the basic St. Lawrence model as described in the text.
[b] Scenario attributes are presented in Table 2.
[c] Trend estimated as continuous rate of change.
[d] Does not include set-aside acreage.

Assuming higher inflation for the most likely situation (STL1MOD1) does not change the comparison with the Coyanosa results, but it does remove the consistent scenario effect on grain sorghum acreage. A most likely situation with lower energy prices was not considered realistic for the St. Lawrence area.

Based on trends, total crop acreage was relatively stable for all scenarios in the St. Lawrence model; however, dryland acreage increased at the expense of irrigated acreage for each scenario. Trends in individual crop acreages differed from the Coyanosa model in that (1) cotton declined in relative importance in all scenarios, (2) grain sorghum did not maintain its share of crop acreage under the low scenario and (3) both wheat and grain sorghum increased their shares of crop acreage under the MOD1 scenario.

This model tended to develop farm plans which included higher levels of irrigation on cotton than are typical in the area. Wheat acreage in the simulation was also generally higher than actual, and grain sorghum acreage was generally lower. The St. Lawrence producers are extremely reluctant to use insecticide on cotton; therefore, they seldom apply higher levels of irrigation, which favor increased insect pest activity on cotton. It is not known whether this aversion to the higher levels of irrigation is an absolute restriction, or whether it simply represents much higher perceived insect control cost than that included in this model. The higher wheat acreage and lower grain acreage of the model relates to customs of the area and the weakness of the model in dealing with variability in irrigation. Both deficiencies of the model in development of representative farm plans tend to inflate estimates of both the mean and variance of net income and rate of return.

Effects on Farm Survival

Coyanosa. Farm survival in this study was equated with solvency; thus, the simulated farm 'survived' as long as it had or could borrow sufficient resources to operate and meet fixed cash obligations. Selected measures of farm survival for the Coyanosa model under alternative scenarios are shown in Table 14. On the average, the Coyanosa farm survived about 5 years for all scenarios except the HIGH scenario where the average life was 7.9 years. The differences between the average lives of the other scenarios were not statistically significant, which is explained by examining the high degree of dispersion in terms of the standard deviations.

The probabilities of surviving a given number of years, as shown in Table 14, provide more information on the implications of alternative scenarios for farm survival. These probabilities are based on the 20 simulations of each 10 year period for each scenario. Thus, a 50 percent probability of surviving eight years means that the simulated farm was still solvent at the end of eight years in 10 of the 20 simulations. Comparing the most likely (COY1BASE), pessimistic (COY1LOW), and optimistic (COY1HIGH) situations, the survival rate for the Coyanosa farm for the entire 10 year period ranged from 15 percent (COY1LOW) to 65 percent (COY1HIGH). Under the most likely situation with higher inflation (COY1MOD1) the rate of survival was even lower than the COY1LOW situation with only a 10 percent probability of survival. However, assuming the most likely situation with lower energy prices (COY1MOD2),

Table 14. Selected Measures of Farm Survival for Alternative Scenarios, Coyanosa Model (COY1)[a], 1978-87.

Item	Units	Scenario[b]				
		BASE	LOW	MOD1	MOD2	HIGH
Years of Survival						
Mean	Years	4.6a[c]	5.6a	4.4a	5.9a	7.9
Standard Deviation	"	3.0	3.0	3.0	3.3	3.4
Probability of Surviving:						
2 years	Percent	100.0	100.0	100.0	100.0	95.0
3 "	"	75.0	80.0	65.0	85.0	80.0
4 "	"	50.0	65.0	40.0	60.0	80.0
5 "	"	35.0	55.0	25.0	55.0	80.0
6 "	"	20.0	45.0	25.0	45.0	75.0
7 "	"	20.0	40.0	25.0	40.0	75.0
8 "	"	20.0	35.0	25.0	35.0	70.0
9 "	"	20.0	25.0	20.0	35.0	65.0
10 "	"	20.0	15.0	10.0	30.0	65.0

[a] COY1 is the basic Coyanosa model as described in the text.
[b] Scenario attributes are presented in Table 2.
[c] Means followed by the same letter were not significantly different at the 5% level using analysis of variance and Duncan's Multiple Range Test.

the probability of survival increased from 20 percent for COY1BASE to 30 percent for COY1MOD2.

Over one-half of the insolvencies in all scenarios occurred within the first five years of the period. Therefore, caution should be used in applying these results directly as a probability of survival. The failure pattern suggests that changes in the assumed equity position of the farmer would likely change the average life and influence the probability of survival for the 10 year period.

St. Lawrence. The average number of years survived for the St. Lawrence farm (shown in Table 15) was not significantly different under the alternative scenarios. However, for every scenario it was significantly higher than the average number of years survived by the Coyanosa farm; e.g., 9.3 versus 5.6 years for pessimistic (LOW) scenario and 10.0 versus 7.9 years for the optimistic (HIGH) scenario. Likewise, the survival rate was much higher for the St. Lawrence farm, ranging from 80 percent for the pessimistic (LOW) scenario to 100 percent for the most likely (BASE) and optimistic (HIGH) scenarios. These results indicate that the probability of survival for the given farm situation is significantly higher in the St. Lawrence area than Coyanosa area.

Effects on Profitability and Growth Potential

Coyanosa. Selected measures of profitability and growth potential for the Coyanosa model (COY1) are shown in Table 16. The internal rate of return on equity capital was selected as the primary measure of profitability for this study. The internal rates of return were negative

Table 15. Selected Measures of Farm Survival for Alternative Scenarios, St. Lawrence Model (STL1)[a], 1978-87.

Item	Units	Scenario[b]			
		BASE	LOW	MOD1	HIGH
Years of Survival:					
Mean	Years	10.0a[c]	9.3a	9.8a	10.0a
Standard Deviation	"	0.0	2.3	1.1	0.0
Probability of Surviving:					
2 years	Percent	100.0	100.0	100.0	100.0
3 "	"	100.0	95.0	100.0	100.0
4 "	"	100.0	90.0	100.0	100.0
5 "	"	100.0	90.0	100.0	100.0
6 "	"	100.0	90.0	95.0	100.0
7 "	"	100.0	90.0	95.0	100.0
8 "	"	100.0	90.0	95.0	100.0
9 "	"	100.0	90.0	95.0	100.0
10 "	"	100.0	80.0	95.0	100.0

[a]STL1 is the basic St. Lawrence model.
[b]Scenario attributes are presented in Table 2.
[c]Means followed by the same letter were not significantly different at the 5% level using analysis of variance and Duncan's Multiple Range test.

Table 16. Selected Measures of Profitability and Growth Potential for Alternative Scenarios, Coyanosa Model (COY1)[a], 1978-87.

Item	Units	Scenario[b]				
		BASE	LOW	MOD1	MOD2	HIGH
Internal Rate of Return:						
Mean	Percent	-12.0a[c]	-22.6a	-15.3a	-1.4a	36.8
Standard Deviation	"	29.2	29.5	25.7	22.6	47.3
Maximum	"	28.5	30.1	10.0	42.8	128.5
Minimum	"	-114.8	-100.0	-96.6	-48.0	-37.8
Net Farm Income:						
Mean	$/yr.	25,505	1,040	4,901	25,477	108,717
Trend[d]	$/yr.	4,049	-7,593	-3,770	1,477	17,144

[a]COY1 is the basic Coyanosa model as described in the text.
[b]Scenario attributes are presented in Table 2.
[c]Means followed by the same letter were not significantly different at the 5% level using analysis of variance and Duncan's Multiple Range test. Means for net farm income were not tested.
[d]Linear trend.

and not significantly different for all situations except the optimistic case (COY1HIGH). COY1HIGH had a positive 36.8 percent annual rate of return, but the coefficient of variation (1.285) represents a large variation in rates of return.

Mean annual net farm income ranged from $1040 per year for COY1LOW to $108,717 per year for COY1HIGH. There was very little difference between COY1BASE and COY1MOD2 net farm income, but there was a significant difference between these values and the net farm incomes for COY1LOW and COY1MOD1. This result is not consistent with the finding of non-significant differences between the rates of return for all scenarios except COY1HIGH. However, the trends on net farm income were positive for COY1BASE and COY1MOD2; whereas the trends were negative for COY1LOW and COY1MOD1. Therefore the discounting process tended to offset the growing divergence in later years between the net farm incomes for these scenarios.

COY1HIGH provided a fairly good opportunity for growth with an expected rate of return of 36.8 percent and increasing net income. After adjustment for the 10 percent rate of inflation, the real rate of return was still 26.8 percent (36.8 - 10.0) and the trend in net income was greater than the rate of inflation indicating that the real rate of return was increasing through time. COY1BASE and COY1MOD2 provided only marginal opportunities for growth with negative, but increasing rates of return. COY1LOW and COY1MOD1 provided little opportunity for growth with negative and decreasing rates of return.

St. Lawrence. Internal rates of return for the St. Lawrence model (STL1), shown in Table 17, ranged from 11.8 percent for STL1LOW to 52.1

Table 17. Selected Measures of Profitability and Growth Potential for Alternative Scenarios, St. Lawrence Model (STL1)[a], 1978-87.

Item	Units	Scenario[b]			
		BASE	LOW	MOD1	HIGH
Internal Rate of Return:					
Mean	Percent	26.7	11.8a[c]	14.5a	52.1
Std. Dev.	"	6.9	21.6	20.7	13.1
Maximum	"	40.0	43.4	38.0	75.6
Minimum	"	8.7	-37.2	-62.3	31.1
Net Farm Income:					
Mean	$/yr.	64,763	43,687	50,939	142,606
Trend[d]	$/yr.	4,024	-2,911	1,004	18,250

[a]STL1 is the basic St. Lawrence model as described in the text.
[b]Scenario attributes are presented in Table 2.
[c]Means followed by the same letter were not significantly different at the 5% level using analysis of variance and Duncan's Multiple Range test. Means for net farm income were not tested.
[d]Linear trend.

percent for STL1HIGH. STL1MOD1 at 14.5 percent was not significantly different from STL1low and STL1BASE was intermediate with a 26.8 percent rate of return. The rate of return for St. Lawrence was higher than Coyanosa for all scenarios except the HIGH scenario. Although STL1HIGH had a 52.1 percent rate of return compared to a 36.8 percent rate of return for COY1HIGH, the difference was not significant. The net farm income was also greater for St. Lawrence than for Coyanosa in all scenarios.

Growth potential for the St. Lawrence situation was more favorable than for the Coyanosa situation under the BASE, LOW, and MOD1 scenarios. Where growth potential was marginal for Coyanosa under the BASE scenario, it was quite favorable for St. Lawrence with a fairly stable 26.7 percent rate of return and increasing net farm income. There was little or no growth potential for Coyanosa under the LOW and MOD1 scenarios, but even these situations showed a healthy rate of return for St. Lawrence with net income declining for only the low scenario. These results did not indicate a significant difference in growth potential for the two areas under conditions of the HIGH scenario.

Alternative Levels of Risk-Aversion

The effects of alternative levels of risk-aversion upon cropping patterns, survival, profitability, and growth potential in the Coyanosa area under the most likely situation (BASE) were analyzed by comparing results from the more risk-averse (COY2) and the less risk-averse (COY3) models to results from the basic Coyanosa model (COY1). While the basic model (COY1) represents a relatively risk-averse farmer based on other studies, the results seem to indicate that 'he' may not be as risk-averse as the St. Lawrence farmer. The more risk-averse model describes a very risk-averse farmer, and the less risk-averse model describes a strict profit-maximizer (risk-neutral).

Average cropping patterns for the alternative risk-aversion models are shown in Appendix G, Table 1. As the level of risk-aversion decreased, total crop acreage increased from 509.4 acres to 684.9 acres. Cotton acreage increased proportionately more from 287.0 acres to 573.3 acres or nearly double. Grain sorghum and wheat acreage both declined, in terms of absolute acreage and share of total crop acreage, in response to the decreased risk-aversion. These results indicate that total crop acreage tended to increase and cotton tended to replace grain crops as the level of risk-aversion was reduced.

The rate of farm survival also increased in response to decreased risk-aversion (Table 18). The average years of survival for COY1BASE and COY2BASE were not significantly different at 4.6 and 3.1 years, respectively. However, the average years of survival for COY4BASE (the profit-maximizing model) were significantly increased to 8.3 years. The probability of survival was also greater for COY3BASE in all years from three to ten, i.e., 55 percent probability in year 10 for COY3BASE compared to 0 percent probability for COY2BASE.

Table 18 also shows measures of profitability and growth potential for the alternative levels of risk-aversion. The internal rate of return increased as the level of risk-aversion was decreased; however, the difference between COY1BASE and COY2BASE and difference between COY1BASE and COY3BASE were not significant. Dispersion of the rates of return

Table 18. Selected Measures of Farm Survival, Profitability and Growth Potential for Alternative Levels of Risk-Aversion, BASE Scenario, Coyanosa Models (COY1, COY2, COY3), 1978-87.

Item	Units	Model[a]		
		COY1	COY2	COY3
Years of Survival:				
Mean	Years	4.6a[b]	3.1a	8.3
Standard Deviation	"	3.0	0.7	4.1
Probability of Surviving:				
2 years	Percent	100.0	100.0	100.0
3 "	"	75.0	85.0	90.0
4 "	"	50.0	20.0	80.0
5 "	"	35.0	5.0	75.0
6 "	"	20.0	5.0	65.0
7 "	"	20.0	5.0	65.0
8 "	"	20.0	5.0	60.0
9 "	"	20.0	5.0	55.0
10 "	"	20.0	0.0	55.0
Internal Rate of Return:				
Mean	Percent	-12.0bc	-15.0b	1.8c
Standard Deviation	"	29.2	11.4	31.8
Maximum	"	28.5	4.7	51.4
Minimum	"	-114.8	-41.6	-72.0
Net Farm Income:				
Mean	$/year	25,505	-7,048	31,433
Trend[c]	"	4,049	-4,939	1,634

[a]Alternative levels of risk-aversion are represented by the basic Coyanosa model (COY1), a more risk-averse model (COY2), and a less risk-averse model (COY3). These models are fully described in the text

[b]Means followed by the same letter were not significantly different at the 5% level using analysis of variance and Duncan's Multiple Range test. Means for net farm income were not tested.

[c]Linear trend.

also increased as the level of risk-aversion was decreased. Net farm income increased from negative $7,048 for COY2BASE to $31,433 for COY3BASE. The trends in net farm income indicate that the difference between COY1BASE and COY2BASE was widening and the difference between COY1BASE and COY3BASE was narrowing through time.

It was expected that acreage, rate of return, and net farm income would increase with decreased risk-aversion. It was also expected that the dispersion around the mean rate of return would increase in response to lower levels of risk-aversion. These hypotheses were borne out in results just presented. However, it was also expected that the rate of survival would be higher for increased levels of risk-aversion, which was not the case. Instead, COY3BASE with decreased risk-aversion had a greatly increased rate of survival at 55 percent compared to zero for COY2BASE and 20 percent for COY1BASE. The explanation for these results lies in the effects of increased risk-averison on acreage and net income.

Total crop acreage decreased in response to increased levels of risk-aversion (Appendix G, Table 1), reflecting the reluctance of the more risk-averse farmer to purchase resources to plant crops on rented land. This result is theoretically valid since the profit potential of all crops is decreased by the requirement for payment of a crop-share rental. Net farm income also decreased in response to increased levels of risk-aversion because of (1) reduced crop acreage, (2) lower levels of input use, and (3) selection of lower return crops with less variability in income. In fact, net farm income for COY2BASE was reduced below the levels required to meet fixed obligations. Thus, the higher level of risk-aversion reduced annual net farm income to a point which guaranteed financial disaster over time, as equity was eroded. This was not as clearly shown in the case of COY1BASE. The rate of survival for COY1BASE was 20 percent compared to 55 percent for COY3BASE, but average net farm income was not greatly different at $25,505 versus $31,433. These net farm incomes are averages, however, and comparison of the trends in net farm incomes show that COY1BASE net farm income was much lower in the earlier years than COY3BASE. In fact, as shown in Table 18, all the failures for COY1BASE occurred in the first five years; whereas, the failures for COY3BASE were more evenly distributed over the 10 year period.

These results still appear inconsistent with the theory since the risk restraint is specified to require that the farm plan maximize net income above variable costs subject to some degree of certainty of meeting fixed obligations. However, in cases where there was no feasible solution which met these criteria, the risk restraint was modified to require that the plan maximize net income subject to some degree of certainty (same parameter as before modification) of covering variable costs. When the modification took place, fixed obligations were no longer considered in development of the plan, resulting in plans with reduced variation around the mean of net returns above variable costs. Under the modified risk-restraint, there was no reference to fixed obligations and, hence, no reason to expect that net returns above variable costs would be greater, less than, or equal to fixed obligations. Insolvency of the farm occurred through a failure to meet fixed obligations, i.e., loan payments; and the more conservative plans generated under the modified risk restraint were less likely to meet fixed obligations than plans generated under the original restraint. Finally, increasing the level of risk-aversion decreased the chance that any feasible plan could be developed under the risk restraint. Thus, increasing the level of risk-aversion increased the chances that the farm plan would be generated under the modified, rather than the original, risk restraint. In turn, the chance that fixed obligations would not be met and that the farm would not survive was increased.

Based on these results, it appears that the risk restraint should be re-specified to provide a less conservative, rather than a more conservative, plan when there is no feasible plan under the original risk restraint. Therefore, these findings regarding the relationships between risk-aversion, survival, and profitability are valid only as they represent the results of the model as specified. It is not known if these relationships would hold under the model with the above-mentioned re-specification of the risk restraint, and they may or may not be representative of the true relationships between risk-aversion, survival, and profitability in the Coyanosa area.

The levels of risk-aversion represented by the COY1 and COY2 models appear to be relatively high. Therefore, the absolute values for survival and profitability may be too conservative. The results of the profit-maximizing model (COY3) certainly indicate that the level of risk-aversion is a critical assumption.

Alternative Tenure Situations

The effects of alternative tenure situations upon cropping patterns, survival, profitability, and growth potential were analyzed by comparing results from the basic Coyanosa Model (COY1) with renter-only (COY4) and purchaser-only (COY5) models under conditions of the most likely (BASE) scenario. Total acreage, terms for land purchase, and rental arrangements were held constant for all three models. COY1BASE represents a farmer purchasing 320 acres and renting 640 acres, COY4BASE represents a farmer renting 960 acres, and COY5BASE represents a farmer purchasing 960 acres. Assumed rental arrangements were traditional crop-share rental with the landlord receiving one-third of the grain (less harvest cost) and one-fourth of the cotton (less ginning cost). Terms for land purchase were a required down-payment of 25 percent with the balance financed for 20 years at 8 percent annual rate of interest.

The effects of the alternative tenure situations on average cropping patterns are shown in Appendix G, Table 2. Total crop, wheat and grain sorghum acreage were highest for the purchaser-only situation(COY5BASE) and lowest for the renter-only situation (COY4BASE). Cotton acreage was lowest for the purchaser-renter situation (COY1BASE) and highest for the renter-only situation (COY4BASE). As a share of total crop acreage, cotton was relatively stable or increasing and wheat was decreasing in all situations. Grain sorghum was decreasing in the purchaser-only (COY5BASE) situation and relatively stable or increasing in all other situations.

The average years of survival (Table 19) for COY1BASE and COY4BASE were not significantly different at 4.6 and 4.75 years respectively. The purchaser-only situation (COY5BASE) was considerably higher at 7.7 years. Likewise, the probabilities of surviving for a given number of

Table 19. Selected Measures of Farm Survival, Profitability, and Growth Potential for Alternative Tenure Situations, BASE Scenario, Coyanosa Models (COY1, COY4, COY5), 1978-87.

Item	Units	Model[a]		
		COY1	COY4	COY5
Years of Survival:				
Mean	Years	4.6a[b]	4.8a	7.7
Standard Deviation	"	3.0	3.3	3.3
Probability of Surviving:				
2 years	Percent	100.0	95.0	100.0
3 "	"	75.0	65.0	90.0
4 "	"	50.0	40.0	85.0
5 "	"	35.0	35.0	65.0
6 "	"	20.0	35.0	65.0
7 "	"	20.0	25.0	65.0
8 "	"	20.0	25.0	65.0
9 "	"	20.0	25.0	65.0
10 "	"	20.0	25.0	65.0
Internal Rate of Return:				
Mean	Percent	-12.0	-25.4	8.7
Standard Deviation	"	29.2	23.4	21.0
Maximum	"	28.5	22.5	42.6
Minimum	"	-114.8	-58.6	-29.6
Net Farm Income:				
Mean	$/year	25,505	21,995	58,871
Trend[c]	"	4,049	1,395	1,760

[a]Alternative tenure situations are represented by both purchase and rental of land (COY1), rental only (COY4), and purchase only (COY5). These models are fully described in the text.
[b]Means followed by the same letter were not significantly different at the 5% level using analysis of variance and Duncan's Multiple Range test. Means for net farm income were not tested.
[c]Linear trend.

years were similar for COY1BASE and COY4BASE. The rate of survival for the 10 year period was 20 percent for COY1BASE and 25 percent for COY4BASE. The rate of survival for COY5BASE was much higher at 65 percent for the 10 year period. All the failures under the purchaser-only situation occurred within the first four years.

Internal rates of return (Table 19) ranged from -25.4 percent for the renter-only to 8.7 percent for the purchaser-only. The purchaser-renter situation was intermediate with -12.0 percent. Net farm income also ranked in the same order with the purchaser-only net farm income almost twice as large as that of the purchaser-renter or the renter only.

These results suggest that the rental arrangements which are typical of the St. Lawrence area are not suitable for the Coyanosa area. By reviewing the acreages in Appendix G, Table 2, it can be observed that the total acreage available was not planted in either the COY1BASE or the COY4BASE situations. On the average, the renter-only planted 75 percent (including set-aside acreage) of total acreage available and the purchaser-renter planted only 74 percent. The purchaser-only, however, planted 97 percent of the available acreage. In terms of the rental arrangements which were analyzed, the ownership tenure situation was much more profitable than either of the situations involving rent. Alternative rental agreements were not analyzed, thus, these results may not hold for different rental arrangements.

Growth potential was good for the purchaser-only situation (COY5BASE) since rate of return was positive and net farm income was healthy with an upward trend. Net farm income for the renter-only situation (COY4BASE) and the purchaser-renter situation (COY1BASE) was trending upward, but from a much lower level than the purchaser-only situation. However, the purchaser-only had additional land principal payments which were made from net farm income. Therefore, the differences in cash flow available for growth were not as great as they appear for the different tenure situations. The negative rates of return for the renter-only and purchaser-renter situations did not indicate a favorable growth potential.

Profitability of Land Purchase

The results of this study do not provide a true analysis of the net return to land. They do however, provide some proxy measures of the profitability and risk associated with the purchase of irrigated farm land in the Coyanosa area. Several points should be re-emphasized concerning the internal rate of return shown in Table 19 for the farmer purchasing 960 acres of land. First, the rate of return of 8.7 percent is an after-tax rate which embodies the tax rate of the model farmer in this study. Therefore, a direct application of this rate to an investor in a different situation may not be valid. Secondly, this rate of return is a return to total equity, implying the same rate of return for equity in cash, machinery, and land. Thirdly, this rate includes 6 percent return to excess cash which tends to inflate the estimate. Fourthly, since the purchaser is making land principal and interest payments, a portion of the return to land has been deducted as interest expense. Fifthly, family living expenses were used as a proxy for a return to management. A case can be made that the farmer who is purchasing land and building equity actually re-invests a portion of the 'market' return to management by maintaining a lower standard of family living. In this study this tends to over-state the rate of return to capital which would be available to an investor who purchased land and hired the management of the farm. Lastly, the procedure for computing the internal rate of return includes the assumption that net cash outflows from the farm will be re-invested at the same rate of return. Therefore, the land purchaser would have to have sufficient capital to continue to expand the investment, or have access to alternative investments which were equally profitable. The rate of return would be reduced if excess resources were allowed to remain in the business.

The 8.7 percent expected after-tax rate of return for the land purchase alternative at Coyanosa is reasonably high providing a real rate of return of 1.7 percent; i.e., the nominal rate of return (8.7 percent) less the rate of inflation (7 percent). The purchaser has an alternative investment for excess funds by paying off machinery loans which have a 9 percent interest rate. However, this rate is subject to the considerations mentioned above. For the non-farmer investor the rate of return would probably be lower because of the higher cost of management and the differences in income tax rates.

These results provide information on two kinds of risk which the purchaser may face. First, as shown in Table 19, he has a 35 percent probability that the farm will not survive for the ten year period. Secondly, if the farm survives there is a possibility of a lower return than 8.7 percent. In terms of the survival risk, the purchaser's chances of survival increase with each year he survives. At the beginning of the period, he has a 65 percent probability of survival; but at the end of the fourth year, his chances are increased to 100 percent. This suggests, as expected, that alternative levels of beginning equity may increase the probability of survival. In turn, the reduced number of failures may increase the expected rate of return, since each failure has a negative rate of return.

The risk for a land purchaser of a lower rate of return than 8.7 percent is represented by the results for COY5BASE in Table 19. Notice that the standard deviation is 21.0 percent which gives a coefficient of variation of 2.41. Thus, the rate of return is subject to a high degree of variation, which is confirmed by the range from the maximum rate of 42.6 percent to the minimum rate of -29.6 percent. Referring to the previous discussion of the effect of equity levels on survival rate and rate of return, the expected rate of return for simulations which had no failure was 21.8 percent, with a range from 6.0 percent to 42.6 percent. The standard deviation for simulations without failures was 11.8 percent giving a coefficient of variation of 0.54. Thus, if the farm survives for four years, the purchaser faces a much higher expected rate of return. However, these results do not mean that increasing the equity level to insure survival will increase the expected rate of return from 8.7 percent to 21.8 percent, because the rate of return for the simulations with failures is not known for different equity levels.

One alternative for the land purchaser which has not been discussed is that of renting land to a tenant operator. The only results from this study which reflect on this alternative are the results from the renter-only model (COY4BASE) shown in Tables 19. Since these results show a very low expected survival rate and rate of return under the assumed rental arrangements, renting the land to a tenant does not appear to be a viable alternative. It can not be determined from these results if different rental arrangements would provide a profitable alternative for the purchaser and for the renter.

This analysis also has not included the possibility of land value appreciation. These results seem to indicate that land values could appreciate, particularly under the HIGH scenario. However, to make estimates of the rate of land appreciation would require the assignment of probabilities to the various scenarios and the development of a capitalization rate for land purchasers. Referring to Table 17, the basic Coyanosa model had increasing net income for all except the LOW and MOD1 scenarios, which would indicate a rising land value for the BASE, MOD2, and HIGH scenarios. However, it is not possible from these results to quantify an estimate.

SUMMARY AND IMPLICATIONS

Introduction

The 'energy crisis' and general inflation in price of production inputs has caused much concern about the potential effects of continued price increases upon the U.S. food and fiber system. This concern has been dramatically justified in the Trans Pecos region of Texas where natural gas prices have increased by over 450 percent. This price increase, which increased irrigation costs by over 60 percent and production costs for cotton by 8-9¢ per pound of lint, has contributed significantly to the idling of thousands of acres of irrigated farmland and the departure of many farmers from the region.

Cost and return projections for cotton and other crops indicate that the Trans Pecos can compete with many other irrigated regions if currently available improved irrigation management practices are adopted. However, due to uncertainty about the future of irrigation in the region, new farmers are reluctant to move into the region, investors are reluctant to buy land, and lenders are reluctant to furnish capital.

The purpose of this study was to provide information to farmers, investors, and lenders, regarding the future of irrigated crop production in the Trans Pecos. Primary emphasis was placed on answering two questions: (1) Can an irrigated farm survive in the Trans Pecos? and (2) If it survives, how profitable will it be? The answers to these questions also have implications for other irrigated areas. Thus, policy makers need this type of information as they consider energy and farm program legislation. The Trans Pecos provides an excellent opportunity to analyze alternatives which may help improve the probability of survival of irrigation.

The Study Area

The Trans Pecos is a vast, semi-arid region in far west Texas with isolated areas of irrigated crop produciton. Development of large-scale irrigation from groundwater sources began in the 1940's and peaked at about 290,000 acres in 1964. In the following decade, irrigated acreage declined by a third to 184,000 acres. Various factors have been cited for this decline, including (1) declining cotton yields, (2) increased production costs, and (3) changes in the government farm program.

The dramatic natural gas price increase of 1975-76 led to an even greater reduction in irrigated acreage. While the increase in the price of irrigation fuel was not responsible for the total decline of irrigated crop production in the Trans Pecos, it has contributed significantly to the siutation which exists today.

There is great variation across the Trans Pecos, in terms of soil type, groundwater quality, pumping depths and annual rainfall. For this reason, the study was limited to one area to minimize aggregation error. The Coyanosa area of Pecos County, which was selected for this study, has had approximately 40,000 acres under irrigation. The soils are generally well suited to irrigated crop production, and both pumping depths and water quality are more favorable than the average for the Trans Pecos.

The Model

A computer model was developed to generate estimates of potential survival and profitability by recursive simulation of multiple time periods. The four basic steps in the simulation process of this model are (1) development of a farm plan with a mathematical model, (2) generation of stochastic ('actual') prices and yields, (3) simulation and evaluation of the farm plan in operation, and (4) update of the planning situation to reflect changes in expected prices, expected yields, and credit restrictions. The model then returns to step 1 for simulation of the next time period (year). These steps are accomplished by four sub-model: (1) planning, (2) price-yield, (3) financial-accounting, and (4) update.

The planning sub-model simulates development of a farm plan by selecting a set of crop activities to maximize expected net returns, subject to resource and risk restraints. This is accomplished with a modified-MOTAD linear programming model, incorporating a lexicographic utility function. Under this approach, the farmer is assumed to select a farm plan to maximize profits providing the plan has some degree of certainty of meeting fixed obligations.

The price-yield sub-model generates random ('actual') prices and yields and expected prices and yields for the next simulation period. Random prices and yields are drawn from a triangular distribution by a procedure which correlates the values based on a given correlation matrix. These random prices and yields are used to simulate the operation of the farm under the plan selected in the planning sub-model.

Expected prices and yields are then developed with an adaptive expectation or Nerlove-type model for use in the planning sub-model in the next simulation period.

The financial-accounting sub-model implements the farm plan, replaces machinery, pays fixed obligations, develops financial statements, and evaluates credit capacity. Through this process, the operation of the farm is simulated and credit restrictions are developed for the next simulation period.

The update sub-model annually updates the 'actual' prices and yields, expected prices and yields, the risk restraint, and price trends. Updating of prices includes input prices which are changed based on exogenous trends to reflect inflation and energy price increases.

Procedures

Representative model farms were developed for the Coyanosa and St. Lawrence areas. The St. Lawrence model was required to provide comparative estimates of risk and profitability. St. Lawrence, located on the Edwards Plateau, was selected as a comparison area because of (1) similarity to Coyanosa in terms of soils and climate, (2) the well-known expertise of St. Lawrence farmers in managing limited water supplies, and (3) the interest of many young St. Lawrence farmers in relocating to the Coyanosa area.

The St. Lawrence model (STL1) was developed through the cooperation of the Board of Directors of the St. Lawrence Cotton Grower's Association and other interested farmers selected for this project. Both individual interviews and group meetings were utilized to develop crop budgets, yield distributions, machinery complements, financial statements, and farm characteristics for the St. Lawrence model farm. This model was then modified to reflect required management changes and farm characteristics for the Coyanosa area, based on research and demonstration data and expert opinion of research and extension personnel in the Trans Pecos.

Five alternative future scenarios were specified for inflation rates, energy prices, crop prices, and interest rates to be used in application of the farm models. Three of these scenarios represent pessimistic (LOW), optimistic (HIGH), and most likely (BASE) situations. The most likely scenario (BASE) was also modified to assume a higher inflation rate (MOD1) and lower energy prices (MOD2).

The basic Coyanosa model (COY1) was modified to analyze the effects of alternative levels of risk-aversion with a more risk-averse model (COY2) and a less risk-averse model (COY3). The effects of tenure situation were also examined by comparing the basic purchaser-renter situation (COY1) with a renter-only situation (COY4) and a purchaser-only situation (COY5).

Each model application included 20 simulations of a 10 year planning horizon to develop a distribution of outcomes. The basic Coyanosa and St. Lawrence models (COY1 and STL1) were applied under alternative future scenarios to provide comparative estimates of the potential effects of inflation, crop prices, energy prices, and interest rates upon farm survival and profitability. The sensitivity of these estimates to the assumed level of risk-aversion were also tested by applying the more risk-averse (COY2) and less risk-averse (COY3) models under most likely (BASE) conditions. The renter-only (COY4) and purchaser-only (COY5) models were compared to the basic purchaser-renter model (COY1) under the most likely (BASE) scenario to estimate the effects of alternative tenure situations on farm survival and profitability.

Results

Alternative Future Scenarios

Total crop acreage, cotton acreage and wheat acreage generally increased in response to higher levels of overall crop prices in the Coyanosa model. Grain sorghum acreage decreased under these same situations. The scenario effects were not as clear-cut, or consistent when the modified most likely scenarios (MOD1 and MOD2) were considered. Total crop acreage was relatively stable under all scenarios, except the LOW scenario where it decreased through time. Relative importance of the crops was identical for all scenarios with cotton the most important and grain sorghum the least important.

Comparing the St. Lawrence results to those of the Coyanosa model, total crop acreage also increased in response to higher crop prices. However, the effects of alternative scenarios on acreage of each crop were much less consistent for St. Lawrence than they were for Coyanosa. The ranking of the crops in importance was the same for the two areas, but cotton was relatively less important and wheat was relatively more important for St. Lawrence. The importance of cotton, relative to other crops, declined throughout time under all scenarios for the St. Lawrence model.

It can be concluded from these results that higher irrigated acreage can be expected under optimistic conditions than under pessimistic conditions. Also, cotton will remain the primary crop, but comparison of model results with current farm plans in the St. Lawrence area make any conclusion regarding the relative importance of wheat (compared to grain sorghum) questionable. These results also indicate that changes in the relationship among inflation rate, crop prices, energy prices, and interest rate may affect the relative importance of individual crops as much as changes in the absolute levels within each of these variables.

Firm survival in this study was equated to solvency, thus the simulated farm 'survived' as long as it had, or could borrow, sufficient resources to meet fixed obligations. The Coyanosa farm survived about 5 years for all scenarios except the HIGH scenario where the average life was 8 years. There was no significant difference in the average life for other scenarios. The most likely rate of survival was 20 to 30 percent with a high of 65 percent under the optimistic situation and a low of 15 percent for the pessimistic situation. However, the most likely situation with higher inflation had a survival rate of only 10 percent. Over one-half the insolvencies occurred in the first five years suggesting that changes in the assumed beginning equity position of the farm would likely affect the estimates of average life, probability of survival, and profitability (rate of return to equity capital).

The average life of the St. Lawrence farm was higher than the Coyanosa farm under all scenarios, ranging from 9.3 years under the LOW scenario to 10.0 years under the HIGH scenario. The survival rate was also higher for St. Lawrence with 80 percent for the LOW scenario and 100.0 percent for the BASE and HIGH scenarios.

From these results it can be concluded, given the farm situations in this study, that the average life and probability of survival will be significantly higher at St. Lawrence than at Coyanosa. It is particularly important, however, that this conclusion be limited to the assumptions of the comparison model farms. Extrapolation to other situations is not justified without futher study.

The internal rate of return, selected as a measure of profitability, was negative and not significantly different for the Coyanosa model in all cases (scenarios) except the HIGH scenario, which returned 36.8 percent annually. The HIGH scenario also provided the only favorable opportunity for growth.

Rate of return, net farm income, and growth potential were higher for St. Lawrence than Coyanosa under all scenarios except the HIGH scenario. The HIGH scenario rates of return (36.0 percent for Coyanosa and 52.1 percent for St. Lawrence) were not significantly different. These results indicate that the St. Lawrence farm will be more profitable and provide greater growth potential than the Coyanosa farm under all but the most optimistic siutation. No conclusions can be drawn regarding the HIGH scenario comparison, and the conclusion for other scenarios must be restricted to the situations described by the two models.

Alternative Levels of Risk-Aversion

Total crop acreage, cotton acreage, rate of return, average life, and probability of survival increased in response to decreased levels of risk-aversion for the Coyanosa model. Wheat and grain sorghum acreage decreased under decreased levels of risk-aversion. Profitability was expected to increase under this situation; but average life and probability of survival were expected to be highest under higher levels of risk-aversion. It appears that these unexpected results are related to the manner in which the risk restraint was specified in the planning sub-model, rather than to a true relationship between farm survival and risk-aversion. In the more risk-averse model the farm plans, which were selected, had a greater chance of covering variable costs. However, these same plans had a lower chance of covering total costs, i.e., variable plus fixed. Thus, in the more risk-averse model financial failure was less likely in a given year, but more likely over time as equity and credit capacity were eroded.

The level of risk-aversion assumed for the basic models appears to be very high compared to other studies, but somewhat low for the St. Lawrence area farmers. Therefore, generalization of these results to other situations must include consideration of the effects of decreased levels of risk-aversion on survival and profitability. However, from these results it can only be concluded that profitability will be increased for lower levels of risk-averison.

Alternative Tenure Situations

Total crop acreage, wheat acreage and grain sorghum acreage were highest under the purchaser-only tenure situation and lowest under the renter-only situation. However, the effects of tenure situation did not impact consistently upon cotton acreage. Average life and probability of survival were significantly higher for the purchaser-only situation at 7.7 years and 65 percent, respectively. Internal rate of return ranged from -25.4 percent for the renter-only to 8.7 percent for the purchaser-only, and the purchaser-renter was intermediate with -12.0 percent.

These results indicate that the purchaser-only tenure situation will provide a higher rate of survival and profitability than either of the other two situations. They also indicate that the traditional crop-share rental arrangements are not suitable for the Coyanosa area. It is not known if these conclusions would hold under conditions of more suitable rental arrangements.

Analysis of the profitability of land purchase in the Coyanosa area was limited to the model farm situation because the results did not provide a true net return to land estimate. According to the model results, land purchase may be a viable alternative, given the most likely or optimistic scenarios. However, there are indications that there is significant risk of failure and/or low returns which may be greatly influenced by the level of beginning equity.

Limitations and Needs for Further Research

This study uses the representative farm approach, thus, aggregate or regional implication may be subject to bias. Likewise, it must be realized that these results will not likely apply directly to any farm because of the 'average' nature of the input data. Other limitations to the study are the model input data. These limitations are particularly critical as they relate to (1) parameters of the adaptive expectations models and risk restraint, (2) input-output coefficients for new technology, and (3) groundwater depletion rates.

The coefficients of expectation and risk-aversion were assumed a priori in this study. Sensitivity analysis has shown that the estimates of survival and profitability are particularly sensitive to the assumed level of risk-aversion. More research is needed to provide a better basis for estimation of these parameters in a representative farm model.

Input-output coefficients for new technology were estimated subjectively, based on research and extension data. However, additional research is needed to more adequately specify physical relationships; e.g., production functions for water, field efficiency studies of alternative irrigation distribution systems, etc.

Ground water depletion rates were assumed to be zero for both the St. Lawrence and Coyanosa areas. Pumping costs are sensitive to this parameter, but data are not available to project these rates for different assumptions regarding regional irrigated acreage. Depletion rates will likely be greater than the assumed level for this study, decreasing both survivial and profitability estimates. But the comparative effect can not be estimated with the available data.

Further application of this model can eliminate many of the limitations on the conclusions. Specifically, analysis is needed for alternative beginning equity levels, rental arrangements, and land value appreciation rates. However, application of this model is costly, both in terms of data acquisition and of computer time. Therefore, limitations of the theoretical model should be investigated before extending these analyses.

Insufficient data were available to provide a historical validation of this model. Logical validation revealed some theoretical problems with the specification of the risk restraint; however, even more important questions surround this model. This model has extended the methodology by linking a modified MOTAD model with a farm simulation model, but this study provides no basis to assess the effectiveness of the model. Research is needed to compare the cost-effectiveness of this model to that of less sophisticated, less costly models.

REFERENCES

Adams, R. M., G. A. King, and W. E. Johnston. "Effects of Energy Cost Increases and Regional Policies on Agricultural Production." Am. J. Agr. Econ. 59 (1977):444-55.

American Cotton Grower. "Rising Costs Sting Irrigating Grower." Aug. 1976, pp. 10-19.

Anderson, T. W. An Introduction to Multivariate Statistical Analysis. New York: John Wiley and Sons, 1958.

Barry, P. J. and D. R. Willmann. "A Risk-Programming Analysis of Forward Contracting with Credit Constraints." Am. J. Agr. Econ. 58 (1976):62-76.

Baughman, M. L., and H. B. Cooper, et al. Provisions of Electric Power in Texas: Key Issues and Uncertainties. Draft Report prepared by the Center of Energy Studies, University of Texas at Austin for Governor's Energy Advisory Council, Dec. 1976.

Boehlje, M. D. and T. K. White. "A Production-Investment Decision Model of Farm Firm Growth." Am. J. Agr. Econ. 51 (1969):546-63.

Brink, L. and B. McCarl. "The Tradeoff Between Expected Return and Risk Among Cornbelt Farmers." Am. J. Agr. Econ. 60 (1978):259-63.

Brown, R. G. and R. F Meyer. "The Fundamental Theorem of Exponential Smoothing." Oper. Res. 9 (1961):673-87.

Casey, J. E., R. D. Lacewell, and L. L. Jones. Impact of Limited Fuel Supplies on Agricultural Output and Net Returns: Southern High Plains of Texas. Tex. Agr. Exp. Sta. MP-1175, Jan. 1975.

Cassidy, P. A., J. L. Rodgers, and W. O. McCarthy. "A Simulation Approach to Risk Assessment in Investment Analysis." Rev. of Mkting. and Agr. Econ. Mar. 1970.

Chen, J. T. and C. B. Baker. "Marginal Risk Constraint Linear Program for Activity Analysis." Am. J. Agr. Econ. 56 (1974):622-27.

Chien, Y. I. and G. L. Bradford. "A Sequential Model of Farm Firm Growth Process." Am. J. Agr. Econ. 58 (1976):456-65.

Christian, R. Caprock Electric Cooperative. Personal Communication, Mar. 3, 1978.

Clements, A. M., Jr., H. P. Mapp, Jr. and V. R. Eidman. A Procedure for Correlating Events in Farm Firm Simulation Models. Okla. Agr. Exp. Sta. Tech. Bull. T-131, Aug. 1971.

Coble, C. G., and W. A. LePori. Summary Report on Energy Consumption, Conservation, and Projected Needs for Texas Agriculture. Dept. of Agr. Eng. Rpt. S/D-12, Special Project B, Texas A&M University, Dec. 1974.

Condra, G. D. "The Impact of An Increasing Natural Gas Price on Irrigated Crop Production in the Trans Pecos Region of Texas." Mimeographed. Ft. Stockton, Tex.: Tex. Agr. Ext. Serv., 1975.

_____. "Trans Pecos and Edwards Plateau II crop Budgets." Texas Crop Budgets. Tex. Agr. Ext. Serv. MP-1027. 1978.

Condra, G. D. and R. D. Lacewell. "Effect of Alternative Product and Input Prices on Demand for Irrigation Water: Texas High Plains." Tex. Agr. Exp. Sta. TA 11981, Jul. 1975.

Condra, G. D., K. E. Lindsey, C. W. Neeb, and G. L. Philley. "ECONOCOT-A Ray of Hope for the Pecos Valley," Tex. Agr. Ext. Serv. TAP-825, 1978.

Davison, G. and M. Ericksen. "Alternative Economic Settings for Agriculture:1977-81." Agriculture-Food Policy Review. USDA-ERS AFPR-1, pp. 12-29.

Day, R. H. "An Appraoch to Production Response." Agr. Econ. Res. 14 (1962):134-148.

Dvoskin, D. and E. O. Heady. "Commodity Prices and Resource Use Under Various Energy Alternatives in Agriculture.: W. J. Agr. Econ. no.2 (1977). pp. 53-62.

Dvoskin, D., E. O. Heady, and B. C. English. Energy Use in U. S. Agriculture: An Evaluation of National and Regional Impacts from Alternative Energy Policies. The Center for Agricultural and Rural Development, Iowa State Univ. CARD Rpt. 78, Mar. 1978.

Extension Economist-Management. Texas Crop Budgets. Tex. Agr. Ext. Serv. MP-1027, 1978.

Federal Energy Administration. 1976 National Energy Outlook. Washington, Feb. 1976.

Federal Reserve Bank of St. Louis. "Annual U. S. Economic Data." May 1978.

_____. "National Economic Trends." June 5, 1978.

Fisher, B. S. and C. Tanner. "The Formulation of Price Expectation: An Empirical Test of Theoretical Models." Am. J. Agr. Econ. 60 (1978):245-48.

Fox, A. USDA-ESCS. Personal Communication, Apr.-June 1978.

Freund, R. Institute of Statistics, Texas A&M University. Personal Communication, Aug. 1978.

Freund, R. J. "The Introduction of Risk into a Programming Model." Econometrica 14 (1956):253-63.

Godfrey, C. L., C. R. Carter, and G. S. McKee. Land Resource Areas of Texas. Tex. Agr. Exp. Sta. and Tex. Agr. Ext. Serv. B-1070.

Griffiths, J. F. and R. B. Orton. Agroclimatic Atlas of Texas Part 1. Tex. Agr. Exp. Sta. MP-888, Aug. 1968.

Grimes, D. Dept of Water Res. University of California. Personal Communication, Aug. 1977.

Hardin, D. and R. D. Lacewell. "Breakeven Natural Gas Prices for Irrigation: Texas High Plains." Tex. Agr. Exp. Sta. TA13361, Jul. 1977.

Hazell, P. B. R. "A Linear Alternative to Quadratic and Semivariance Programming for Farm Planning Under Uncertainty." Am. J. Agr. Econ. 53 (1971):53-62.

Heidhues, T. "A Recursive Programming Model of Farm Growth in Northern Germany." J. Farm Econ. 48 (1966):668-84.

Hildreth, R. J. and R. B. Orton. Freeze Probabilities in Texas. Tex. Agr. Exp. Sta. MP-657, May 1963.

Hillier, F. S. and G. J. Lieberman. Operations Research. San Francisco: Holden-Day, Inc., 1974.

Hinman, H. R., and R. F. Hutton. "Returns and Risks of Expanding Pennsylvania Dairy Farms with Different Levels of Equity." Am. J. Agr. Econ. 53 (1971):608-11.

Johnson, J. and M. Ericksen. Commodity Program Provisions Under the Food and Agriculture Act of 1977. USDA-ERS-CED. AER no. 389, Oct. 1977.

Johnson, S. R. "A Multiperiod Stochastic Model of Firm Growth." Economics of Firm Growth. S. Dak. Agr. Exp. Sta. Bull. 541, June 1967, pp. 83-134.

Kent, R. Big 3 Machine of Ft. Stockton. Personal Communication, June 1978.

Knutson, R. D., R. D. Lacewell, et al. Analysis of the National Energy Plan: The Effects on Texas Agriculture. Tex. Agr. Exp. Sta., Tex. Agr. Ext. Serv., and Tex. Water Resources Inst. MP-1331, June 1977.

Lacewell, R. D., G. D. Condra, and B. Fish. "Impact of Energy Cost on Food and Fiber Production." Tex. Agr. Exp. Sta. TA 12500, Mar. 1976.

Lin, W. W. and H. S. Chang. "Specification of Bernoullian Utility In Decision Analysis." Agr. Econ. Res. no. 1 (1978). pp. 30-36.

Lin, W., G. W. Dean, and C. V. Moore. "An Empirical Test of Utility vs. Profit Maximization in Agricultural Production." Am. J. Agr. Econ. 56 (1974):397-508.

Longnecker, D. E., and P. R. Lyerly. Some Relations Among Irrigation Water Quality, Soil Characteristics and Management Practices in the Trans-Pecos Area. Tex. Agr. Exp. Sta. MP-373. Sep. 1959.

Lynch, D. "Losing Land to Energy Costs." Business Week, Oct. 4, 1976, p. 20.

Mapp, H. P., Jr. and C. L. Dobbins. "Implications of Rising Energy Costs for Irrigated Farms in the Oklahoma Panhandle." Am. J. Agr. Econ. 58 (1976):971-77.

Markowitz, H. M. Portfolio Selection. New York: John Wiley and Sons, Inc., 1959.

Martin, J. R. and J. S. Plaxico. Polyperiod Analysis of the Growth and Capital Accumulation of Farms in the Rolling Plains of Oklahoma and Texas. USDA-ERS Tech. Bull. 1381, Sep. 1967.

Martin, J. R., C. F. Lard, and T. J. Al-Bandar. "An Exploratory Approach: Incorporating Risks and Uncertainty Into A Polyperiod Growth Model." Paper presented at a joint meeting of the W-104 and GP-12 committees, Denver, Colorado, June 1970.

Moonan, W. J. "Linear Transformation to a Set of Stochastically Dependent Normal Variables." Am. Stat. Assn. J. 52(1957):247-52.

Moore, J. and M. Murphy. Texas Agricultural Experiment Station at Pecos. Personal Communication, 1978.

Moriak, T. F. "Implications of Energy and Environment upon Growth in the Food and Fiber Sector." Am. J. Agr. Econ. 57 (1975):819-22.

Naylor, T. H., J. L. Balintfy, D. S. Burdick, and K. Chu. Computer Simulation Techniques. New York: John Wiley and Sons, Inc. 1966.

Nerlove, M. The Dynamics of Supply: Estimation of Farmers' Response to Price. Baltimore: The John Hopkins Press, 1958.

New, L. Irrigation Specialist, Texas Agricultural Extension Service. Personal Communication. 1978.

Newsweek. "Crisis on the Pecos." Apr. 19, 1976, pp.75-78.

Odle, J. "High Energy Costs Threaten Irrigated Agriculture." Progressive Farmer, Feb. 1977, pp. 18-19.

Pate, T. L., J. J. Hefner, and C. W. Neeb. A Cotton Management Program to Reduce Cost of Cotton Insect Control in the Pecos Area. Tex. Agr. Expt. Sta. MP-1023, Feb. 1972.

Patrick, G. F., and L. M. Eisgruber. "The Impact of Managerial Ability and Capital Structure on Growth of the Farm Firm." Am. J. Agr. Econ. 50 (1968):491-506.

Penn, J. B. and G. D. Irwin. Constrained Input-Output Simulations of Energy Restrictions in the Food and Fiber System. USDA-ERS AER 280, Feb. 1977.

Quance, L., G. Plato, and A. Smith. "U. S. Agricultural Outlook Up-Date and Projections for the West to 1985 and 2000." W. J. Agr. Econ. no.1 (1977), pp. 122-35.

Richardson, J. R. and G. D. Condra. An Empirical Procedure for Correlating Stochastic Values from Non-Normal Distributions. Forthcoming technical report of the Dept of Agr. Econ. Texas A & M University.

Richardson, J. W. and H. P. Mapp, Jr. "Use of probabilistic Cash Flows in Analyzing Investments Under Conditions of Risk and Uncertainty." S. J. Agr. Econ. no.2 (1976), pp. 19-24.

Russell, L. Texas Production Credit Association. Personal Communication, 1978.

Schmedemann, I. W., A. B. Wooten, and H. C. McQuaide. "An Analysis of Land Values and Related Factors in the Pecos Pump Area, Reeves County, Texas." Report submitted by the Tex. Agr. Exp. Sta. to the Federal Intermediate Credit Bank of Houston, Jul. 1973.

Schurle, B. W. and B. L. Erven. "Expected Returns and Risk—A Trade-off in Farm Enterprise Choice." Ohio Agr. Res. and Dev. Center ESS-545, Jul. 1977.

Seawright, A. Federal Intermediate Credit Bank of Houston. Personal Communication, 1978.

Shipley, J. Texas Agricultural Experiment Station at Bushland, Personal Communication, 1978.

Shipley, J. and D. V. Goss. "Impact of Energy Cost on Irrigated Production, High Plains of Texas." Tex. Agr. Exp. Sta. TA 13572, Jul. 1977.

Shumway, C. R. and T. Gebremeskel. "Impact of Risk Averse Behavior on Fertilizer Demand of Tame Forages." S. J. Agr. Econ. no. 1 (1978). pp. 51-8.

Sindt, R. P. "An Economic Analysis of Potential Agricultural Adjustments in Reeves County, Texas: A Mathematical Programming Approach with Both Micro and Macro Models." Ph.D. Thesis, Texas A&M University, 1972.

Smith, D. and D. F. Capstick. "Establishing Priorities Among Multiple Management Goals." S. J. Agr. Econ. no. 2 (1976), pp. 37-43.

Stevens, J. Community Public Service Co. Personal Communication, Mar. 17, 1978.

Soil Conservation Service. "General Soil Map of Pecos County Texas." in cooperation with the Texas Agricultural Experiment Station. Temple, Tex., Apr. 1974.

Sprow, F. B., "Evaluation of Research Expenditure Using Triangular Distribution Functions and Monte Carlo Methods." J. Ind. and Eng. Chem. 7 (1967):35-38.

Stewart, G. Small Business Administration of El Paso. Personal Communication, 1978.

Taylor, B. W. and R. M. North. "The Measurement of Economic Uncertainty in Public Water Resource Development." Am. J. Agr. Econ. 58 (1976):635-43.

Texas Crop and Livestock Reporting Service. County Statistics. Austin, 1968-77.

_____. Prices received and Paid by Texas Farmers. Austin, 1968-77.

_____. 1976 Pump Irrigation and Energy Survey-Texas High Plains and Trans-Pecos Areas. Austin, 1976.

Texas Governor's Energy Advisory Council. An Analysis of President Carter's National Energy Plan. Austin, June 1977.

Texas Water Development Board. Inventories of Irrigation in Texas 1958, 1964, 1969, and 1974. Report no. 196, Austin, Oct. 1975.

Thomas, W., L. Blakeslee, L. Rogers, and N. Whittlesey. "Separable Programming for Considering Risk in Farm Planning." Am. J. Agr. Econ. 54 (1972):260-66.

Thomson, K. J. and P. B. R. Hazell. "Reliability of Using the Mean Absolute Deviation to Derive Efficient E,V Farm Plans." Am. J. Agr. Econ. 54 (1972):503-6.

Tidwell, M. Rio Grande Electric Cooperative, Inc. Personal Communication, Mar. 8, 1978.

U. S. Dept. of Agriculture. "Regional Planning Series of Food and Agriculture Projections to 1985 and 2000." USDA-ERS-NEAD working paper, 1978.

U. S. Dept. of the Treasury. Farmers Tax Guide. IRS Pub. 225, Washington, 1978.

Van Arsdall, R. T. and P. Devlin. "Price Impacts of Alternative Energy Future on the U. S. Food System." Mimeographed. USDA-ERS, no. 1977.

Van Arsdall, R. T. and I. Starbird. "Energy, Another Dilemma Fared by Cotton Producers." Paper presented at the annual meeting of the National Cotton Council, Dallas, Tex., 1978.

Whitson, R. E. "Evaluating the Relationship Between Income and Uncertainty for a Texas Ranch Organization." Ph.D. Thesis, Texas A&M University, 1974.

Whitson, R. D., P. J. Barry, and R. D. Lacewell. "Vertical Integration for Risk Management: An Application to a Cattle Ranch." S. J. Agr. Econ. no.2 (1976), pp. 45-50.

Yeh, C. "Prices, Farm Outputs, and Income Projections under Alternative Assumed Demand and Supply Conditions." Am. J. Agr. Econ. 58 (1976):703-11

APPENDIX A

THE LINEAR PROGRAMMING MATRIX OF THE ST. LAWRENCE (STL1) PLANNING SUB-MODEL

Definitions of Linear Programming Activities and Restraints

Columns (Activities or Enterprises)

Crop production:

Cols. 1-2	CT = cotton WT = wheat GS = grain sorghum
Cols. 3-4	DR = dryland PP = preplant irrigation
Col. 5	number of postplant irrigations
Col. 6	1 = production on owned land 2 = production on rented land

Set-aside activity:

Cols. 1-4	STSD = activity for compliance with farm program

Input purchase:

Cols. 1-2	BY
Cols. 2-3	EL = electricity DS = diesel OE = other energy inputs SL = seasonal labor

Crop sale:

Cols. 1-2	SL
Cols. 3-4	CT = cotton WT = wheat GS = grain sorghum
Col. 6	1 = sales from owned land 2 = sales from rented land

Transfer activities:

```
Cols. 1-8  COWNSTSD = set-aside
           CRNTSTSD =  "     "
           CSL1     = seasonal labor
           CSL2     =    "       "
           CSL3     =    "       "
           CSL4     =    "       "
```

MOTAD activities:

```
Cols. 1-4  RISK

Cols. 5-8  year of deviation
```

Right hand side:

```
Cols. 1-8  RHSL9999
```

Rows (Restraints)

Objective function:

```
Cols. 1-3  OBJ
```

Resource requirements:

```
Cols. 1-8  OWNDLAND = owned land
           RENTLAND = rented land
           OWNDWAT_ = owned water in period (Col. 8)
           RENTWAT_ = rented  "    "    "        "
           LABORHR_ = labor hours "    "         "
           TRACTHR_ = tractor hours in period (Col. 8)
           ELECCOST = electricity requirements in dollars
           DSLCOST  = diesel             "         "     "
           OENGCOST = other energy       "         "     "
           OPCASH   = operating capital requirements
```

Farm program restraints:

```
Cols. 1-8  OWNDNCA  = normal crop acreage on owned land
           RENTNCA  =   "     "     "     "    "    "
           STSDOWND = set-aside on owned land
           STSDRNTD =  "    "    " rented  "
```

Cropping pattern restraints:

Cols. 1-8 MAXCOTAC = maximum cotton acreage
COTEQUAL = ratio of cotton on owned and rented land

Yield transfers:

Cols. 1-4 YELD

Cols. 5-6 CT = cotton
WT = wheat
GS = grain sorghum

Col. 8 1 = production from owned land
2 = production from rented land

Other transfers:

Cols. 1-8 STSDTRNS = set-aside
SLTRNS = seasonal labor

MOTAD rows:

Cols. 1-8 RISK = risk restraint
MOTA00__ = gross return deviation in period (Cols. 7-8)

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	CTDR0111	CTPP0112	CTPP1113	CTPP2114	CTPP3115	WTDR0121	WTPP0122	WTPP1123	1....1
OBJ	27.98000-	39.44800-	44.90000-	46.79000-	49.10000-	1.67000-	3.22000	12.58000	OBJ
OWNDLAND	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	OWNDLAND
OWNDNCA	.67000	.67000	.67000	.67000	.67000	1.00000	1.00000	1.00000	OWNDNCA
STSDGWND	.06700	.06700	.06700	.06700	.06700	.20000	.20000	.20000	STSDOWND
OWNDWAT1	.	.	.	.	.	.	12.00000	12.00000	OWNDWAT1
OWNDWAT2	.	12.00000	12.00000	12.00000	12.00000	.	.	6.00000	OWNDWAT2
OWNDWAT3	.	.	6.00000	12.00000	18.00000	.	.	.	OWNDWAT3
MAXCOTAC	1.00000	1.00000	1.00000	1.00000	1.00000	.	.	.	MAXCOTAC
COTEQUAL	1.00000	1.00000	1.00000	1.00000	1.00000	.	.	.	COTEQUAL
LABORHR1	.38000	.38000	.38000	.38000	.38000	.86000	2.30000	2.30000	LABORHR1
LABORHR2	2.29000	3.73000	3.73000	3.73000	3.73000	.24000	.24000	.84000	LABORHR2
LABORHR3	2.34000	2.34000	3.28000	3.88000	4.48000	.12000	.18000	.18000	LABORHR3
LABORHR4	2.34000	2.41000	2.58000	2.58000	2.58000	.	.	.	LABORHR4
TRACTHR1	.	.	.	.	.	.54000	.74000	.74000	TRACTHR1
TRACTHR2	1.23000	1.25000	1.25000	1.25000	1.25000	.	.	.	TRACTHR2
TRACTHR3	.63000	.63000	.91000	.91000	.91000	.	.05000	.05000	TRACTHR3
TRACTHR4	.55000	.60000	.73000	.73000	.73000	.	.	.	TRACTHR4
ELECCOST	.	17.04000	25.56000	34.08000	42.60000	.	17.04000	25.56000	ELECCOST
DSLCOST	9.07000	9.65000	10.77000	10.77000	10.77000	2.07000	2.74000	2.74000	DSLCOST
OENGCOST	5.02000	5.02000	5.02000	5.02000	5.02000	.	.	.	OENGCOST
YELDCT01	107.00000-	247.00000-	395.00000-	543.00000-	642.00000-	.	.	.	YELDCT01
YELDWT01	.	.	.	.	.	18.00000-	25.00000-	35.00000-	YELDWT01
OPCASH	27.98000	39.44000	44.90000	46.79000	49.10000	1.67000	3.22000-	12.58000-	OPCASH
RISK	27.98000-	39.44000-	44.90000-	46.79000-	49.10000-	1.67000-	3.22000	12.58000	RISK
MOTA0001	36.64000	14.60000	23.36000	32.12000	37.96000	25.76000	9.11000-	12.75000-	MOTA0001
MOTA0002	31.58000	48.28000	77.25000	106.22000	125.53000	2.78000-	25.81000	36.14000	MOTA0002
MOTA0003	9.73000-	.46000-	.74000-	1.02000-	1.21000-	4.58000-	30.04000-	42.06000-	MOTA0003

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	WTPP2124	WTPP3125	WTPP4126	GSDR0131	GSPP0132	GSPP1133	GSPP2134	CTOR0211	2....1
OBJ	11.44000	10.29000	9.15000	9.44000-	14.20000-	15.34000-	16.48000-	27.98000-	OBJ
OWNDLAND	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	.	OWNDLAND
RENTLAND	.	.	.	.	.	.	.	1.00000	RENTLAND
OWNDNCA	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	.	OWNDNCA
RENTNCA	.	.	.	.	.	.	.	.67000	RENTNCA
STSDOWND	.20000	.20000	.20000	.10000	.10000	.10000	.10000	.	STSDOWND
STSDRENT	.	.	.	.	.	.	.	.06700	STSDRENT
OWNDWAT1	12.00000	12.00000	12.00000	.	12.00000	.	.	.	OWNDWAT1
OWNDWAT2	12.00000	18.00000	18.00000	.	.	12.00000	12.00000	.	OWNDWAT2
OWNDWAT3	.	.	6.00000	.	.	6.00000	12.00000	.	OWNDWAT3
MAXCOTAC	.	.	.	.	.	.	.	1.00000	MAXCOTAC
COTEQUAL	.	.	.	.	.	.	.	.50000-	COTEQUAL
LABORHR1	2.30000	2.30000	2.30000	.24000	.24000	.24000	.24000	.38000	LABORHR1
LABORHR2	1.44000	2.04000	2.04000	2.14000	3.82000	3.82000	3.82000	2.29000	LABORHR2
LABORHR3	.18000	.18000	.78000	1.76000	2.07000	2.67000	3.27000	2.34000	LABORHR3
LABORHR4	.	.	.	.24000	.24000	.24000	.24000	2.34000	LABORHR4
TRACTHR1	.74000	.74000	.74000	.	.	.	.	.	TRACTHR1
TRACTHR2	.	.	.	1.16000	1.36000	1.36000	1.36000	1.23000	TRACTHR2
TRACTHR3	.05000	.05000	.05000	.38000	.62000	.62000	.62000	.63000	TRACTHR3
TRACTHR4	.	.	.	.	.	.	.	.55000	TRACTHR4
ELECCOST	34.08000	42.60000	51.12000	.	17.04000	25.56000	34.08000	.	ELECCOST
DSLCOST	2.74000	2.74000	2.74000	5.78000	7.37000	7.37000	7.37000	9.07000	DSLCOST
OENGCOST	.	.	.	6.50000	6.50000	6.50000	6.50000	5.02000	OENGCOST
YELDWT01	44.00000-	50.00000-	53.00000-	.	.	.	.	.	YELDWT01
YELDGS01	.	.	.	11.00000-	23.00000-	38.00000-	49.00000-	.	YELDGS01
YELDCT02	.	.	.	.	.	.	.	80.00000-	YELDCT02
OPCASH	11.44000-	10.29000-	9.15000-	9.44000	14.20000	15.34000	16.48000	27.98000	OPCASH
RISK	11.44000	10.29000	9.15000	9.44000-	14.20000-	15.34000-	16.48000-	27.98000-	RISK
MOTA0001	16.03000-	18.21000-	19.31000-	32.82000	16.66000	27.76000	35.69000	27.48000	MOTA0001
MOTA0002	45.43000	51.63000	54.73000	.46000	7.38000-	12.30000-	15.81000-	23.69000	MOTA0002
MOTA0003	52.88000-	60.09000-	63.69000-	4.14000-	4.27000	7.11000	9.14000	7.30000-	MOTA0003

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	CTPP0212	CTPP1213	CTPP2214	CTPP3215	WTDR0221	WTPP0222	WTPP1223	WTPP2224	3....1
OBJ	39.44000-	44.90000-	46.79000-	49.10000-	1.67000-	3.22000	12.58000	11.44000	OBJ
RENTLAND	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	RENTLAND
RENTNCA	.67000	.67000	.67000	.67000	1.00000	1.00000	1.00000	1.00000	RENTNCA
STSDRENT	.06700	.06730	.06700	.06700	.20000	.20000	.20000	.20000	STSDRENT
RENTWAT1	.	.	.	.	.	12.00000	12.00000	12.00000	RENTWAT1
RENTWAT2	12.00000	12.00000	12.00000	12.00000	.	.	6.00000	12.00000	RENTWAT2
RENTWAT3	.	6.00000	12.00000	18.00000	.	.	.	.	RENTWAT3
MAXCOTAC	1.00000	1.00000	1.00000	1.00000	.	.	.	.	MAXCOTAC
COTEQUAL	.50000-	.50000-	.50000-	.50000-	.	.	.	.	COTEQUAL
LABORHR1	.38000	.38000	.38000	.38000	.86000	2.30000	2.30000	2.30000	LABORHR1
LABORHR2	3.73000	3.73000	3.73000	3.73000	.24000	.24000	.84000	1.44000	LABORHR2
LABORHR3	2.34000	3.28000	3.88000	4.48000	.12000	.18000	.18000	.18000	LABORHR3
LABORHR4	2.41000	2.58000	2.58000	2.58000	.	.	.	.	LABORHR4
TRACTHR1	.	.	.	.	.54000	.74000	.74000	.74000	TRACTHR1
TRACTHR2	1.25000	1.25000	1.25000	1.25000	.	.	.	.	TRACTHR2
TRACTHR3	.63000	.91000	.91000	.91000	.	.05000	.05000	.05000	TRACTHR3
TRACTHR4	.60000	.73000	.73000	.73000	.	.	.	.	TRACTHR4
ELECCOST	17.04000	25.56000	34.08000	42.60000	.	17.04000	25.56000	34.08000	ELECCOST
DSLCOST	9.65000	10.77000	10.77000	10.77000	2.07000	2.74000	2.74000	2.74000	DSLCOST
OENGCOST	5.02000	5.02000	5.02000	5.02000	.	.	.	.	OENGCOST
YELDCT02	185.00000-	296.00000-	407.00000-	481.00000-	.	.	.	.	YELDCT02
YELDWT02	.	.	.	.	12.00000-	17.00000-	23.00000-	29.00000-	YELDWT02
OPCASH	39.44000	44.90000	46.79000	49.10000	1.67000	3.22000-	12.58000-	11.44000-	OPCASH
RISK	39.44000-	44.90000-	46.79000-	49.10000-	1.67000-	3.22000	12.58000	11.44000	RISK
MOTA0001	10.98000	17.52000	24.12000	28.50000	17.26000	6.31000-	8.54000-	10.77000-	MOTA0001
MOTA0002	36.31000	57.94000	79.76000	94.25000	1.86000-	17.89000	24.21000	30.53000	MOTA0002
MOTA0003	.34000-	.55000-	.76000-	.89000-	3.07000-	20.83000-	28.18000-	35.53000-	MOTA0003

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	WTPP3225	WTPP4226	GSDR0231	GSPP0232	GSPP1233	GSPP2234	STSD0G00	BYEL0019	4....1
OBJ	10.29000	9.15000	9.44000-	14.20300-	15.34000-	16.48000-	1.67000-	1.00000-	OBJ
RENTLAND	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	.	.	RENTLAND
RENTNCA	1.00000	1.00000	1.00000	1.00030	1.00000	1.00000	.	.	RENTNCA
STSDRENT	.20000	.20000	.10000	.10000	.10000	.10000	.	.	STSDRENT
RENTWAT1	12.00000	12.00000	.	.	.	.	.	.	RENTWAT1
RENTWAT2	18.00000	18.00000	.	12.00000	12.00000	12.00000	.	.	RENTWAT2
RENTWAT3	.	6.00000	.	.	6.00000	12.00000	.	.	RENTWAT3
LABORHR1	2.30000	2.30000	.24000	.24000	.24000	.24000	.86000	.	LABORHR1
LABORHR2	2.04000	2.04000	2.14000	3.82000	3.82000	3.82000	.24000	.	LABORHR2
LABORHR3	.18000	.78000	1.76000	2.07000	2.67000	3.27000	.12000	.	LABORHR3
LABORHR4	.	.	.24000	.24000	.24000	.24000	.	.	LABORHR4
TRACTHR1	.74000	.74000	.	.	.	.	.54000	.	TRACTHR1
TRACTHR2	.	.	1.16000	1.36000	1.36000	1.36000	.	.	TRACTHR2
TRACTHR3	.05000	.05000	.38000	.62000	.62000	.62000	.	.	TRACTHR3
ELECCOST	42.60000	51.12000	.	17.04000	25.56000	34.08000	.	1.00000-	ELECCOST
DSLCOST	2.74000	2.74000	5.78000	7.37000	7.37000	7.37000	2.07000	.	DSLCOST
OENGCOST	.	.	5.50000	6.50000	6.50000	6.50000	.	.	OENGCOST
YELDWT02	34.00000-	36.00000-	.	.	.	.	.	.	YELDWT02
YELDGS02	.	.	7.00000-	15.00000-	25.00000-	33.00000-	.	.	YELDGS02
OPCASH	10.29000-	9.15000-	9.44000	14.20000	15.34000	16.48000	1.67000	1.00000	OPCASH
STSDTRNS	.	.	.	.	.	.	1.00000-	.	STSDTRNS
RISK	10.29000	9.15000	9.44000-	14.20000-	15.34000-	16.48000-	1.67000-	1.00000-	RISK
MOTA0001	12.62000-	13.37000-	21.99000	11.32000	18.60000	24.26000	.	.	MOTA0001
MOTA0002	35.79000	37.89000	.31000	5.02000-	8.24000-	10.75000-	.	.	MOTA0002
MOTA0003	41.66000-	44.11000-	2.77000-	2.90000	4.76000	6.21000	.	.	MOTA0003

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	BYDS0029	BYOE0039	BYSL0049	SLCT0118	SLWT0128	SLGS0138	SLCT0218	SLWT0228	5....1
OBJ	1.00000-	1.00000-	2.75000-	.46600	2.34000	3.11000	.46600	2.34000	OBJ
DSLCOST	1.00000-	.	.	.	.	.	.	.	DSLCOST
OENGCOST	.	1.00000-	.	.	.	.	.	.	OENGCOST
YELDCT01	.	.	.	1.00000	.	.	.	.	YELDCT01
YELDWT01	.	.	.	.	1.00000	.	.	.	YELDWT01
YELDGS01	.	.	.	.	.	1.00000	.	.	YELDGS01
YELDCT02	.	.	.	.	.	.	1.00000	.	YELDCT02
YELDWT02	.	.	.	.	.	.	.	1.00000	YELDWT02
OPCASH	1.00000	1.00000	2.75000	.	.	.	.	.	OPCASH
SLTRNS	.	.	1.00000-	.	.	.	.	.	SLTRNS
RISK	1.00000-	1.00000-	2.75000-	.46600	2.34000	3.11000	.46600	2.34000	RISK

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	SLGS0238	COWNSTSD	CRNTSTSD	CSL1	CSL2	CSL3	CSL4	RISK1975	6....1
OBJ	3.11000	.	.	.	.	.	.	.01000-	OBJ
OWNCLAND	.	1.00000	.	.	.	.	.	.	OWNDLAND
RENTLAND	.	.	1.00000	.	.	.	.	.	RENTLAND
OWNDNCA	.	1.00000	.	.	.	.	.	.	OWNDNCA
RENTNCA	.	.	1.00000	.	.	.	.	.	RENTNCA
STSDCWND	.	1.00000-	.	.	.	.	.	.	STSDOWND
STSDRENT	.	.	1.00000-	.	.	.	.	.	STSDRENT
LABORHR1	.	.	.	1.00000-	.	.	.	.	LABORHR1
LABORHR2	.	.	.	.	1.00000-	.	.	.	LABORHR2
LABORHR3	.	.	.	.	.	1.00000-	.	.	LABORHR3
LABORHR4	.	.	.	.	.	.	1.00000-	.	LABORHR4
YELDGS02	1.00000	.	.	.	.	.	.	.	YELDGS02
STSDTRNS	.	1.00000	1.00000	.	.	.	.	.	STSDTRNS
SLTRNS	.	.	.	1.00000	1.00000	1.00000	1.00000	.	SLTRNS
RISK	3.11000	.	.	.	.	.	.	1.41900-	RISK
MOTA0001	.	.	.	.	.	.	.	1.00000	MOTA0001

	RISK1976	RISK1977	RISK1978	RISK1979	RISK1980	RISK1981	RISK1982	RISK1983	7....1
OBJ	.01000-	.01000-	.01000-	.01000-	.01000-	.01000-	.01000-	.01000-	OBJ
RISK	1.41900-	1.41900-	1.41900-	1.41900-	1.41900-	1.41900-	1.41900-	1.41900-	RISK
MOTA0002	1.00000	.	.	.	.	.	.	.	MOTA0002
MOTA0003	.	1.00000	.	.	.	.	.	.	MOTA0003
MOTA0004	.	.	1.00000	.	.	.	.	.	MOTA0004
MOTA0005	.	.	.	1.00000	.	.	.	.	MOTA0005
MOTA0006	.	.	.	.	1.00000	.	.	.	MOTA0006
MOTA0007	.	.	.	.	.	1.00000	.	.	MOTA0007
MOTA0008	.	.	.	.	.	.	1.00000	.	MOTA0008
MOTA0009	.	.	.	.	.	.	.	1.00000	MOTA0009

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	RISK1984	RISK1985	RISK1986	RHSL9999	
OBJ	.01000-	.01000-	.01000-	.	OBJ
OWNDLAND	.	.	.	288.00000	OWNDLAND
RENTLAND	.	.	.	576.00000	RENTLAND
OWNDNCA	.	.	.	224.00000	OWNDNCA
RENTNCA	.	.	.	449.00000	RENTNCA
OWNDWAT1	.	.	.	1210.0000	OWNDWAT1
OWNDWAT2	.	.	.	2420.0000	OWNDWAT2
OWNDWAT3	.	.	.	2420.0000	OWNDWAT3
RENTWAT1	.	.	.	2247.0000	RENTWAT1
RENTWAT2	.	.	.	4494.0000	RENTWAT2
RENTWAT3	.	.	.	4494.0000	RENTWAT3
MAXCOTAC	.	.	.	579.00000	MAXCOTAC
LABORHR1	.	.	.	833.00000	LABORHR1
LABORHR2	.	.	.	1667.0000	LABORHR2
LABORHR3	.	.	.	1667.0000	LABORHR3
LABORHR4	.	.	.	833.00000	LABORHR4
TRACTHR1	.	.	.	666.00000	TRACTHR1
TRACTHR2	.	.	.	1334.0000	TRACTHR2
TRACTHR3	.	.	.	1334.0000	TRACTHR3
TRACTHR4	.	.	.	666.00000	TRACTHR4
OPCASH	.	.	.	185000.00	OPCASH
RISK	1.41900-	1.41900-	1.41900-	49000.000	RISK
MOTA0010	1.00000	.	.	.	MOTA0010
MOTA0011	.	1.00000	.	.	MOTA0011
MOTA0012	.	.	1.00000	.	MOTA0012

APPENDIX B

SUMMARY OF SELECTED CHARACTERISTICS OF THE ST. LAWRENCE MODEL

Table B-1. Irrigation Water Pumped Per Acre for Crop Production, St. Lawrence Model Farm

Crop	Period				
	Nov.-Dec.	Jan.-Apr.	May-Aug.	Sep.-Oct.	Annual
	----------------------Ac.-Ins.----------------------				
Cotton					
Dryland					
PP+0[a]		12.0			12.0
PP+1		12.0	6.0		18.0
PP+2		12.0	12.0		24.0
PP+3		12.0	18.0		30.0
Wheat					
Dryland					
PP+0	12.0				12.0
PP+1	12.0	6.0			18.0
PP+2	12.0	12.0			24.0
PP+3	12.0	18.0			30.0
PP+4	12.0	18.0	6.0		36.0
Grain Sorghum					
Dryland					
PP+0		12.0			12.0
PP+1		12.0	6.0		18.0
PP+2		12.0	12.0		24.0

[a]PP stands for preplant irrigation; +0 refers to the number of postplant irrigations.

Source: Condra, Gary D., Edwards Plateau II Crop Budgets, 1978.

Table B-2. Parameters of the Triangular Crop Price Distributions, St. Lawrence Model

Crop	Most Likely	Farm Program 1[a]		Farm Program 2[b]	
		Minimum	Maximum	Minimum	Maximum
	----------------------	% of Base	----------------------		
Cotton	100	96	104	63	169
Wheat	"	80	120	66	195
Grain Sorghum	"	91	109	74	171

[a]Assumes a policy which restricts price movements within ranges approximating the current spread between loan and target prices (BASE, MOD1, and MOD2 scenarios).

[b]Assumes a policy which allows price movements approximating the extremes of recent historical records (LOW and HIGH scenarios).

Table B-3. Correlation Matrix for Crop Prices, Texas

Crop	Cotton	Wheat	Grain Sorghum
Cotton	1.0	0.80	0.75
Wheat		1.00	0.95
Grain Sorghum			1.00

Source: Texas Crop and Livestock Reporting Service, Prices Paid and Received By Farmers, 1968-77.

Table B-4. Parameters of the Triangular Crop Yield Distributions, St. Lawrence Model

Crop	Irrigation Level	Units	Parameters		
			Most Likely	Minimum	Maximum
			--------------------% of Base--------------		
Cotton					
	Dryland	#'s/ac.	100	0	330
	PP+0	"	"	34	150
	PP+1	"	"	50	150
	PP+2	"	"	"	"
	PP+3	"	"	"	"
Wheat					
	Dryland	bus/ac.	100	0	200
	PP+0	"	"	60	140
	PP+1	"	"	"	"
	PP+2	"	"	"	"
	PP+3	"	"	"	"
	PP+4	"	"	"	"
Grain Sorghum					
	Dryland	cwts./ac.	100	0	350
	PP+0	"	"	62	171
	PP+1	"	"	60	157
	PP+2	"	"	60	133

Table B-5. Correlation Matrix for Crop Yields, St. Lawrence Model

Crop	Cotton		Wheat		Grain Sorghum	
	Dryland	Irrigated	Dryland	Irrigated	Dryland	Irrigated
Cotton						
Dryland	1.00	0.68	-0-	-0-	0.74	0.11[a]
Irrigated		1.00	-0-	-0-	0.26[a]	0.28[a]
Wheat						
Dryland			1.00	-0-	0.40[a]	0.58[a]
Irrigated				1.00	-0-	-0-
Grain Sorghum						
Dryland					1.00	0.33[a]
Irrigated						1.00

[a]Coefficients were not significant at the 10% level.

Source: Texas Crop and Livestock Reporting Service, County Statistics, 1968-77.

Table B-6. Beginning Machinery and Equipment Complement, St. Lawrence Model, 1978

Item	Number Owned	Age (Years)	Life (Years)	Replacement Cost New
Tractor (125 H.P)	2	N,5	9	$25,500
Shredder (4R)	1	2	9	2,300
Tandem Disk	1	5	6	2,200
MB Plow (4B w/ Packer)	1	5	15	3,700
Chisel (13 shank)	1	5	15	2,200
Lister (7R)	2	N,5	15	2,000
Planter (6R)	2	N,5	15	2,400
Cultivator (6R)	2	N,3	10	1,800
Rolling Cultivator (6R)	1	5	15	2,400
Blade	1	5	15	1,300
Cotton Trailer (32')	1	2	8	2,700
Stripper (2R)	2	N,3	8	10,500
Module Builder	1	2	8	18,000
Grain Drill (14')	1	5	15	2,400
Pickup (½ ton)	2	N,1	3	5,000
Irrigation Pump #1	1	N	4	2,000
" " #2	"	"	"	"
" " #3	"	1	"	"
" " #4	"	"	"	"
" " #5	"	2	"	"
" " #6	"	"	"	"
" " #7	"	3	"	"
Irrigation Pipe	N/A	N	10	4,500

APPENDIX C

THE LINEAR PROGRAMMING MATRIX OF THE COYANOSA (COY1) PLANNING SUB-MODEL

Definitions of Linear Programming Activities and Restraints

Columns (Activities or Enterprises)

Crop production:

Cols. 1-2	CT = cotton WT = wheat GS = grain sorghum
Cols. 3-4	DR = dryland PP = preplant irrigation
Col. 5	number of postplant irrigations
Col. 6	1 = production on owned land 2 = production on rented land

Set-aside activity:

Cols. 1-4	STSD = activity for compliance with farm program

Input purchase:

Cols. 1-2	BY
Cols. 2-3	EL = electricity DS = diesel OE = other energy inputs SL = seasonal labor

Crop sale:

Cols. 1-2	SL
Cols. 3-4	CT = cotton WT = wheat GS = grain sorghum
Col. 6	1 = sales from owned land 2 = sales from rented land

Transfer activities:

Cols. 1-8 COWNSTSD = set-aside
CRNTSTSD = " "
CSL1 = seasonal labor
CSL2 = " "
CSL3 = " "
CSL4 = " "

MOTAD activities:

Cols. 1-4 RISK

Cols. 5-8 year of deviation

Right hand side:

Cols. 1-8 RHSL9999

Rows (Restraints)

Objective function:

Cols. 1-3 OBJ

Resource requirements:

Cols. 1-8 OWNDLAND = owned land
RENTLAND = rented land
OWNDWAT_ = owned water in period (Col. 8)
RENTWAT_ = rented " " " "
LABORHR_ = labor hours " " "
TRACTHR_ = tractor hours in period (Col. 8)
ELECCOST = electricity requirements in dollars
DSLCOST = diesel " " "
OENGCOST = other energy " " "
OPCASH = operating capital requirements

Farm program restraints:

Cols. 1-8 OWNDNCA = normal crop acreage on owned land
RENTNCA = " " " " " "
STSDOWND = set-aside on owned land
STSDRNTD = " " " rented "

Cropping pattern restraints:

Cols. 1-8 MAXCOTAC = maximum cotton acreage
COTEQUAL = ratio of cotton on owned and rented land

Yield transfers:

Cols. 1-4 YELD

Cols. 5-6 CT = cotton
WT = wheat
GS = grain sorghum

Col. 8 1 = production from owned land
2 = production from rented land

Other transfers:

Cols. 1-8 STSDTRNS = set-aside
SLTRNS = seasonal labor

MOTAD rows:

Cols. 1-8 RISK = risk restraint
MOTA00__ = gross return deviation in period (Cols. 7-8)

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	CTDR0111	CTPP0112	CTPP1113	CTPP2114	CTPP3115	CTPP4116	WTDR0121	WTPP0122	1....1
OBJ	99.99000-	40.16000-	45.98000-	48.23000-	50.90000-	51.26000-	99.99000-	2.50000	OBJ
OWNDLAND	50.00000	1.00000	1.00000	1.00000	1.00000	1.00000	50.00000	1.00000	OWNDLAND
OWNDNCA	.	.67000	.67000	.67000	.67000	.67000	.	1.00000	OWNDNCA
STSDOWND	.	.06700	.06700	.06700	.06700	.06700	.	.20000	STSDOWND
OWNDWAT1	.	.	.	.	.	.	.	12.00000	OWNDWAT1
OWNDWAT2	.	12.00000	12.00000	12.00000	12.00000	12.00000	.	.	OWNDWAT2
OWNDWAT3	.	.	6.00000	12.00000	18.00000	24.00000	.	.	OWNDWAT3
MAXCOTAC	.	1.00000	1.00000	1.00000	1.00000	1.00000	.	.	MAXCOTAC
COTEQUAL	.	1.00000	1.00000	1.00000	1.00000	1.00000	.	.	COTEQUAL
LABORHR1	.	.38000	.38000	.38000	.38000	.38000	.	2.30000	LABORHR1
LABORHR2	.	3.73000	3.73000	3.73000	3.73000	3.73000	.	.24000	LABORHR2
LABORHR3	.	2.34000	3.28000	3.88000	4.48000	5.08000	.	.18000	LABORHR3
LABORHR4	.	2.41000	2.58000	2.58000	2.58000	2.58000	.	.	LABORHR4
TRACTHR1	.	.	.	.	.	.	.	.74000	TRACTHR1
TRACTHR2	.	1.25000	1.25000	1.25000	1.25000	1.25000	.	.	TRACTHR2
TRACTHR3	.	.63000	.91000	.91000	.91000	.91000	.	.05000	TRACTHR3
TRACTHR4	.	.60000	.73000	.73000	.73000	.73000	.	.	TRACTHR4
ELECCCST	.	26.04000	39.06000	52.08000	65.10000	78.12000	.	26.04000	ELECCOST
DSLCOST	.	9.55000	10.77000	10.77000	10.77000	10.77000	.	2.74000	DSLCOST
OENGCOST	.	25.32000	31.82000	38.32000	44.82000	44.82000	.	17.50000	OENGCOST
YELDCT01	.	250.00000-	501.00000-	616.00000-	691.00000-	721.00000-	.	.	YELDCT01
YELDWT01	.	.	.	.	.	.	.	18.00000-	YELDWT01
OPCASH	.	40.16000	45.98000	48.23000	50.90000	51.26000	.	2.50000-	OPCASH
RISK	.	40.16000-	45.98000-	48.23000-	50.90000-	51.26000-	.	2.50000	RISK
MOTA0001	.	27.69000	55.38000	68.12000	76.42000	79.74000	.	9.25000	MOTA0001
MOTA0002	.	120.19000	240.38000	295.67000	331.73000	346.15000	.	15.28000	MOTA0002
MOTA0003	.	40.35000-	80.69000-	99.25000-	111.35000-	116.19000-	.	5.52000-	MOTA0003

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	WTPP1123	WTPP2124	WTPP3125	WTPP4126	GSDR0131	GSPP0132	GSPP1133	GSPP2134	2....1
OBJ	11.50000	10.00000	8.49000	6.99000	99.99000-	14.92000-	16.42000-	17.92000-	OBJ
OWNDLAND	1.00000	1.00000	1.00000	1.00000	50.00000	1.00000	1.00000	1.00000	OWNDLAND
OWNDNCA	1.00000	1.00000	1.00000	1.00000	.	1.00000	1.00000	1.00000	OWNDNCA
STSDOWND	.20000	.20000	.20000	.20000	.	.10000	.10000	.10000	STSDOWND
OWNDWAT1	12.00000	12.00000	12.00000	12.00000	.	12.00000	.	.	OWNDWAT1
OWNDWAT2	6.00000	12.00000	18.00000	18.00000	.	.	12.00000	12.00000	OWNDWAT2
OWNDWAT3	.	.	.	6.00000	.	.	6.00000	12.00000	OWNDWAT3
LABORHR1	2.30000	2.30000	2.30000	2.30000	.	.24000	.24000	.24000	LABORHR1
LABORHR2	.84000	1.44000	2.04000	2.04000	.	3.82000	3.82000	3.82000	LABORHR2
LABORHR3	.18000	.18000	.18000	.78000	.	2.07000	2.67000	3.27000	LABORHR3
LABORHR4	.	.	.	.	.	.24000	.24000	.24000	LABORHR4
TRACTHR1	.74000	.74000	.74000	.74000	.	.	.	.	TRACTHR1
TRACTHR2	.	.	.	.	.	1.36000	1.36000	1.36000	TRACTHR2
TRACTHR3	.05000	.05000	.05000	.05000	.	.62000	.62000	.62000	TRACTHR3
ELECCOST	39.06000	52.08000	65.10000	78.12000	.	26.04000	39.06000	52.08000	ELECCOST
DSLCOST	2.74000	2.74000	2.74000	2.74000	.	7.37000	7.37000	7.37000	DSLCOST
DENGCOST	17.50000	17.50000	17.50000	17.50000	.	40.70000	40.70000	40.70000	DENGCOST
YELDWT01	33.00000-	44.00000-	53.00000-	59.00000-	.	.	.	.	YELDWT01
YELDGS01	.	.	.	.	.	6.00000-	24.00000-	37.00000-	YELDGS01
OPCASH	11.50000-	10.00000-	8.49000-	6.99000-	.	14.92000	16.42000	17.92000	OPCASH
RISK	11.50000	10.00000	8.49000	6.99000	.	14.92000-	16.42000-	17.92000-	RISK
MOTA0001	16.76000	22.54000	27.16000	30.05000	.	3.44000-	14.46000-	22.03000-	MOTA0001
MOTA0002	27.69000	37.24000	44.88000	49.65000	.	4.47000-	18.77000-	28.60000-	MOTA0002
MOTA0003	10.00000-	13.45000-	16.21000-	17.93000-	.	.96000	4.02000	6.13000	MOTA0003

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	GSPP3135	CTDR0211	CTPP0212	CTPP1213	CTPP2214	CTPP3215	CTPP4216	WTDR0221	3....1
OBJ	18.28000-	99.99000-	40.16000-	45.98000-	48.23000-	74.39000-	51.26000-	99.99000-	OBJ
OWNDLAND	1.00000	.	.	.	.	.	.	.	OWNDLAND
RENTLAND	.	50.00000	1.00000	1.00000	1.00000	1.00000	1.00000	50.00000	RENTLAND
OWNDNCA	1.00000	.	.	.	.	.	.	.	OWNDNCA
RENTNCA	.	.	.67000	.67000	.67000	.67000	.67000	.	RENTNCA
SYSDOWND	.10000	.	.	.	.	.	.	.	SYSDOWND
STSDRENT	.	.	.06700	.06700	.06700	.06700	.06700	.	STSDRENT
OWNDWAT2	12.00000	.	.	.	.	.	.	.	OWNDWAT2
OWNDWAT3	18.00000	.	.	.	.	.	.	.	OWNDWAT3
RENTWAT2	.	.	12.00000	12.00000	12.00000	12.00000	12.00000	.	RENTWAT2
RENTWAT3	.	.	.	6.00000	12.00000	18.00000	24.00000	.	RENTWAT3
MAXCOTAC	.	.	1.00000	1.00000	1.00000	1.00000	1.00000	.	MAXCOTAC
COTEQUAL	.	.	.50000-	.50000-	.50000-	.50000-	.50000-	.	COTEQUAL
LABORHR1	.24000	.	.38000	.38000	.38000	.38000	.38000	.	LABORHR1
LABORHR2	3.82000	.	3.73000	3.73000	3.73000	3.73000	3.73000	.	LABORHR2
LABORHR3	3.97000	.	2.34000	3.28000	3.88000	4.48000	5.08000	.	LABORHR3
LABORHR4	.24000	.	2.41000	2.58000	2.58000	2.58000	2.58000	.	LABORHR4
TRACTHR2	1.36000	.	1.25000	1.25000	1.25000	1.25000	1.25000	.	TRACTHR2
TRACTHR3	.62000	.	.63000	.91000	.91000	.91000	.91000	.	TRACTHR3
TRACTHR4	.	.	.60000	.73000	.73000	.73000	.73000	.	TRACTHR4
ELECCOST	65.10000	.	26.04000	39.06000	52.08000	65.10000	78.12000	.	ELECCOST
DSLCOST	7.37000	.	9.65000	10.77000	10.77000	10.77000	10.77000	.	DSLCOST
OENGCOST	40.70000	.	25.32000	31.82000	38.32000	44.82000	44.82000	.	OENGCOST
YELOGS01	48.00000-	.	.	.	.	.	.	.	YELOGS01
YELOCT02	.	.	188.00000-	376.00000-	462.00000-	518.00000-	541.00000-	.	YELOCT02
OPCASH	18.28000	.	40.16000	45.98000	48.23000	50.90000	51.26000	.	OPCASH
RISK	18.28000-	.	40.16000-	45.98000-	48.23000-	50.90000-	51.26000-	.	RISK
MOTA0001	28.92000-	.	20.82000	41.53000	51.06000	57.37000	59.84000	.	MOTA0001
MOTA0002	37.54000-	.	90.38000	180.29000	221.63000	249.04000	259.61000	.	MOTA0002
MOTA0003	8.04000	.	30.34000-	60.52000-	99.25000-	83.59500-	87.14900-	.	MOTA0003

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	WTPP0222	WTPP1223	WTPP2224	WTPP3225	WTPP4226	GSDR0231	GSPP0232	GSPP1233	4....1
OBJ	2.50000	11.50000	10.00000	8.49000	6.99000	99.99000-	14.92000-	16.42000-	OBJ
RENTLAND	1.00000	1.00000	1.00000	1.00000	1.00000	50.00000	1.00000	1.00000	RENTLAND
RENTNCA	1.00000	1.00000	1.00000	1.00000	1.00000	.	1.00000	1.00000	RENTNCA
STSDRENT	.20000	.20000	.20000	.20000	.20000	.	.10000	.10000	STSDRENT
RENTWAT1	12.00000	12.00000	12.00000	12.00000	12.00000	.	12.00000	.	RENTWAT1
RENTWAT2	.	6.00000	12.00000	18.00000	18.00000	.	.	12.00000	RENTWAT2
RENTWAT3	.	.	.	.	6.00000	.	.	6.00000	RENTWAT3
LABORHR1	2.30000	2.30000	2.30000	2.30000	2.30000	.	.24000	.24000	LABORHR1
LABORHR2	.24000	.84000	1.44000	2.04000	2.04000	.	3.82000	3.82000	LABORHR2
LABORHR3	.18000	.18000	.18000	.18000	.78000	.	2.07000	2.67000	LABORHR3
LABORHR4	.	.	.	.	.	.	.24000	.24000	LABORHR4
TRACTHR1	.74000	.74000	.74000	.74000	.74000	.	.	.	TRACTHR1
TRACTHR2	.	.	.	.	.	.	1.36000	1.36000	TRACTHR2
TRACTHR3	.05000	.05000	.05000	.05000	.05000	.	.62000	.62000	TRACTHR3
ELECCOST	26.04000	39.06000	52.08000	65.10000	78.12000	.	26.04000	39.06000	ELECCOST
DSLCOST	2.74000	2.74000	2.74000	2.74000	2.74000	.	7.37000	7.37000	DSLCOST
OENGCOST	17.50000	17.50000	17.50000	17.50000	17.50000	.	40.70000	40.70000	OENGCOST
YELDWT02	12.00000-	22.00000-	30.00000-	35.00000-	40.00000-	.	.	.	YELDWT02
YELDGS02	.	.	.	.	.	.	3.00000-	16.00000-	YELDGS02
OPCASH	2.50000-	11.50000-	10.00000-	8.49000-	.	.	14.92000	16.42000	OPCASH
RISK	2.50000	11.50000	10.00000	8.49000	6.99000	.	14.92000-	16.42000-	RISK
MOTA0001	6.36000	10.98000	15.03000	17.91000	20.23000	.	2.07000-	9.64600-	MOTA0001
MOTA0002	10.50000	18.14000	24.82000	29.60000	33.42000	.	2.68000-	12.51000-	MOTA0002
MOTA0003	3.79000-	6.55000-	8.97500-	10.69000-	12.02000-	.	.57000	2.68000	MOTA0003

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	GSPP2234	GSPP3235	STSD0000	BYEL0019	BYDS0029	BYOE0039	BYSL0049	SLCT0118	5....1
OBJ	17.92000-	18.28000-	1.67000-	1.00000-	1.00000-	1.00000-	2.75000-	.52800	OBJ
RENTLAND	1.00000	1.00000	.	.	.	.	.	.	RENTLAND
RENTNCA	1.00000	1.00000	.	.	.	.	.	.	RENTNCA
STSDRENT	.10000	.10000	.	.	.	.	.	.	STSDRENT
RENTWAT2	12.00000	12.00000	.	.	.	.	.	.	RENTWAT2
RENTWAT3	12.00000	18.00000	.	.	.	.	.	.	RENTWAT3
LABORHR1	.24000	.24000	.86000	.	.	.	.	.	LABORHR1
LABORHR2	3.82000	3.82000	.24000	.	.	.	.	.	LABORHR2
LABORHR3	3.27000	3.87000	.12000	.	.	.	.	.	LABORHR3
LABORHR4	.24000	.24000	.	.	.	.	.	.	LABORHR4
TRACTHR1	.	.	.54000	.	.	.	.	.	TRACTHR1
TRACTHR2	1.36000	1.36000	.	.	.	.	.	.	TRACTHR2
TRACTHR3	.62000	.62000	.	.	.	.	.	.	TRACTHR3
ELECCOST	52.08000	65.10000	.	1.00000-	.	.	.	.	ELECCOST
DSLCOST	7.37000	7.37000	2.07000	.	1.00000-	.	.	.	DSLCOST
OENGCOST	40.70000	40.70000	.	.	.	1.00000-	.	.	OENGCOST
YELDCT01	.	.	.	.	.	.	.	1.00000	YELDCT01
YELDGS02	24.00000-	32.00000-	.	.	.	.	.	.	YELDGS02
OPCASH	17.92000	18.28000	1.67000	1.00000	1.00000	1.00000	2.75000	.	OPCASH
STSDTRNS	.	.	1.00000-	.	.	.	.	.	STSDTRNS
SLTRNS	.	.	.	.	.	.	1.00000-	.	SLTRNS
RISK	17.92000-	18.28000-	1.67000-	1.00000-	1.00000-	1.00000-	2.75000-	.52800	RISK
MOTA0001	14.46000-	19.28000-	.	.	.	.	.	.	MOTA0001
MOTA0002	18.77000-	25.03000-	.	.	.	.	.	.	MOTA0002
MOTA0003	4.02000	5.36000	.	.	.	.	.	.	MOTA0003

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	SLWT0128	SLGS0138	SLCT0218	SLWT0228	SLGS0238	COWNSTSD	CRNTSTSD	CSL1	6....1
OBJ	2.43000	3.53000	.52800	2.43000	3.53000	.	.	.	OBJ
OWNDLAND	.	.	.	.	.	1.00000	.	.	OWNDLAND
RENTLAND	.	.	.	.	.	.	1.00000	.	RENTLAND
OWNDNCA	.	.	.	.	.	1.00000	.	.	OWNDNCA
RENTNCA	.	.	.	.	.	.	1.00000	.	RENTNCA
STSDOWND	.	.	.	.	.	1.00000-	.	.	STSDOWND
STSDRENT	.	.	.	.	.	.	1.00000-	.	STSDRENT
LABORHR1	.	.	.	.	.	.	.	1.00000-	LABORHR1
YELDWT01	1.00000	.	.	.	.	.	.	.	YELDWT01
YELDGS01	.	1.00000	.	.	.	.	.	.	YELDGS01
YELDCT02	.	.	1.00000	.	.	.	.	.	YELDCT02
YELDWT02	.	.	.	1.00000	.	.	.	.	YELDWT02
YELDGS02	.	.	.	.	1.00000	.	.	.	YELDGS02
STSDTRNS	.	.	.	.	.	1.00000	1.00000	.	STSDTRNS
SLTRNS	.	.	.	.	.	.	.	1.00000	SLTRNS
RISK	2.43000	3.53000	.52800	2.43000	3.53000	.	.	.	RISK

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	CSL2	CSL3	CSL4	RISK1975	RISK1976	RISK1977	RISK1978	RISK1979	7....1
OBJ	.	.	.	.	.	.	.01000-	.01000-	OBJ
LABORHR2	1.00000-	.	.	.	.	.	.	.	LABORHR2
LABORHR3	.	1.00000-	.	.	.	.	.	.	LABORHR3
LABORHR4	.	.	1.00000-	.	.	.	.	.	LABORHR4
SLTRNS	1.00000	1.00000	1.00000	.	.	.	.	.	SLTRNS
RISK	.	.	.	1.41900-	1.41900-	1.41900-	1.41900-	1.41900-	RISK
MOTA0001	.	.	.	1.00000	.	.	.	.	MOTA0001
MOTA0002	.	.	.	.	1.00000	.	.	.	MOTA0002
MOTA0003	.	.	.	.	.	1.00000	.	.	MOTA0003
MOTA0004	.	.	.	.	.	.	1.00000	.	MOTA0004
MOTA0005	.	.	.	.	.	.	.	1.00000	MOTA0005

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	RISK1980	RISK1981	RISK1982	RISK1983	RISK1984	RISK1985	RISK1986	RHSL9999	8....1
OBJ	.01000-	.01000-	.01000-	.01000-	.01000-	.01000-	.01000-	.	OBJ
OWNDLAND	.	.	.	.	.	.	.	288.00000	OWNDLAND
RENTLAND	.	.	.	.	.	.	.	576.00000	RENTLAND
OWNDNCA	.	.	.	.	.	.	.	224.00000	OWNDNCA
RENTNCA	.	.	.	.	.	.	.	449.00000	RENTNCA
OWNDWAT1	.	.	.	.	.	.	.	2017.0000	OWNDWAT1
OWNDWAT2	.	.	.	.	.	.	.	4033.0000	OWNDWAT2
OWNDWAT3	.	.	.	.	.	.	.	4033.0000	OWNDWAT3
RENTWAT1	.	.	.	.	.	.	.	3745.0000	RENTWAT1
RENTWAT2	.	.	.	.	.	.	.	7490.0000	RENTWAT2
RENTWAT3	.	.	.	.	.	.	.	7490.0000	RENTWAT3
MAXCOTAC	.	.	.	.	.	.	.	579.00000	MAXCOTAC
LABORHR1	.	.	.	.	.	.	.	833.00000	LABORHR1
LABORHR2	.	.	.	.	.	.	.	1667.0000	LABORHR2
LABORHR3	.	.	.	.	.	.	.	1667.0000	LABORHR3
LABORHR4	.	.	.	.	.	.	.	833.00000	LABORHR4
TRACTHR1	.	.	.	.	.	.	.	666.00000	TRACTHR1
TRACTHR2	.	.	.	.	.	.	.	1334.0000	TRACTHR2
TRACTHR3	.	.	.	.	.	.	.	1334.0000	TRACTHR3
TRACTHR4	.	.	.	.	.	.	.	666.00000	TRACTHR4
OPCASH	.	.	.	.	.	.	.	225000.00	OPCASH
RISK	1.41900-	1.41900-	1.41900-	1.41900-	1.41900-	1.41900-	1.41900-	49000.000	RISK
MOTA0006	1.00000	.	.	.	.	.	.	.	MOTA0006
MOTA0007	.	1.00000	.	.	.	.	.	.	MOTA0007
MOTA0008	.	.	1.00000	.	.	.	.	.	MOTA0008
MOTA0009	.	.	.	1.00000	.	.	.	.	MOTA0009
MOTA0010	.	.	.	.	1.00000	.	.	.	MOTA0010
MOTA0011	.	.	.	.	.	1.00000	.	.	MOTA0011
MOTA0012	.	.	.	.	.	.	1.00000	.	MOTA0012

APPENDIX D

SUMMARY OF SELECTED CHARACTERISTICS OF THE COYANOSA MODEL

Table D-1. Irrigation Water Pumped Per Acre for Crop Production, Coyanosa Model

Crop	Period				
	Nov.-Dec.	Jan.-Apr.	May-Aug.	Sep.-Oct.	Annual
	-----------------------Ac.-Ins.-----------------------				
Cotton					
PP+0[a]		12.0			12.0
PP+1		12.0	6.0		18.0
PP+2		12.0	12.0		24.0
PP+3		12.0	18.0		30.0
PP+4		12.0	24.0		36.0
Wheat					
PP+0	12.0				12.0
PP+1	12.0	6.0			18.0
PP+2	12.0	12.0			24.0
PP+3	12.0	18.0			30.0
PP+4	12.0	18.0	6.0		36.0
Grain Sorghum					
PP+0		12.0			12.0
PP+1		12.0	6.0		18.0
PP+2		12.0	12.0		24.0
PP+3		12.0	18.0		30.0

[a]PP stands for preplant irrigation; +0 refers to the number of postplant irrigations.

Source: Condra, Gary D., Edwards Plateau II Crop Budgets, 1978.

Table D-2. Beginning Machinery and Equipment Complement, Coyanosa Model (COY1), 1978

Item	Number Owned	Age (Years)	Life (Years)	Replacement Cost New
Tractor (125 H.P.)	2	N,5	9	$25,500
Shredder (4R)	1	2	9	2,300
Tandem Disk	1	5	6	2,200
MB Plow (4B w/ Packer)	1	5	15	3,700
Chisel (13 shank)	1	5	15	2,200
Lister (7R)	2	N,5	15	2,000
Planter (6R)	2	N,5	15	2,400
Cultivator (6R)	2	N,3	10	1,800
Rolling Cultivator (6R)	1	5	15	2,400
Blade	1	5	15	1,300
Cotton Trailer (32')	1	2	8	2,700
Stripper (2R)	2	N,3	8	10,500
Module Builder	1	2	8	18,000
Grain Drill (14')	1	5	15	2,400
Pickup (½ ton)	2	N,1	3	5,000
Irrigation Pump #1	1	N	4	4,000
" " #2	"	1	"	"
" " #3	"	2	"	"
" " #4	"	3	"	"
Irrigation Pipe	N/A	N	10	6,750

Table D-3. Beginning Balance Sheet, Coyanosa Models (COY4 and COY5), 1978

Item	COY4	COY5
Assets:		
Cash	$ 16,748	$ 16,748
Land	-0-	192,000
Machinery	106,649	140,249
Total Assets	$123,397	$348,997
Liabilities		
Operating Loans	-0-	-0-
Land Mortgage	-0-	$144,000
Machinery Loans	$ 41,150	66,350
Income Tax Due	-0-	-0-
Total Liabilities	$ 41,150	$210,350
Net Worth	$ 82,247	$138,647

APPENDIX E

AN EXAMPLE OF THE FARM SIMULATION MODEL COMPUTER OUTPUT

PRODUCT PRICES, YIELDS, ACREAGE -- YEAR 1

	COTTON	WHEAT	GRAIN SORGHUM	FORAGE SORGHUM
DRYLAND				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	0.0	0.0	0.0	0.0
EXPECTED YIELD	0.0	0.0	0.0	0.0
PREPLANT + 0				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	243.82	13.80	7.69	0.0
EXPECTED YIELD	250.00	18.00	6.00	0.0
PREPLANT + 1				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	506.81	25.00	29.93	0.0
EXPECTED YIELD	501.00	33.00	24.00	0.0
PREPLANT + 2				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	147.83	136.78	0.0	0.0
ACTUAL YIELD	623.38	33.63	64.19	0.0
EXPECTED YIELD	616.00	44.00	37.00	0.0
PREPLANT + 3				
ACREAGE				
OWNED	99.83	68.13	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	699.40	40.52	39.50	0.0
EXPECTED YIELD	691.00	53.00	48.00	0.0
PREPLANT + 4				
ACREAGE				
OWNED	93.17	0.0	0.0	0.0
RENTED	238.17	0.0	0.0	0.0
ACTUAL YIELD	729.81	44.84	0.0	0.0
EXPECTED YIELD	721.00	59.00	0.0	0.0
PREPLANT + 5				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	0.0	0.0	0.0	0.0
EXPECTED YIELD	0.0	0.0	0.0	0.0
ACTUAL PRICE	0.50	2.32	3.29	0.0
EXPECTED PRICE	0.56	2.43	3.53	0.0

INPUT CHARACTERISTICS

	PRICE	INFLATION RATE
IRRIGATION FUEL	1.000	0.0700
MACHINERY FUEL	1.000	0.1000
OTHER ENERGY	1.000	0.1000
SEASONAL LABOR	2.750	0.0700

MISCELLANECUS

VARIABLE COST	
INFLATION RATE	0.070
SHORT TERM INTEREST RATE	0.090
ANNUAL PERCENTAGE RATE	
FOR PURCHASED MACHINERY	0.045

AD VALOREM TAX RATES/$1

LAND	0.01
MACHINERY	0.01

MACHINE 4 WAS PURCHASED FOR $ 2200.00
MACHINE 25 WAS PURCHASED FOR $ 4000.00

INCOME AND EXPENSE STATEMENT -- YEAR 1

INCOME

COTTON	169379.19
WHEAT	13536.36
GRAIN SORGHUM	0.0
FORAGE SORGHUM	0.0
INVESTMENT	0.0
GROSS INCOME	182915.50

EXPENSES

IRRIGATION FUEL	51641.08
MACHINERY FUEL	6962.43
OTHER ENERGY	28575.86
SEASONAL LABOR	7128.19
OTHER VARIABLE COST	27382.61
FULL TIME LABOR	8000.00
INSURANCE AND AD VALOREM TAX	1802.00
OPERATING LOAN INTEREST	4722.39
OTHER INTEREST	7486.00
NET CASH INCOME	39214.98

TAX CALCULATIONS

NET CASH INCOME	39214.98	
DEPRECIATION		14872.01
FIRST YEAR DEPRECIATION		250.73
NET FARM INCOME	24092.25	
EXEMPTIONS		3000.00
RECAPTURED DEPRECIATION	176.37	
TAXABLE INCOME	21269.62	
GROSS TAX DUE		3814.52
INVESTMENT CREDIT		216.91
NET TAX DUE, YEAR 2		3597.61

CASH CALCULATIONS

BEGINNING CASH	16748.00	
NET CASH INCOME	39214.98	
LAND PAYMENT		2400.00
MACHINERY PAYMENT		12050.00
CASH PAID FOR NEW MACHINERY		1313.41
FAMILY LIVING		15000.00
INCOME TAX PAID		0.0
CARRYOVER OPERATING LOAN		0.0
ENDING CASH	25199.57	

BALANCE SHEET

ASSETS

CASH	25199.57
LAND	112000.00
MACHINERY	106556.69
TOTAL ASSETS	243756.25

LIABILITIES

OPERATING LOANS	0.0
LAND MORTGAGE	45600.00
MACHINERY LOANS	40240.22
INCOME TAX DUE	3597.61
TOTAL LIABILITIES	85840.19
NET WORTH	157916.06

PRODUCT PRICES, YIELDS, ACREAGE -- YEAR 2

	COTTON	WHEAT	GRAIN SORGHUM	FORAGE SORGHUM
DRYLAND				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	0.0	0.0	0.C	0.0
EXPECTED YIELD	0.0	0.0	0.0	0.0
PREPLANT + 0				
ACREAGE				
OWNED	0.0	0.0	0.C	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	220.68	17.97	4.21	0.0
EXPECTED YIELD	246.91	15.90	6.85	0.0
PREPLANT + 1				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	227.98	0.0	0.0	0.0
ACTUAL YIELD	469.24	32.57	17.13	0.0
EXPECTED YIELD	503.91	29.00	26.96	0.0
PREPLANT + 2				
ACREAGE				
OWNED	0.0	0.0	127.26	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	577.17	43.79	40.93	0.0
EXPECTED YIELD	619.69	38.81	50.59	0.0
PREPLANT + 3				
ACREAGE				
OWNED	113.99	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	647.56	52.78	25.19	0.0
EXPECTED YIELD	695.20	46.76	43.75	0.0
PREPLANT + 4				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	675.71	58.39	0.C	0.0
EXPECTED YIELD	725.40	51.92	0.C	0.0
PREPLANT + 5				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	0.0	0.0	0.C	0.0
EXPECTED YIELD	0.0	0.0	0.0	0.0
ACTUAL PRICE	0.55	2.93	3.75	0.0
EXPECTED PRICE	0.51	2.34	3.34	0.0

INPUT CHARACTERISTICS

	PRICE	INFLATION RATE
IRRIGATION FUEL	1.070	0.0700
MACHINERY FUEL	1.100	0.1000
OTHER ENERGY	1.100	0.1000
SEASONAL LABOR	2.942	0.0700

MISCELLANEOUS

VARIABLE COST	
INFLATION RATE	0.070
SHORT TERM INTEREST RATE	0.090
ANNUAL PERCENTAGE RATE	
FOR PURCHASED MACHINERY	0.045

AD VALOREM TAX RATES/$1

LAND	0.01
MACHINERY	0.01

MACHINE 21 WAS PURCHASED FOR $ 5350.00
MACHINE 24 WAS PURCHASED FOR $ 4280.00

INCOME AND EXPENSE STATEMENT -- YEAR 2

INCOME

COTTON	84836.50
WHEAT	0.0
GRAIN SORGHUM	19543.52
FORAGE SORGHUM	0.0
INVESTMENT	0.0
GROSS INCOME	104380.00

EXPENSES

IRRIGATION FUEL	24560.09
MACHINERY FUEL	5164.14
OTHER ENERGY	19297.13
SEASONAL LABOR	573.53
OTHER VARIABLE COST	19928.21
FULL TIME LABOR	8560.00
INSURANCE AND AD VALOREM TAX	2185.57
OPERATING LOAN INTEREST	4384.07
OTHER INTEREST	7469.31
NET CASH INCOME	12257.92

TAX CALCULATIONS

NET CASH INCOME	12257.92		
DEPRECIATION		14986.66	
FIRST YEAR DEPRECIATION		0.0	
NET FARM INCOME	-2728.73		
EXEMPTIONS		3000.00	
RECAPTURED DEPRECIATION	247.15		
TAXABLE INCOME	-5481.58		
GROSS TAX DUE			0.0
INVESTMENT CREDIT			0.0
NET TAX DUE, YEAR 3			0.0

CASH CALCULATIONS

BEGINNING CASH	25199.57	
NET CASH INCOME	12257.92	
LAND PAYMENT		2400.00
MACHINERY PAYMENT		12838.04
CASH PAID FOR NEW MACHINERY		1806.46
FAMILY LIVING		16049.99
INCOME TAX PAID		3597.61
CARRYOVER OPERATING LOAN		0.0
ENDING CASH	765.39	

BALANCE SHEET

ASSETS

CASH	765.39
LAND	112000.00
MACHINERY	99042.88
TOTAL ASSETS	211808.25

LIABILITIES

OPERATING LOANS	0.0
LAND MORTGAGE	43200.00
MACHINERY LOANS	32821.56
INCOME TAX DUE	0.0
TOTAL LIABILITIES	76021.50
NET WORTH	135786.75

PRODUCT PRICES, YIELDS, ACREAGE -- YEAR 3

	COTTON	WHEAT	GRAIN SORGHUM	FORAGE SORGHUM
DRYLAND				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	0.0	0.0	0.0	0.0
EXPECTED YIELD	0.0	0.0	0.0	0.0
PREPLANT + 0				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	271.94	12.69	7.69	0.0
EXPECTED YIELD	233.80	16.93	5.53	0.0
PREPLANT + 1				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	112.26	0.0	0.0	0.0
ACTUAL YIELD	558.63	23.00	29.50	0.0
EXPECTED YIELD	486.58	30.78	22.05	0.0
PREPLANT + 2				
ACREAGE				
OWNED	0.0	0.0	123.64	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	687.11	30.94	64.14	0.0
EXPECTED YIELD	598.43	41.30	45.76	0.0
PREPLANT + 3				
ACREAGE				
OWNED	56.13	38.86	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	770.91	37.28	39.47	0.0
EXPECTED YIELD	671.38	49.77	34.47	0.0
PREPLANT + 4				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	804.43	41.25	0.0	0.0
EXPECTED YIELD	700.56	55.16	0.0	0.0
PREPLANT + 5				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	0.0	0.0	0.0	0.0
EXPECTED YIELD	0.0	0.0	0.0	0.0
ACTUAL PRICE	0.60	3.16	4.03	0.0
EXPECTED PRICE	0.52	2.77	3.60	0.0

INPUT CHARACTERISTICS

	PRICE	INFLATION RATE
IRRIGATION FUEL	1.145	0.0700
MACHINERY FUEL	1.210	0.1000
OTHER ENERGY	1.210	0.1000
SEASONAL LABOR	3.148	0.0700

MISCELLANEOUS

VARIABLE COST INFLATION RATE	0.070
SHORT TERM INTEREST RATE	0.090
ANNUAL PERCENTAGE RATE FOR PURCHASED MACHINERY	0.045

AD VALOREM TAX RATES/$1

LAND	0.01
MACHINERY	0.01

MACHINE 20 WAS PURCHASED FOR $ 5724.49
MACHINE 23 WAS PURCHASED FOR $ 4579.59

INCOME AND EXPENSE STATEMENT -- YEAR 3

INCOME

COTTON	53957.66
WHEAT	4581.64
GRAIN SORGHUM	31959.61
FORAGE SORGHUM	0.0
INVESTMENT	0.0
GROSS INCOME	90498.88

EXPENSES

IRRIGATION FUEL	19472.23
MACHINERY FUEL	3504.54
OTHER ENERGY	14278.06
SEASONAL LABOR	0.0
OTHER VARIABLE COST	11399.80
FULL TIME LABOR	9159.19
INSURANCE AND AD VALOREM TAX	2110.43
OPERATING LOAN INTEREST	4417.21
OTHER INTEREST	7054.18
NET CASH INCOME	19103.23

TAX CALCULATIONS

NET CASH INCOME	19103.23		
DEPRECIATION		15237.60	
FIRST YEAR DEPRECIATION		0.0	
NET FARM INCOME	3865.63		
EXEMPTIONS		3000.00	
RECAPTURED DEPRECIATION	325.88		
TAXABLE INCOME	1191.51		
GROSS TAX DUE			0.0
INVESTMENT CREDIT			0.0
NET TAX DUE, YEAR 4			0.0

CASH CALCULATIONS

BEGINNING CASH		765.39	
NET CASH INCOME		19103.23	
LAND PAYMENT			2400.00
MACHINERY PAYMENT			12373.91
CASH PAID FOR NEW MACHINERY			1932.30
FAMILY LIVING			17173.48
INCOME TAX PAID			0.0
CARRYOVER OPERATING LOAN			0.0
ENDING CASH		-14011.08	

BALANCE SHEET

ASSETS

CASH	0.0
LAND	112000.00
MACHINERY	91859.31
TOTAL ASSETS	203859.31

LIABILITIES

OPERATING LOANS	14011.08
LAND MORTGAGE	40800.00
MACHINERY LOANS	26244.55
INCOME TAX DUE	0.0
TOTAL LIABILITIES	81055.63
NET WORTH	122803.69

PRODUCT PRICES, YIELDS, ACREAGE -- YEAR 4

	COTTON	WHEAT	GRAIN SORGHUM	FORAGE SORGHUM
DRYLAND				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	0.0	0.0	0.0	0.0
EXPECTED YIELD	0.0	0.0	0.0	0.0
PREPLANT + 0				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	196.51	17.80	6.61	0.0
EXPECTED YIELD	252.87	14.81	6.61	0.0
PREPLANT + 1				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	430.19	32.26	26.07	0.0
EXPECTED YIELD	522.60	26.89	25.97	0.0
PREPLANT + 2				
ACREAGE				
OWNED	0.0	0.0	46.58	0.0
RENTED	386.00	0.0	0.0	0.0
ACTUAL YIELD	529.13	43.38	57.88	0.0
EXPECTED YIELD	642.77	36.12	54.95	0.0
PREPLANT + 3				
ACREAGE				
OWNED	193.00	25.43	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	593.66	52.28	35.62	0.0
EXPECTED YIELD	721.14	43.53	36.97	0.0
PREPLANT + 4				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	619.47	57.84	0.0	0.0
EXPECTED YIELD	752.49	48.20	0.0	0.0
PREPLANT + 5				
ACREAGE				
OWNED	0.0	0.0	0.0	0.0
RENTED	0.0	0.0	0.0	0.0
ACTUAL YIELD	0.0	0.0	0.0	0.0
EXPECTED YIELD	0.0	0.0	0.0	0.0
ACTUAL PRICE	0.65	3.44	4.23	0.0
EXPECTED PRICE	0.58	3.23	4.00	0.0

INPUT CHARACTERISTICS

	PRICE	INFLATION RATE
IRRIGATION FUEL	1.225	0.0700
MACHINERY FUEL	1.331	0.1000
OTHER ENERGY	1.331	0.1000
SEASONAL LABOR	3.369	0.0700

MISCELLANEOUS

VARIABLE COST	
INFLATION RATE	0.070
SHORT TERM INTEREST RATE	0.090
ANNUAL PERCENTAGE RATE	
FOR PURCHASED MACHINERY	0.045

AD VALOREM TAX RATES/$1

LAND	0.01
MACHINERY	0.01

MACHINE 2 WAS PURCHASED FOR $ 31238.56
MACHINE 22 WAS PURCHASED FOR $ 4900.16

INCOME AND EXPENSE STATEMENT -- YEAR 4

INCOME

COTTON	172917.44
WHEAT	4576.49
GRAIN SORGHUM	11412.93
FORAGE SORGHUM	0.0
INVESTMENT	0.0
GROSS INCOME	188906.75

EXPENSES

IRRIGATION FUEL	45017.26
MACHINERY FUEL	8983.31
OTHER ENERGY	34316.84
SEASONAL LABOR	7627.85
OTHER VARIABLE COST	35698.20
FULL TIME LABOR	9800.33
INSURANCE AND AD VALOREM TAX	2038.59
OPERATING LOAN INTEREST	9399.61
OTHER INTEREST	6185.04
NET CASH INCOME	29839.74

TAX CALCULATIONS

NET CASH INCOME	29839.74	
DEPRECIATION		15556.37
FIRST YEAR DEPRECIATION		4045.48
NET FARM INCOME	10237.90	
EXEMPTIONS		3000.00
RECAPTURED DEPRECIATION	3711.17	
TAXABLE INCOME	10949.07	
GROSS TAX DUE		979.76
INVESTMENT CREDIT		979.76
NET TAX DUE, YEAR 5		0.0

CASH CALCULATIONS

BEGINNING CASH	0.0	
NET CASH INCOME	29839.74	
LAND PAYMENT		2400.00
MACHINERY PAYMENT		10415.29
CASH PAID FOR NEW MACHINERY		6281.89
FAMILY LIVING		18375.62
INCOME TAX PAID		0.0
CARRYOVER OPERATING LOAN		14011.08
ENDING CASH	-21644.13	

BALANCE SHEET

ASSETS

CASH	0.0
LAND	112000.00
MACHINERY	101096.06
TOTAL ASSETS	213096.06

LIABILITIES

OPERATING LOANS	21644.13
LAND MORTGAGE	38400.00
MACHINERY LOANS	34674.93
INCOME TAX DUE	0.0
TOTAL LIABILITIES	94719.00
NET WORTH	118377.06

YEAR	1	2	3	4	5	6	7	8	9	10
INCOME										
COTTON	169379.19	84836.50	53957.66	172917.44	0.0	0.0	0.0	0.0	0.0	0.0
WHEAT	13536.36	0.0	4581.64	4576.49	0.0	0.0	0.0	0.0	0.0	0.0
GRAIN SORGHUM	0.0	19543.52	31959.61	11412.93	0.0	0.0	0.0	0.0	0.0	0.0
GROSS INCOME	182915.50	104380.00	90498.88	188906.75	0.0	0.0	0.0	0.0	0.0	0.0
SELECTED EXPENSES										
IRRIGATION FUEL	51641.08	24560.09	19472.23	45017.26	0.0	0.0	0.0	0.0	0.0	0.0
DIESEL FUEL	6962.43	5164.14	3504.54	8983.31	0.0	0.0	0.0	0.0	0.0	0.0
OTHER ENERGY	28575.86	19297.13	14278.06	34316.84	0.0	0.0	0.0	0.0	0.0	0.0
SEASONAL LABOR	7128.19	573.53	0.0	7627.85	0.0	0.0	0.0	0.0	0.0	0.0
FULL TIME LABOR	8000.00	8560.00	9159.19	9800.33	0.0	0.0	0.0	0.0	0.0	0.0
INSURANCE & TAXES	1802.00	5783.18	2110.43	2038.59	0.0	0.0	0.0	0.0	0.0	0.0
INTEREST	12208.39	11853.38	11471.39	15584.65	0.0	0.0	0.0	0.0	0.0	0.0
NET CASH INCOME	39214.98	12257.92	19103.23	29839.74	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL DEPRECIATION	15122.73	14986.66	15237.60	19601.84	0.0	0.0	0.0	0.0	0.0	0.0
NET FARM INCOME	24092.25	-2728.73	3865.63	10237.90	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX F

AN EXAMPLE OF THE SIMULATION SUMMARY PROGRAM COMPUTER OUTPUT

NET CASH FLOW

SCENARIO 2 AREA 1

SIMULATION	YEARS 1	2	3	4	5	6	7	8	9	10	RATE OF RETURN
1	8451.57	-24434.18	-14776.46	-7633.05	0.0	0.0	0.0	0.0	0.0	0.0	0.056
2	58459.56	-89345.88	-43688.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.147
3	-24075.13	-36214.70	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.054
4	4972.87	-18213.37	-26854.30	32545.02	13929.70	28080.03	71958.75	39702.75	-4947.44	-48235.44	0.188
5	55358.75	21587.44	28590.25	16264.94	73344.06	-38935.38	-82806.94	-30070.59	-71463.56	-116993.19	-1.148
6	44553.06	-17650.87	16159.81	33591.62	-48471.83	25584.95	49133.63	47208.38	32575.69	-89410.88	0.285
7	52961.81	-64973.53	-42343.02	2933.11	-15282.30	0.0	0.0	0.0	0.0	0.0	-0.020
8	-14403.51	-48583.53	-53467.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.308
9	-42224.69	-40432.87	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.179
10	-34615.94	-39656.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.134
11	5852.05	-60763.93	-53210.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.296
12	-3184.26	-44628.94	-46021.87	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.199
13	50330.56	-31270.06	-55105.80	-45113.98	0.0	0.0	0.0	0.0	0.0	0.0	-0.144
14	14608.62	-20781.20	-34748.09	21155.59	-42415.72	0.0	0.0	0.0	0.0	0.0	-0.007
15	-33261.50	-13928.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.021
16	20476.53	-25438.03	-10742.26	64693.51	-37092.11	16296.55	-41131.86	33242.89	69070.38	-443.25	0.179
17	62855.25	-29484.50	-43616.39	-37500.07	-48661.04	0.0	0.0	0.0	0.0	0.0	-0.197
18	2682.80	-8414.20	-38411.48	-1710.32	0.0	0.0	0.0	0.0	0.0	0.0	0.034
19	-1706.57	3178.26	-51693.74	-59253.27	0.0	0.0	0.0	0.0	0.0	0.0	-0.264
20	-36678.38	-26084.59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.065
MEAN	9570.64	-30776.63	-31328.57	1815.72	-14949.88	7756.54	-711.60	22520.84	6308.77	-63770.69	
STD. DEV.	34737.54	24506.90	25655.71	37511.23	44971.75	31538.14	73346.13	35522.35	60011.66	50799.47	
MAXIMUM	62855.25	21587.44	28590.25	64693.51	73344.06	28080.03	71958.75	47208.38	69070.38	0.0	
MINIMUM	-42224.69	-89345.88	-55105.80	-59253.27	-48661.04	-38935.38	-82806.94	-30070.59	-71463.56	-116993.19	

NET WORTH

SCENARIO 2 AREA 1

SIMULATION	YEARS 1	2	3	4	5	6	7	8	9	10
1	157916.06	135786.75	122803.69	118377.06	0.0	0.0	0.0	0.0	0.0	0.0
2	207924.06	120883.00	78988.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	125389.38	91479.56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	154437.31	138528.81	113468.00	149219.38	166974.00	196727.50	269954.13	313759.00	320339.56	279936.25
5	204823.25	228715.56	259099.25	278570.56	355739.56	318477.63	236938.50	210970.00	151034.44	41873.38
6	194017.56	178671.56	196624.81	233422.81	188775.88	216034.31	266435.75	317746.25	361849.94	280271.19
7	202426.31	139757.63	99208.13	105347.56	93890.25	0.0	0.0	0.0	0.0	0.0
8	135060.94	88782.38	37108.63	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	107239.81	69111.81	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	114848.56	77497.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	155316.50	96857.56	45440.63	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	146280.19	103956.19	59727.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	199795.06	170829.88	117517.50	75609.94	0.0	0.0	0.0	0.0	0.0	0.0
14	164073.06	145596.75	112642.13	137004.06	98413.38	0.0	0.0	0.0	0.0	0.0
15	116203.00	104579.63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	169941.00	146807.88	137859.00	205758.94	172491.75	190461.75	150597.69	187942.69	268541.13	275930.00
17	212319.75	185140.06	143317.13	109023.50	64187.38	0.0	0.0	0.0	0.0	0.0
18	152147.25	146037.94	109419.94	110916.00	0.0	0.0	0.0	0.0	0.0	0.0
19	147757.88	153241.06	103340.81	47293.88	0.0	0.0	0.0	0.0	0.0	0.0
20	112786.13	89006.44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MEAN	159034.81	130563.00	115770.81	142776.44	162924.38	230425.25	230981.50	257604.44	275441.25	219502.69
STD. DEV.	34737.55	41149.59	56373.55	69625.63	97151.31	59701.86	55596.48	67818.13	91299.81	118435.94
MAXIMUM	212319.75	228715.56	259099.25	278570.56	355739.56	318477.63	269954.13	317746.25	361849.94	280271.19
MINIMUM	107239.81	69111.81	37108.63	47293.88	64187.38	190461.75	150597.69	187942.69	151034.44	41873.38

NET FARM INCOME

SCENARIO 2 AREA 1

SIMULATION	YEARS 1	2	3	4	5	6	7	8	9	10
1	24092.25	-2728.73	3865.63	10237.90	0.0	0.0	0.0	0.0	0.0	0.0
2	74100.25	-44845.76	-25046.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	-8434.45	-18106.86	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	20613.55	2562.99	-8212.20	50415.97	48225.43	60072.45	111843.50	113902.00	74034.81	9169.57
5	70999.44	64382.22	68389.88	57420.47	111640.56	28514.04	-57112.36	-4047.34	-41328.98	-84685.81
6	60193.77	19400.91	37152.23	59519.97	-9086.00	45426.82	80359.88	102736.56	104704.63	-14252.24
7	68602.50	-23465.19	-23700.92	20804.06	7306.33	0.0	0.0	0.0	0.0	0.0
8	1237.17	-30475.70	-34825.11	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	-26584.02	-22325.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	-18975.27	-21548.39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	21492.73	-39767.77	-34568.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	12456.42	-25672.54	-27379.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	65971.25	8843.82	-36291.79	-27243.02	0.0	0.0	0.0	0.0	0.0	0.0
14	30249.30	2819.21	-16105.98	39026.55	-13429.30	0.0	0.0	0.0	0.0	0.0
15	-17620.83	4179.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	36117.21	335.00	7899.84	82564.56	14536.51	36422.48	-12490.71	59266.12	115941.63	81652.38
17	78495.94	17433.39	-23096.62	-19629.11	-26776.53	0.0	0.0	0.0	0.0	0.0
18	18323.48	11789.65	-19064.73	16160.64	0.0	0.0	0.0	0.0	0.0	0.0
19	13934.11	22415.43	-29937.58	-41382.34	0.0	0.0	0.0	0.0	0.0	0.0
20	-21037.70	-7976.76	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MEAN	25211.32	-4137.51	-10728.08	22535.94	18916.69	42608.92	30650.06	67964.31	63338.02	-2029.00
STD. DEV.	34737.55	25471.84	29510.23	39716.08	47485.05	13538.25	78796.75	53481.16	71990.50	68579.69
MAXIMUM	78495.94	64382.22	68389.88	82564.56	111640.56	60072.45	111843.50	113902.00	115941.63	81652.38
MINIMUM	-26584.02	-44845.76	-36291.79	-41382.34	-26776.53	28514.04	-57112.36	-4047.34	-41328.98	-84685.81

IRRIGATED COTTON ACREAGE

SCENARIO 2 AREA 1

SIMULATION	1	2	3	4	YEARS 5	6	7	8	9	10
1	579.00	341.97	168.39	579.00	0.0	0.0	0.0	0.0	0.0	0.0
2	579.00	579.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	579.00	25.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	579.00	320.28	212.50	579.00	579.00	579.00	579.00	579.00	579.00	579.00
5	579.00	579.00	579.00	579.00	579.00	579.00	579.00	66.54	122.47	579.00
6	579.00	579.00	311.05	579.00	579.00	543.10	579.00	579.00	579.00	579.00
7	579.00	579.00	44.17	214.76	514.37	0.0	0.0	0.0	0.0	0.0
8	579.00	93.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	579.00	77.79	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	579.00	148.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	579.00	261.17	65.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	579.00	18.06	10.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	579.00	579.00	127.77	182.70	0.0	0.0	0.0	0.0	0.0	0.0
14	579.00	252.16	282.89	369.36	579.00	0.0	0.0	0.0	0.0	0.0
15	579.00	135.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	579.00	424.25	132.27	579.00	579.00	579.00	579.00	579.00	579.00	579.00
17	579.00	579.00	145.77	247.61	121.19	0.0	0.0	0.0	0.0	0.0
18	579.00	219.29	310.37	265.70	0.0	0.0	0.0	0.0	0.0	0.0
19	579.00	237.15	281.07	372.86	0.0	0.0	0.0	0.0	0.0	0.0
20	579.00	50.84	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MEAN	579.00	303.97	178.02	413.45	504.37	570.03	579.00	450.89	464.87	579.00
STD. DEV.	0.00	212.49	142.29	168.13	170.67	17.95	0.0	256.23	228.26	0.00
MAXIMUM	579.00	579.00	579.00	579.00	579.00	579.00	579.00	579.00	579.00	579.00
MINIMUM	579.00	18.06	10.10	182.70	121.19	543.10	579.00	66.54	122.47	579.00

IRRIGATED WHEAT ACREAGE

SCENARIO 2 AREA 1

SIMULATION	YEARS 1	2	3	4	5	6	7	8	9	10
1	204.91	0.0	38.86	25.43	0.0	0.0	0.0	0.0	0.0	0.0
2	204.91	204.91	183.83	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	204.91	168.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	204.91	364.13	193.96	68.13	25.43	25.43	25.43	68.13	25.43	68.13
5	204.91	68.13	68.13	204.91	68.13	204.91	204.91	0.0	0.0	68.13
6	204.91	25.43	0.0	68.13	68.13	0.0	0.0	0.0	0.0	0.0
7	204.91	68.13	57.94	353.96	0.0	0.0	0.0	0.0	0.0	0.0
8	204.91	0.0	136.66	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	204.91	462.12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	204.91	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	204.91	23.91	376.21	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	204.91	168.08	168.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	204.91	68.13	472.59	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	204.91	302.22	387.09	333.98	204.91	0.0	0.0	0.0	0.0	0.0
15	204.91	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	204.91	0.0	0.0	25.43	25.43	68.13	68.13	68.13	68.13	25.43
17	204.91	204.91	288.61	408.76	315.52	0.0	0.0	0.0	0.0	0.0
18	204.91	0.0	0.0	265.38	0.0	0.0	0.0	0.0	0.0	0.0
19	204.91	415.18	388.21	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	204.91	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MEAN	204.91	127.17	184.01	159.47	101.08	74.62	74.62	34.07	23.39	40.42
STD. DEV.	0.00	131.56	138.12	140.12	108.31	80.49	80.49	27.81	25.86	24.22
MAXIMUM	204.91	462.12	472.59	408.76	315.52	204.91	204.91	68.13	68.13	68.13
MINIMUM	204.91	23.91	38.86	25.43	25.43	25.43	25.43	68.13	25.43	25.43

IRRIGATED GRAIN SORGHUM ACREAGE

SCENARIO 2 AREA 1

SIMULATION	YEARS 1	2	3	4	5	6	7	8	9	10
1	0.0	127.26	123.64	46.58	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	14.66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	7.89	0.0	46.58	46.58	46.58	0.0	46.58	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	188.78	176.28	0.0
6	0.0	46.58	134.17	0.0	0.0	82.34	74.33	74.33	46.58	74.33
7	0.0	0.0	130.56	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	182.81	54.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	2.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	170.42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	145.31	5.76	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	162.83	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	173.43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	108.89	174.10	46.58	46.58	0.0	0.0	0.0	0.0	46.58
17	0.0	0.0	171.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	154.66	134.32	144.30	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	120.36	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	192.28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MEAN	0.0	65.96	62.40	47.33	13.31	32.23	30.23	65.78	67.36	30.23
STD. DEV.	0.0	64.41	59.31	52.99	19.21	30.10	27.16	71.19	65.13	27.16
MAXIMUM	0.0	192.28	174.10	162.83	46.58	82.34	74.33	188.78	176.28	74.33
MINIMUM	0.0	2.90	5.76	46.58	46.58	46.58	46.58	74.33	46.58	46.58

ENDING NET WORTH

MEAN	106981.625
STD. DEV.	77477.250
MAXIMUM	280271.188
MINIMUM	37108.625

INTERNAL RATE OF RETURN

MEAN	-0.120
STD. DEV.	0.291
MAXIMUM	0.285
MINIMUM	-1.148

PROBABILITY OF SURVIVAL

1	1.00
2	1.00
3	0.75
4	0.55
5	0.35
6	0.20
7	0.20
8	0.20
9	0.20
10	0.20

APPENDIX G

RISK AVERSION AND TENURE RESULTS OF THE COYANOSA MODELS

Table G-1. Cropping Patterns for Alternative Levels of Risk-Aversion, BASE Scenario, Coyanosa Models (COY1, COY2, COY3), 1978-87

Item	Units	Model[a]		
		COY1	COY2	COY3
Cotton Acreage:				
Mean	Acres[d]	460.3	287.0	573.3
Trend[b]	Percent	5.6	7.5	-0-
Wheat Acreage:				
Mean	Acres[d]	103.7	140.4	103.2
Trend[b]	Percent	-20.5	-12.2	-13.6
Grain Sorghum Acreage:				
Mean	Acres[d]	41.4	82.0	8.4
Trend[b]	Percent	21.7	-43.2	30.0
Total Crop Acreage[c]:				
Mean	Acres[d]	605.4	509.4	684.9
Trend[b]	Percent	0.5	1.0	-1.8
Dryland Acreage:				
Mean	Acres[d]	-0-	-0-	-0-
Trend[b]	Percent	-0-	-0-	-0-
Irrigated Acreage[c]:				
Mean	Acres[d]	605.4	509.4	684.9
Trend[b]	Percent	0.5	1.0	-1.8

[a]Alternative levels of risk-aversion are represented by the basic Coyanosa model (COY1), a more risk-averse model (COY2), and a less risk-averse model (COY3). These models are fully described in the text.
[b]Trend estimated as continuous rate of change.
[c]Does not include set-aside acreage.
[d]Land acres, not planted acreage.

Table G-2. Cropping Patterns for Alternative Tenure Situations, BASE Scenario, Coyanosa Models (COY1, COY4, COY5), 1978-87

Item	Units	Model[a]		
		COY1	COY4	COY5
Cotton Acreage:				
Mean	Acres[d]	460.3	529.6	503.2
Trend[b]	Percent	5.6	2.4	-0.1
Wheat Acreage:				
Mean	Acres[d]	103.7	54.1	171.9
Trend[b]	Percent	-20.5	-15.5	-1.6
Grain Sorghum Acreage:				
Mean	Acres[d]	41.4	3.7	71.1
Trend[b]	Percent	21.7	-0-	-6.9
Total Crop Acreage[c]:				
Mean	Acres[d]	605.4	587.4	746.2
Trend[b]	Percent	0.5	0.1	-0.5
Dryland Acreage[c]:				
Mean	Acres[d]	-0-	-0-	-0-
Trend[b]	Percent	-0-	-0-	-0-
Irrigated Acreage[c]:				
Mean	Acres[d]	605.4	587.4	746.2
Trend[b]	Percent	0.5	0.1	-0.5

[a]The alternative tenure situations are represented by both purchase and rental of land (COY1), rental only (COY4), and purchase only COY5). These models are fully described in the text.
[b]Trend estimated as continuous rate of change
[c]Does not include set-aside acreage.
[d]Land acres, not planted acreage.