ADJUSTMENTS IN A FARM BUSINESS IN RESPONSE TO
AN ENERGY CRISIS

by

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CHAPTER I

INTRODUCTION

The energy problem in the United States can be summarized by saying that at present prices the quantity of energy demanded domestically has exceeded the quantity domestically supplied. The growth of this domestic energy gap between the quantity supplied and quantity demanded for energy is illustrated by the following quotation from a recent preliminary report of the Ford Foundation Energy Policy Project.

> "From 1950 to 1973, U. S. energy consumption increased at an average annual growth rate of 3.5 percent, while domestic production rose more slowly at just under 3 percent. In the eight years after 1965, consumption raced ahead at 4.5 percent a year; but since 1970 growth in domestic production has been at a virtual standstill."[1/]

There have been many causes of this domestic energy gap. On the consumption side there have been increases in the use of high energy using transportation; manufacturing and agricultural technology; and home use items such as heating, appliances, and color television sets. Factors that have operated to limit domestic energy production are: environmental constraints, price regulations and controls which kept energy prices below what they would have been otherwise, and the foreign tax credit which encouraged oil companies to produce oil abroad

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[1/] Exploring Energy Choices. A Preliminary Report of the Ford Foundation's Energy Policy Project, The Ford Foundation, 1974.

rather than domestically.[1/] Another cause of the gap between the quantity supplied and quantity demanded for energy is that until the energy crisis occurred in 1973, energy was relatively inexpensive compared to other items. Although inflation caused energy prices to appear to be increasing during the 1960's, energy prices actually declined both in terms of constant dollars[2/] and relative to other goods.[3/] Past declining energy prices caused both an increase in the rate of consumption and a decrease in the rate of production of energy in the U. S.

If the energy problem is viewed as a "gap" between supply and demand, one might ask why we would not expect a new equilibrium of supply and demand to be reached at a higher price. ("Discouraging energy consumption and encouraging domestic production by raising the relative price of energy" is the stated overall aim of President Ford's administration energy program.)[4/] While letting the price of energy increase is a probable long range solution, there are several aspects of the energy problem which will act to slow down this process of supply/demand adjustment in the short run.

[1/] Ibid.

[2/] Landsberg, Hans H. "Low-Cost Abundant Energy: Paradise Lost?" Resources for the Future, Inc., 1755 Massachusetts Avenue, N. W., Washington, D. C., 1973.

[3/] Exploring Energy Choices. A Preliminary Report of the Ford Foundation's Energy Policy Project, The Ford Foundation, 1974.

[4/] Economic Report of the President, transmitted to the Congress February, 1975, United States Government Printing Office, Washington, 1975, p. 21.

First, energy consumption and production patterns do not change rapidly. Investments in high energy using equipment and energy inefficient construction are not easily reversed. In the short run, even at higher energy prices it may be less costly to use energy inefficient technology than to invest in new technology. Also, consumers probably will not immediately change their energy consumption habits. Thus, a large decrease in consumption cannot be expected until long run capital investment patterns and consumer habits have had time to adjust. On the energy production side, a similar time lag can be expected to occur. It will take time to develop energy sources that are presently available. It will also take time for research efforts to discover new energy resources. A recent blueprint for Project Independence, a program proposed by former President Nixon to reduce U. S. dependence on foreign oil and released by the Federal Energy Administration suggested that there would be little impact on domestic supplies of energy from research and development before 1985.[1/]

Second, there is uncertainty associated with both the price and availability of foreign energy. Since the 1973 price increases by the Organization of Petroleum Exporting Countries (OPEC) and the boycott placed on the U. S. by the OPEC's Arab members, there has been a strong drive in the U. S. "to reduce our dependence on imported petroleum

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[1/] Gillette, Robert, 'Energy "Blueprint" Sees Little R & D Impact Before 1985', Science, Vol. 186, p. 718, November 22, 1974 products."[1/] At the same time, it appears that energy imports must increase in the short run in order to achieve the projected consumption[2/] of energy in the U. S.[3/] The international interplay involved in the U. S. energy gap could work to keep the gap with us.

Third, there are income distributional and equity problems associated with increasing energy prices. Rising energy prices will tend to increase returns to present owners of energy sources while causing financial hardships for low-income and fixed-income families.[4/]

A fourth consideration is environmental effects of increased energy production. Many people feel that increased energy production can be expected to result in increased pollution and land spoilage.

A fifth factor that could hinder the "higher prices" solution from eliminating the energy gap is U. S. politics. Politicians know that voters are generally not happy about large price increases.

[1/]Bromley, Daniel W. "The Food System and Project Independence: Economic Issues and Research Opportunities," Paper presented to the annual meeting of the Western Agricultural Economics Association; Moscow, Idaho, July 26, 1974.

[2/]Most of the projections referred to were made "assuming relative and absolute price levels similar to those that existed prior to October, 1973."

[3/]Division of Agricultural Sciences University of California, A Hungry World: The Challenge to Agriculture, General Report by University of California Food Task Force, July, 1974, pp. 266-268.

[4/]Doering, Otto C. III, "Energy Policy Issues For Agriculture" Increasing Understanding of Public Problems and Policies - 1974, Farm Foundation, 600 S. Michigan Avenue; Chicago, Illinois, p. 46.

These five factors tend to complicate the energy problem and to make it unlikely that prices of energy will rise enough to eliminate the supply/demand energy gap in the short run.

This brief analysis is not meant to imply that rising energy prices is not the most probable long range solution for eliminating the energy gap; but it is meant to suggest that in light of the five factors of the energy problem that were mentioned above, we cannot expect the energy gap to be eliminated quickly.

Statement of Problem

A segment of the energy problem to which this research will be directed is, "How should a profit maximizing Virginia farmer adjust his farm business in response to circumstances which could occur as a result of the present domestic energy gap?"

This problem will be approached from a farm manager point of view. Thus, questions that an individual farm manager would need to answer will be considered.

Two general circumstances which might force a farmer to make adjustments in his farm business are: (1) an increase in the costs of energy related inputs relative to the costs of other inputs; (2) a decrease in the quantities of energy related inputs available. Each of these circumstances could cause a profit maximizing farm operator to make adjustments in his farm business.

While these circumstances will have impacts on all types of livestock and crop farming in Virginia, this study will concentrate on the impacts of these circumstances on the crop enterprises of a grade-A dairy farm. Thus, this study will provide an example of how a Virginia farm business might be adjusted.

Two distinguishing features of this research are that it will evaluate responses to the energy situation from the farm manager's point of view and that it will explore short run responses and adjustments. This "short run responses and adjustments" phenomenon is an area of research need recently discussed by Whittlesey and Butcher.[1/]

Purpose and Objectives

The general hypothesis of this study is that under energy crisis conditions, the income attained and the levels of energy inputs used will vary according to the method of tillage and the type of manure system.

The need for this type of study has been expressed by Virginia extension farm management specialists desiring answers for farmers who may be asking how they should respond to an energy crisis.

The purpose of this research is to meet the needs of farm managers as decision makers. This research could be called "conditional normative" as it will tell a decision maker what he sould do in order to maximize his returns to fixed resources in response to a given set of circumstances.

[1/] Whittlesey, N. K. and Butcher, W. R., "Energy Research Opportunities for Agricultural Economists," American Journal of Agricultural Economics, May, 1975.

The overall objective of this research is to provide information concerning alternative management adjustments to the circumstances which could occur as a result of an energy crisis. More specific objectives are to develop the following farm management models:

(1) A farm planning model that provides information about the optimum combination of crop enterprises, inputs, and output levels under circumstances of rising prices of energy related inputs relative to other inputs.

(2) A farm planning model that provides information about the optimum combination of crop enterprises, inputs, and output levels under circumstances of limited available quantities of energy related inputs.

(3) Farm planning models with the capacity to compare the expected income, crop enterprise levels, and energy usage resulting from alternative technologies. Specific technological alternatives which this study will consider are (a) the effects of a liquid manure system compared with a solid manure system, (b) the effects of using conventional tillage compared with reduced tillage.

Questions to be Answered

A general question which this study will consider is, "How can a farm operator adjust his farm business in response to different circumstances that may occur as a result of an energy crisis?" Some more specific questions related to the two different circumstances that could arise are as follows.

A. Given projected price increases of fuel, nitrogen fertilizer, and pesticides:

(1) How can a profit maximizing farmer adjust his farm business in terms of enterprise combinations and levels of input use?

(2) How will income be affected?

(3) How much will income change as a result of using the following alternative farming methods:[1/]

(a) Conventional tillage vs. reduced tillage?

(b) Solid vs. liquid manure systems?

(4) How will these alternative farming methods affect the total quantity of energy used and how will they affect the amounts of fuel, nitrogen fertilizer, and pesticides used?

(5) As price levels of energy inputs are increased will it be profitable to substitute reduced tillage for conventional tillage?

B. For decreases in the quantities available of energy related inputs:

(1) How can a profit maximizing farmer adjust his farm business in terms of enterprise combinations and levels of input use?

(2) How will income be affected?

(3) How much will income vary as a result of using the alternative farming methods listed above?

[1/] Pimentel, David, et al, "Food Production and the Energy Crisis," Science, Vol. 182, pp. 443-449, April 19, 1974.

(4) How will these alternative farming methods affect the total quantity of energy used; and how will they affect the amounts of fuel, nitrogen fertilizer, and pesticides used?

(5) As the quantities available of energy inputs are decreased will it be profitable to substitute reduced tillage for conventional tillage?

CHAPTER II

RELEVANT THEORY

Since the purpose of this study is to provide information concerning energy related management decisions, the relevant economic theory is "theory of the firm." Farm firm management involves the problem of seeking to consider a large body of information in order to arrive at rational, economic decisions. There are numerous, different ways to achieve certain quantities of inputs or outputs. There are also various limitations of the resource situation which a farm manager would need to consider. Because of these conditions, a linear programming (L. P.) model will be used. L. P. is a management technique which is especially useful for management problems which involve numerous alternatives and numerous resource limitations.

L. P. models are generally developed under the assumptions of linearity, divisibility, additivity, finiteness, and single-value expectations.[1&2/] Linearity means that it is assumed that the input/output and input/input ratios of the various productive processes are fixed and that they are independent of the amount of the output produced. The

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[1/] Heady, E. O. and Candler, W., Linear Programming Methods, The Iowa State University Press, Ames, Iowa, 1958, p. 17-18.

[2/] Dorfman, R., Application of Linear Programming to the Theory of the Firm, University of California, Berkeley California, 1951, pp. 80-81.

assumption of divisibility allows individual inputs and outputs to be expressed in terms of fractional units instead of in whole numbers only. Additivity means that the sum of the inputs or outputs of individual activities in a L. P. model is equal to the total amount of inputs and outputs found in the final solution. The assumption of finiteness means that the number of resource restrictions and productive processes which need to be considered is limited. Single-value expectations means that it is assumed that the exact value of numbers used in a L. P. model is known. These assumptions limit the complexity of certain firm management problems to the extent that they can be expressed and solved in a way that is "operationally meaningful."[1/]

L. P. models are "conditional normative" in that they tell a firm manager what he "ought" to do to achieve specified goals when he faces a set of specified circumstances.

There are three basic components in the mathematical representation of a L. P. model. These three components are the objective, the productive processes (also called activities), and the restrictions.[2/] The objective represents the goal which the firm is seeking to optimize, the processes represent alternative means which can be used to obtain the goal, and the restrictions state the limitations of the quantities of resources available to the firm or set other constraints on the

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[1/]Dorfman, R., Application of Linear Programming to the Theory of the Firm, University of California, Berkeley, California, 1951, p. 80.

[2/]Heady, E. O. and Candler, W., Linear Programming Methods, The Iowa State University Press, Ames, Iowa, 1958, pp. 2-4.

firm activities within which the firm manager may need or want to operate.

A concept which defines certain limits within which levels of inputs used in a productive process are normally allowed to vary is the law of diminishing marginal physical returns. The marginal physical product (MPP) is defined as the amount of output resulting from a unit increase in the amount of a variable input while holding the amounts of all other inputs constant. The law of diminishing marginal physical returns explains how the MPP changes in response to incremental increases in the level of a variable input. This law can be illustrated using the classical production function and associated MPP and average physical product curves (see Figure 1). As the amount of one variable input is increased (starting at a level of zero and holding all other inputs constant), initially the MPP will be positive and increasing then the MPP will be positive but decreasing, and finally a point will be reached after which the MPP will be negative. The production function can be divided into three stages as illustrated in Figure 1. Economic theory tells us that a rational producer will use a quantity level of variable inputs in a productive process such that he is operating in stage II on his production function. For purposes of this research it is generally assumed that the crop enterprise productive processes used in the L. P. model are at input levels placing them in stage II.

Assuming a profit maximization problem, the L. P. problem can be expressed mathematically as follows:

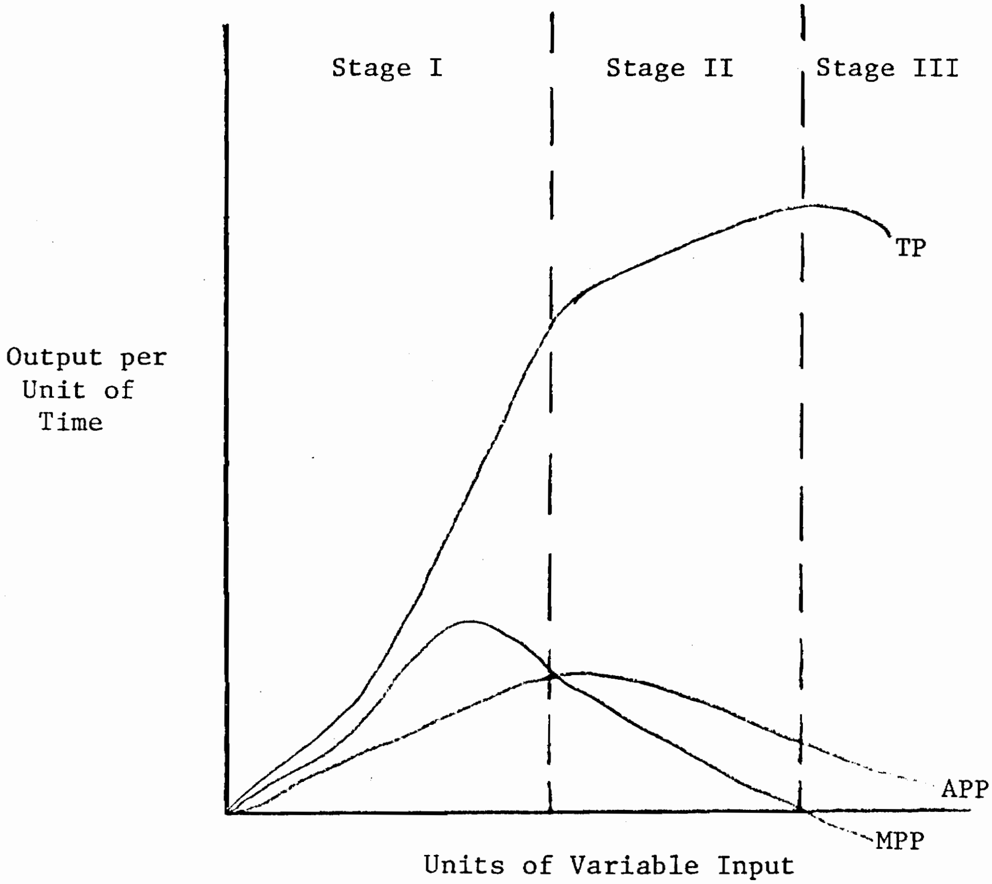

Figure 1. Illustration of Stages of Production Using Classical Production Function and Associated Marginal Curves.

$$
\begin{aligned}
\text{Maximize:} \quad & f = c_1x_1 + c_2x_2 + \dots\dots\dots\dots\; c_nx_n && (1)\\
\text{Subject to:} \quad & a_{11}x_1 + a_{12}x_2 + \dots\dots\dots\; a_{1n}x_n \leq b_1 && (2)\\
& a_{21}x_1 + a_{22}x_2 + \dots\dots\dots\; a_{2n}x_n \leq b_2 && (3)\\
& \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots && \\
& a_{m1}x_1 + a_{m2}x_2 + \dots\dots\dots\; a_{mn}x_n \leq b_m && (4)\\
& x_i \geq 0 \; (i=1, \dots\dots\; n) && (5)
\end{aligned}
$$

where (1) represents the objective to be maximized; (2), (3), and (4) represent the constraining rows; and each column containing an x_i represents a productive process. Statement (5) restricts the levels of the processes to nonnegative values. The c, a, and b values represent respectively the amount of profit for a process, the level of inputs required by a process, and the numerical restrictions placed on the model. Note that the linear inequalities (2), (3), (4)--which are maximum restrictions in this example--could also be equalities or minimum restrictions depending on the nature of the problem.

Baumol[1/] (and many others) have illustrated graphically the theory of a single product firm. Assume the problem is to maximize profits on a grade-A dairy farm with two feed restrictions: available grain and roughage (expressed in corn equivalents and hay equivalents respectively), and three feeding processes: low grain and high roughage, medium grain and medium roughage, and high grain and low roughage. The two restrictions can be represented by the vertical and horizontal axis in a

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[1/] Baumol, W. J., Economic Theory and Operations Analysis, Third Edition, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1972, pp. 294-312.

two-dimensional diagram. The three processes can be represented as rays through the origin (see Figure 2). The maximum quantity of grain and roughage available are OY and OX respectively. So the rectangle OXSY is the feasible region for this problem. The kinked line $a_1a_2a_3$ depicts an iso-product line or isoquant representing 5000 pounds of milk, which can be produced by alternative quantities of hay and corn. The lines $b_1b_2b_3$ and $c_1c_2c_3$ are also iso-product lines. The point S represents the maximum production of milk attainable in this case because it is the point of intersection of the highest iso-product line attainable with the feasible region.

It should be noted that even though all three processes in Figure 2 are expressed as linear relationships, the assumptions of L. P. do not imply constant marginal returns. To illustrate this concept, if the quantity of hay equivalent is fixed at 1,000 tons (line DG), note that it takes increasing amounts of corn equivalent to get the same increase in the amount of milk. That is, with the supply of roughage fixed at 1,000 tons, to go from 5,000 pounds of milk production to 10,000 pounds requires an additional 1,800 bushels of grain, while the next step from 10,000 pounds of milk to 15,000 pounds requires an additional 2,900 bushels of grain. Thus, diminishing returns is illustrated as it is taking larger increases in the amount of grain to achieve the same increase in the amount of milk.[1/]

1/This paragraph imitates a discussion found in Swanson, E. R., "Programming Optimal Farm Plans," Farm Size and Output Research; a Study in Research Methods, Southern Cooperative Series Bulletin No. 56, June 1958, pp. 48 and 49.

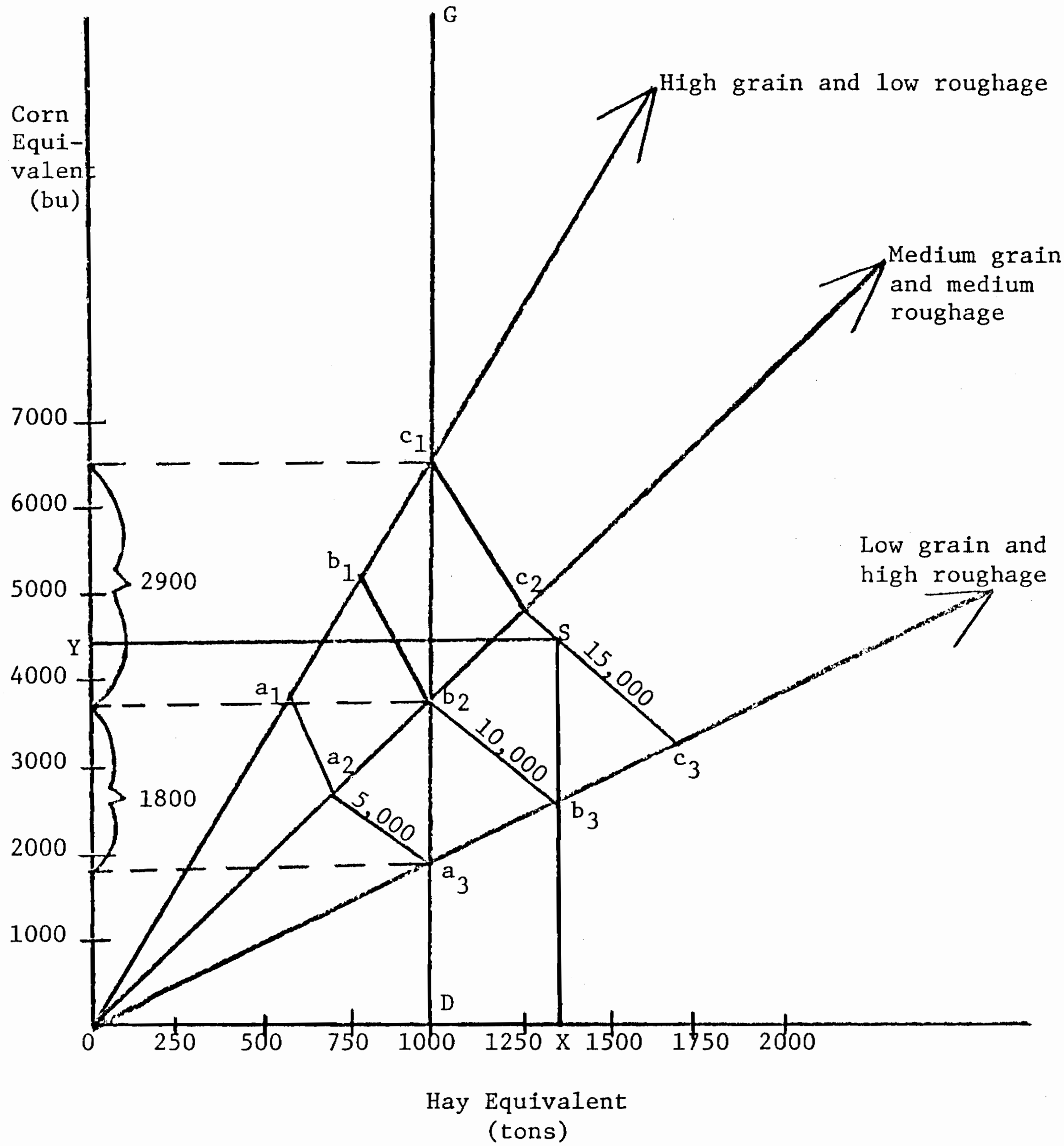

Figure 2. Illustration of L. P. Optimal Solution and Diminishing Returns.

It might be possible that using only one process, low grain and high roughage, might be the least cost method of producing low quantities of milk. However, using only low grain and high roughage might not maximize profits because it may be possible to produce a higher output with greater difference between product value and input costs by using a different combination of grain and roughage.

Henderson and Quandt[1/] define the rate of technical substitution (RTS) as the negative of the slope of the tangent to a point on an isoquant. This slope is the rate at which one input must be substituted for another in order to maintain the same output level. The RTS at a point on an isoquant is equal to the ratio of the marginal physical products of the two inputs. Given two variable inputs such as grain and roughage, economic theory tells us that the optimum combination of these inputs on a given iso-product curve is at input levels where the RTS is equal to the ratio of the prices of the inputs.

How to locate the profit maximizing level of production could be illustrated by referring back to Figure 2. The optimum combination of inputs for each isoquant is located at the point on the isoquant where the RTS is equal to the ratio of the prices of the two inputs. The locus of these optimum input combination points is called the expansion path. The profit maximizing level of production is located on the expansion path at the point where the level of each input used is such that the value of the marginal physical product of each input is equal

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[1/] Henderson, J. M., and Quandt, R. E., Microeconomic Theory, Second Edition, McGraw-Hill Book Company New York, New York, 1971.

to the price of the input (if this point is within the feasible region). In order to illustrate this profit maximizing level of production on Figure 2, the price of milk and the costs of the inputs could be used to locate points of equal amounts of profit on each process ray. Iso-profit lines could be drawn similar to the iso-product lines. Then the profit maximizing level of production would be a point on the expansion path, and on the highest iso-profit line attainable by the feasible region.

CHAPTER III

LITERATURE REVIEW

Energy in Agricultural in General

Various articles have been written relating the energy crisis to agriculture. The Steinharts[1/] have analyzed energy use in the total U. S. food system. Pimentel, et al,[2/] and Heichel and Frink[3/] have specialized in analysis of energy uses on the farm and have made some suggestions for energy conservation. Frank[4/] quantified energy usage in milk production on an example dairy farm.

In my opinion, a weakness of the studies of Pimentel, Heichel and Frink, and the Steinharts is that they discuss energy uses in terms of a common denominator such as kilocalories. Frank discusses electricity in terms of kilowatt hours per cow and liquid fuel in terms of gallons

[1/] Steinhart, J. S. and C. E., "Energy Use in the U. S. Food System," Science, Vol. 184, pp. 307-316, April 19, 1974.

[2/] Pimentel, D., et al, "Food Production and the Energy Crisis," Science, Vol. 182, pp. 443-449, November 2, 1973.

[3/] Heichel, G. H. and Frink, C. R., "Anticipating the Energy Needs of American Agriculture," Journal of Soil and Water Conservation, pp. 48-53, January-February 1975.

[4/] Frank, G. G., "Direct Energy Use in Milk Production: Methodology and Coefficient," Paper presented at the American Agricultural Economics Association meetings at Columbus, Ohio, August 1975.

per cow. As Castle[1/] has pointed out "The reduction of all energy to a common denominator ... overlooks the differing capacity of varying energy sources to serve the interests of mankind." Batie,[2/] in response to a Heichel paper presentation, stressed the importance of societies "value system" of inputs and outputs and observed that "farmers are attempting to maximize income, not energy output."

Similar Studies

Eidman, Dobbins, and Schwartz;[3/] Raikes and Harris;[4/] and Forester and Rask[5/] have done energy related studies using specified farming situations.

The findings of Eidman, Dobbins, and Schwartz, for irrigated farms in the high plains area of Oklahoma indicated that "adaption of certain

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[1/] Castle, E. N., "Discussion," Paper presented in a session entitled "Recent Resource Problems of Less Developed Countries," American Journal of Agricultural Economics, May 1975.

[2/] Batie, S. S., "Discussion of G. H. Heichel's presentation of 'Agricultural Production and Energy Resources'", Presented at College of Agriculture and Life Sciences Colloquia on January 23, 1975 at Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

[3/] Eidman, V.; Dobbins, C.; and Schwartz, H., "The Impact of Changing Energy Prices on Net Returns, Production Methods and Kilocalories of Output for Representative Irrigated Farms," Paper presented at the American Agricultural Economics Association meetings at Columbus, Ohio, August 1975.

[4/] Raikes, R. and Harris, D. G., "Corn Prices, the Fuel Shortage and Optimal Corn Harvesting Strategies," Southern Journal of Agricultural Economics, July 1974, pp. 241-245.

[5/] Forster, D. L. and Rask, N., "Short-run Corn--Soybean Production Decisions With Variable Energy and Product Prices," Paper presented at the American Agricultural Economics Association meetings at Columbus, Ohio, August 1975.

reduced tillage cropping programs will increase the level of fossil fuel inputs used" but also "result in relatively greater increases in net returns." Their analysis also suggested the "hypothesis that relatively little change in tillage practices will occur unless fuel prices increase by about fifty percent."

In his M.S. research, Schwartz[1/] also found that "when maximizing the net kilocalories of energy a large negative net return is associated with the results."

The Raikes and Harris study entitled "Corn Prices, the Fuel Shortage and Optimal Corn Harvesting Strategies" suggests that "given higher corn prices and no rationing of propane, propane use for corn drying would increase sharply, even with much higher propane prices."

Forster and Rask analyzed a "typical" Ohio corn belt farming situation. Their study entitled "Short-Run Corn--Soybean Production Decisions With Variable Energy and Product Prices" concluded that "at recent price ranges of 2.50 and 3.50 dollars per bushel for corn and 20 to 40 cents per pound for nitrogen, application rates of nitrogen on corn are not greatly affected" and that "changing nitrogen prices, however, do have an impact on the proportion of cropland in corn."

[1/] Schwartz, H. J., "An Economic Analysis of Energy Use and Agricultural Output for Representative Farms in the Oklahoma Panhandle," M.S. Thesis, Oklahoma State University, Stillwater, 1975.

Wittmuss, Olson, and Lane[1/] found that "substantial fuel savings are possible nationally by using minimum tillage practices for row crop production." The difference in fuel usage in this study was due to fewer machinery operations in reduced tillage preharvest practices.

There is an article by Walker[2/] in which he attempted "to quantity the on-farm energy inputs in crop production." This article contains a lot of information about the amount of energy used for various inputs and various farm machinery operations. Walker found that fertilization was often the largest energy using input. Walker also pointed out the importance of analyzing the total operation when making an analysis of the energy inputs used in crop production.

There have been numerous farm management studies in Virginia which used L. P. models on a specified resource situation.

Reynolds and Kline[3/] used a L. P. model of a typical resource situation "selected from data collected on 17 grade-A dairy farms located in the Roanoke-Franklin-Henry County area of West Central Virginia." They investigated feeding alternatives and three different levels of milk production per cow.

[1/]Wittmuss, H., Olson, L., and Lane, D., "Energy Requirements for Conventional Versus Minimum Tillage," Journal of Soil and Water Conservation, March-April 1975, pp. 72-75.

[2/]Walker, J. N., "Energy Usage in Crop Systems," Energy in Agriculture, Proceedings of Conference-Workshop in Atlanta, Georgia, October 1-3, 1975, Southern Regional Education Board, 130 Sixth Street, N. W., Atlanta, Georgia 30313, pp. 42-50.

[3/]Reynolds, R. K. and Kline, R. G., "Reducing Cost on Selected Grade-A Dairy Farms," Technical Bulletin 163, Virginia Agricultural Experiment Station, Blacksburg, Virginia, June 1963.

Walker, Kline, and Arnold[1/] used a L. P. model to evaluate farm adjustment opportunities on a typical flue-cured tobacco farm in Southside Virginia. An initial "basic optimum plan" was developed for the typical farm. Then "other plans were derived to determine the effects on: (1) farm net revenue to fixed factors, and (2) enterprise combinations when the amount of an important resource was increased or decreased or the net revenue to a major enterprise was changed."

Huffman and Kline[2/] used a L. P. model to evaluate forage systems for grade-A dairy farms. Their research implied that "farmers could increase profits by more intensive use of cropland for forages such as corn silage and alfalfa haylage."

Vaughn, Hughes, and Smith;[3/] and Holter[4/] have recently completed energy related studies at Virginia Polytechnic Institute and State University.

[1/] Walker, H. W., Kline, R. G. and Arnold, C. J., "Farms Adjustment Opportunities Southside Virginia," Technical Bulletin 150, Virginia Agricultural Experiment Station, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, May 1961.

[2/] Huffman, C. L. and Kline, R. G., Evaluation of Forage Systems Including Gas-Tight Silos For Dairy Farms, Research Division Bulletin 57, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061, October 1970, p. 1.

[3/] Vaughn, D. H., Hughes, H. A., and Smith, E. S., "Effects of No-Tillage Practices on the Energy Requirements for Corn Production in Virginia," Paper presented at the 1976 Southeast Region Meeting American Society of Agricultural Engineers, Civic Auditorium, Mobile, Alabama, February 1-4, 1976.

[4/] Holter, J. B., "Revolutionary Concepts in Energy Management - Dairy Cattle," Paper presented at 30th Virginia Feed Convention and Nutrition Conference, Williamsburg, Virginia, February 20, 1976.

Vaughn, et al, compared energy requirements of no-tillage and conventional tillage corn in Virginia. They found that "no-tillage offers potential energy savings as well as better labor efficiency with increased crop yields." Energy savings in this study were due to fewer machinery operation when reduced tillage was used.[1/]

Holter's paper summarized the quantities of "major fossil fuel inputs" used in producing dairy feed. He concluded that "it appears ... that efficient handling of manure from the cow to the field and judicious use of manure nitrogen to spare chemical (manufactured) nitrogen offer the most significant potential for conservation of fossil fuel on most dairy farms."

[1/] The terms "no-tillage" and "reduced tillage" are used interchangably in this paragraph.

CHAPTER IV

PROCEDURES

A. Description of the Model

In order to answer the questions set forth in the problem statement, a L. P. farm planning model was developed for a representative farm. Grade-A dairy was chosen as the type of farm.

Three reasons why grade-A dairy was selected as the type of farm to use in this analysis are: First, grade-A dairy farms are more homogeneous throughout the state and are more widely distributed throughout the state than other major types of farming in Virginia. Information related to grade-A dairy farming would have a broader geographical application than information related to most other types of farming. Second, due to dairy cooperatives and government price controls, grade-A dairy farming faces a more stable marketing situation than other major types of farming. Because of this stability, the price used for the primary output of a grade-A dairy farm (that is, the price for milk) will more nearly reflect the statewide price. Third, since the use of manure as a substitute for commercial nitrogen fertilizer is an area of interest for potential energy savings, a farm with both crop and livestock activities was desired.

Due to differences in yields and levels of input use for crops in different areas of the state, Botetourt County was chosen as the location of the representative farm. A particular county was chosen so that yield and input data could be better specified. Sources of these data were written and verbal estimates of agricultural scientists. An attempt was made to set up a model that would represent a typical grade-A dairy farm during the next few years. Yields and input levels and cultural practices generally recommended by the College of Agriculture and Life Sciences at Virginia Polytechnic Institute and State University were used. In general, the prices used represent projected 1976-80 prices expressed in 1976 dollars.

The assumptions of a L. P. model imply a certain fixed level of managerial ability. The input/output data and recommended practices used in this study imply an above average level of managerial ability.

As mentioned previously in the theory chapter, three basic components of a L. P. model are the objective, the productive processes or activities, and the restrictions. These three components can be used as an outline to explain the details of how the model used in this research was constructed.

The Objective

The objective function was to maximize returns to fixed resources. Since the purpose of this research is to evaluate short run adjustment alternatives; the number of cows, amount of land, on-farm labor, machinery, buildings, and equipment were considered fixed. Numbers in the objective function for the dairy enterprises were net returns to fixed resources and feed (see Dairy Budgets, Appendix B, Tables 1 and 2).

The other numbers in the objective function represent the negative returns (i.e., costs) associated with producing feed, buying feed, or hiring labor.

The Activities

The activities can be divided into three groups -- the dairy budgets, the crop budgets, and the buying activities.

a. Dairy Budgets

There are two different dairy budgets, one representing a dairy enterprise with a solid manure system and the other representing a dairy enterprise with a liquid manure system.

Details which these two budgets have in common are as follows. Both represent a one-year costs and returns summary of a grade-A dairy in dry lot with 100 cows and 15,000 pounds average yearly production of milk. Included in the receipts of both budgets are the sales of cull animals and calves and a credit for fertilizer nutrients furnished in the manure produced by the cows. The only feed costs included in the budgets are salt and minerals, milk replacer, and calf starter. The major feed costs for the dairy enterprises are charged to the crop activities. There is no charge for labor as on-farm labor is considered to be a fixed resource. Only variable expenses are included in these budgets. The returns figure represents returns to fixed resources and feed (with the exception of the minor feed items mentioned above which are included in the budgets).

The price of milk used ($9.42/cwt) was the average price received for 1975 as of November 1975 according to Virginia Dairy Herd Improvement Association Records.[1/]

The two dairy budgets differ in that the liquid manure systems furnishes more fertilizer nutrients and has higher repair costs. The dollar total of these two differences causes the liquid manure system to be more profitable in terms of variable costs.[2/]

b. Crop Budgets

The crop budgets were generated using the Virginia Polytechnic Institute and State University version of the Oklahoma State University Crop Budget Generator.[3/] Only the variable costs for each budget were included in the L. P. model. However, fixed costs information is included in the budgets shown in Appendix D. Information about operating inputs, amounts and types of fuel used, the amount of labor used, cash expenses, and machinery costs are also included in Appendix D and E. The fuel information was used directly in the L. P. model. Other information related to variable costs was included in the variable costs

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[1/]Patterson, W. N., "Dairy Guidelines," Series 375, November 1975, Virginia Dairy Herd Improvement Association Program Summary, 1965-75, Extension Division, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

[2/]Note that this initial investment costs of the liquid manure system are higher. See Appendix A, Table 3.

[3/]Tsang, C. S. and Brant, W. L., "Users Manual of OSU Crop Budget Generator, V.P.I. & S.U. Version," Department of Agricultural Economics, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, April 1975.

figure used in the L. P. matrix. Labor costs were not included in the budgets because on-farm labor is considered a fixed resource. Fertilizer was charged to the crop budgets even though substantial amounts were transferred from the dairy activity in the L. P. model.

Crops for which crop budgets were generated included alfalfa hay, alfalfa silage, orchard grass/red clover hay (mixed hay), corn grain, corn silage, wheat grain, pasture, and a corn silage/barley silage double crop. Yields for the silage budgets are expressed on an "as fed" basis and assume storage lesses of 8 percent. Budget titles were used to designate the crop, yield, type of land, and method of tillage. Multiple budgets were prepared for most of the crops to reflect differences in type of land or method of tillage (or both). For example, the following four budgets were prepared for corn grain; corn grain on land A using conventional tillage, corn grain on land A using reduced tillage, corn grain on land B using conventional tillage, corn grain on land B[1/] using reduced tillage (see Appendix D, Tables 1-21).

The only crops for which both reduced and conventional tillage budgets were prepared were corn grain, corn silage, and the double crop which contained corn silage.

In the budgets used for this study, an attempt was made to set fertilizer and pesticide usage at levels which represent practices generally recommended by extension personnel at Virginia Polytechnic

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[1/] The meaning of land A and B will be explained in the restrictions section.

Institute and State University. Yields were set at levels considered to be typical for these practices. A question that could be raised about using these types of budgets to study usage of energy related inputs is "as the costs and quantities available of the energy inputs are varied, would it be profitable to reduce the quantities of inputs used and achieve a lower yield?" In order to explore this question, two special budgets were developed by taking the budgets for corn silage on land A using reduced and conventional tillage and reducing the amounts of nitrogen and pesticides by 67 percent and reducing the yields by 40 percent (see Appendix D, Tables 7 and 10).

The reduced corn tillage budgets had higher yields, higher quantities of fertilizer used, higher quantities of pesticides used, and lower amounts of tillage machinery used than the conventional corn tillage budgets.

Specific differences in machinery operations used for conventional corn tillage and machinery operations used for reduced corn tillage are as follows: (1) a stalk shredder was used for corn grain when conventional tillage was used, but not when reduced tillage was used; (2) once-over plowing and disking were used for corn planting when conventional tillage was used, but not when reduced tillage was used; (3) slightly more sprayer time was used with reduced corn tillage; and (4) once-over fertilizer spreading and disking were used for a cover crop when reduced tillage was used, but no cover crop was planted when conventional tillage was used.

Once-over plowing, disking, planting with a grain drill, and fertilizer spreading were used for the barley silage in all of the double crop budgets.

On farms of this size it is probably expected that some of the larger pieces of machinery would be custom hired rather than owned. However, for purposes of this research it is assumed that all machinery used is owned. This assumption was made because it seemed to facilitate the gathering of information concerning fuel usage.

c. Buying Activities

Buying activities included buying labor and buying feed. Labor was divided into four time periods according to season. The periods were December/January/February/March, April/May, June/July/August, and September/October/November. Labor could be hired in any of these four periods if additions to on-farm labor were needed and profitable. Feed which could be bought included soybean meal, corn grain, alfalfa hay, and orchard grass/red clover hay. A grinding and mixing activity was included to cover the costs of grinding and mixing corn grain.

Restrictions

Restrictions associated with the general farm operation include cows, land, labor, and feed.

The capacity of buildings and equipment was assumed to be 100 cows so the number of cows was fixed at 100.

The average amount of open land for 60 grade-A dairy farms which participated in the Virginia Polytechnic Institute and State University farm account system in 1973[1/] was 288 acres. When adjustments were made for a herd size of 100 cows and for the level of management used in this study, the amount and types of land used were as follows: (1) land suitable for continuous row crops using conventional tillage, 46 acres, designated land A; (2) land suitable for rotational row crops using conventional tillage, 95 acres, designated land B; (3) land suitable for hay crops but not for row crops, 19 acres designated land C; (4) land suitable for pasture only, 130 acres, designated land D.

The lactating cows were assumed to be on dry lot for the initial farm planning models. The amount of pastureland needed to meet the dry matter feeding requirement of the replacements and dry cows during the seven months pasture was considered available was 130 acres (see Pasture Budget, Appendix D, Table 17).

There were two other restrictions associated with land use. There was a row crop restriction which limited to 32 acres the amount of land which could be used for the total of conventional tillage corn and reduced tillage double crop corn grown in any one year on land B. This restriction was used because it was considered to be an unwise management practice to grow these crops on the same B land more often than one out of every three years. Then there was a pasture restriction which restricted the type of land which could be used for pasture to land D only.

[1/] Reynolds, R. K., "Farm Account Analysis; Aggregates of Farm Business Accounts by Farm Types in Extension Districts 1973," MB-214, Department of Agricultural Economics, Virginia Polytechnic Institute and State University Farm Account System, November 1974.

This pasture restriction was relaxed for part of the analysis in which energy inputs were restricted.

On-farm labor was restricted to 6,500 hours per year which is the amount of labor furnished by 2½ men working 50 hours per week for 52 weeks. This labor availability was considered to be evenly distributed throughout the year. Note that the labor restriction was a conditional restriction because, as mentioned earlier, additional labor could be hired (at $2.25/hour) if it were profitable.

The only other farm operation restriction was that enough feed had to be provided to feed the 100 cow herd. This restriction was included in the L. P. model by setting minimum limits on the amount of dry matter and crude protein needed by the 100 cow herd[1/] and by setting a high and low range for crude fiber. These feeding requirements were met by the transfer of feed nutrients in the form of dry matter, crude protein, and crude fiber from the crop growing and buying activities to the dairy activities. Dairy herd feeding information is summarized in Appendix C.

Crop machinery and capital were not considered restrictive.

B. Explanation of Analysis

Once the initial L. P. matrix was set up with the objective, activities, and restrictions as explained above, the analysis was accomplished as follows.

[1/] Requirements for the 100 cow herd included requirements for the lactating cows, dry cows, and replacements.

There were actually five different analyses using five different combinations of manure handling and corn tillage. This could be thought of as five farms with similar resource situations, but different manure-corn tillage combinations. The five different combinations of activities were (1) a farm with a solid manure system which used conventional corn tillage, (2) a farm with a solid manure system which used reduced corn tillage, (3) a farm with a liquid manure system which used conventional corn tillage, (4) a farm with a liquid manure system which used reduced corn tillage, (5) a farm which could use either a solid or liquid manure system and could use either or both conventional or reduced corn tillage.

There were two different variations in the situation facing the operator which were applied to each of the five farms (i.e., the five manure-corn tillage combinations). These variations were an increase in the cost of certain energy related inputs and a decrease in the supply of these inputs. The inputs whose supplies and costs were varied were gasoline, diesel fuel, liquid petroleum gas, nitrogen fertilizer, atrazine, paraquat, furadan, and sevin. These inputs will be called "energy inputs" for the rest of this discussion.

An initial L. P. run was made with costs of the energy inputs at what was considered 1976 levels and with the energy input restrictions at quantity levels which were not restrictive.

The budget generator and L. P. procedures with a change row were then used to run the analysis with the costs of energy inputs increased by 25, 50, 75, and 100 percent.[1/]

The supplies of energy inputs were restricted as follows. The quantity restrictions on the energy inputs were initially set at levels which were slightly higher than their highest level of use. This was done so that these quantity levels would not be restrictive in the initial L. P. run. These energy input levels were multiplied by .2 to set up a change column in the L. P. matrix similar to the change row used earlier to vary the objective function. L. P. procedures were then used to decrease the quantities available of the energy inputs by 20, 40, 60, and 80 percent. The model was run with each decrease in supplies.

Two other changes were made in the model for the analysis in which quantities of energy inputs were restricted.

First, the pasture restriction was relaxed so that pasture could be used to feed the lactating cows, and so that cropland (i.e., land A, B, and C) could be used for pasture if it were profitable. A 35 dollar per acre charge was placed on all cropland which was transferred to pasture use. This charge represents pasture establishment costs.

Second, a 25 percent increase in purchased feed costs was added for each 20 percent decrease in the quantities of energy inputs.

[1/] Note that an increase in the fuel prices automatically increases the machinery lubricant costs because the budget generator calculates lubricant costs as 15 percent of the fuel costs. See Kletke, D. D., "Operations Manual For the Oklahoma State University Enterprise Budget Generator," Research Report P-719, Agricultural Experiment Station, Oklahoma State University, June 1975, p. 24.

These two changes were added to the model when quantities of energy inputs were decreased because it was thought that farm operators would probably pasture their cows if an energy shortage limited their crop activities, and it was also thought that an energy shortage situation would be accompanied by increases in the prices of purchased feed.

Various count rows were included in the model to sum energy usage in terms of costs, quantities of individual inputs, kilocalories, and gasoline equivalents. The pesticide 2, 4, D which was used on the pasture was included in the count rows but its supply and cost were not varied.

Count rows were also added to provide information about quantities of different types of feed used and annual costs.

A picture of the L. P. matrix and an explanation of the meaning of the rows and columns is included in Appendix F.

CHAPTER V

RESULTS

Initial Models

As mentioned in the procedures chapter, farm planning models were developed for 100-cow grade-A dairy farms with similar general resource restrictions using five different combinations of manure systems and corn tillage methods. These five different combinations were (1) a farm with a solid manure system which used conventional corn tillage, (2) a farm with a solid manure system which used reduced corn tillage, (3) a farm with a liquid manure system which used conventional corn tillage, (4) a farm with a liquid manure system which used reduced corn tillage, and (5) a farm which could use either a solid or liquid manure system and could use either or both conventional or reduced corn tillage.

Crops

For each situation the optimum combination of crops was determined with costs of the energy inputs at what was considered 1976 levels and with the energy input restrictions at quantity levels which were not restrictive. Results of this initial analysis are summarized in Table 1.

The major difference in the crop systems between the two different methods of tillage was in the amount and type of grain produced and purchased. When reduced tillage only was used 5,790 bushels of corn grain was produced, no corn grain was purchased, and no wheat grain was

Table 1. Initial Models for a Hundred-Cow Dairy With Alternative Manure and Tillage Systems - Summary of Returns and Crops.[a]

Item	Units	Liquid[b] CT & RT	Solid CT	Solid RT	Liquid RT	Liquid CT
Returns to fixed resources	$	88,160	82,657	84,602	87,498	85,553
Crops produced (types)						
Corn grain	Bu.	4,934	--	5,790	5,790	--
Wheat grain	Bu.	--	1,869	--	--	1,869
Corn silage	Ton	1,100	922	918	918	922
Barley silage	Ton	135	206	206	206	206
Alfalfa silage	Ton	--	46	50	50	46
Alfalfa hay	Ton	46	46	46	46	46
Crops produced (activities)[c]						
Wheat grain, land B[d]	Acre	--	53	--	--	53
Corn silage, CT, land A	Acre	45	46	--	--	46
Corn silage, CT, land B	Acre	11	--	--	--	--
Alfalfa silage, land B	Acre	--	10	11	11	10
Alfalfa hay, land C	Acre	19	19	19	19	19
Pasture, land D[e]	Acre	130	130	130	130	130
Double crop,[f] CT, land B	Acre	21	32	--	--	32
Corn grain, RT, land A	Acre	1	--	46	46	--
Corn grain, RT, land B	Acre	50	--	5	5	--
Corn silage, RT, land B	Acre	13	--	47	47	--
Double crop, RT, land B	Acre	--	--	32	32	--
Crops purchased						
Soybean meal	Cwt.	1,864	1,571	1,668	1,668	1,571
Corn grain	Bu.	--	4,002	--	--	4,002

[a]Costs of inputs in the initial model were considered to be at 1976 price levels. A detailed list of these prices is included in Appendix A, Table 1.

[b]Liquid and solid refer to type of manure system, and CT and RT refer respectively to conventional and reduced corn tillage.

[c]Detailed budgets for these activities can be found in Appendix D.

[d]Types of land are defined as follows:
Land A - land suitable for continuous row crops using conventional tillage.
Land B - land suitable for rotational row crops using conventional tillage.
Land C - land suitable for hay crops but not for row crops.
Land D - land suitable for pasture only.

[e]Pasture was restricted to land D and used for replacements and dry cows only.

[f]Double crop refers to barley silage followed by corn silage grown on the same land during a one year period.

produced. When conventional tillage only was used no corn grain was produced, 4,002 bushels of corn grain was purchased, and 1,869 bushels of wheat grain was produced. There were not large differences in the amounts of corn silage and alfalfa silage produced or in the amount of soybean meal purchased. Identical amounts of barley silage and alfalfa hay were produced.

The optimum combination of crops for the farm organization which used both methods of corn tillage was similar to the farms which used only reduced corn tillage in that a large quantity of corn grain was produced (4,934 bushels), no corn grain was purchased, and no wheat grain was produced. The crop combination for the farm using both methods of corn tillage was different from the farm organizations using only one method of corn tillage in that when both methods of corn tillage were used, more corn silage was produced, less barley silage was produced, and no alfalfa silage was produced.

There were no differences in the optimum combination of crops between the two manure systems.

Returns[1/]

Farm organizations using reduced corn tillage had returns 1,945 dollars higher than farms using conventional corn tillage (Table 1).

[1/] Note that returns in this discussion refers to returns to fixed resources, including 100 dairy cows, land, buildings, livestock and crop system machinery and equipment, manure system, and on-farm labor.

The farm organization with the highest returns used a liquid manure system and both methods of corn tillage. This farm's returns were 662 dollars higher than the farm organization which used a liquid manure system and reduced corn tillage only, which had the second highest returns.

Returns for farms with a liquid manure system were 2,896 dollars higher than returns for farms with a solid manure system.

Energy Use

The results of the quantities and costs of energy inputs used by the initial analysis of the five farm organizations are summarized in Table 2.

Farm organizations using reduced corn tillage were higher energy users than farm organizations using conventional corn tillage. There was a 3,971 dollar difference in energy input costs and a difference of 1,882 gallons of gasoline equivalents (GEQ) between the two methods of tillage. As compared to farms with reduced corn tillage, farms with conventional corn tillage used less of each energy input except diesel fuel.[1/] However, on the basis of dollars of returns to fixed resources per energy used, farms using conventional corn tillage used energy with greater technical efficiency than farms using reduced corn tillage (see

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[1/]All farm organizations used identical amounts of 2, 4, D as pasture was the only crop on which 2, 4, D was used and pasture acreage was identical for all the farm organizations.

Table 2. Initial Models for a Hundred-Cow Dairy with Alternative Manure and Tillage Systems - Summary of Energy Inputs Used.

Item	Units	Liquid[a/] CT and RT	Solid CT	Solid RT	Liquid RT	Liquid CT
Energy inputs						
Gasoline	Gal.	171	96	178	178	96
Liquid petroleum gas	Gal.	988	---	1,159	1,159	---
Diesel	Gal.	1,176	1,401	1,170	1,170	1,401
Atrazine	Lb.	353	195	326	326	195
Paraquat	Pt.	64	---	131	131	---
Furadan	Lb.	644	---	1,306	1,306	---
Sevin	Lb.	32	---	65	65	---
2, 4, D[b/]	Lb.	65	65	65	65	65
Nitrogen purchased[c/]	Lb.	14,766	14,023	18,634	15,118	10,507
Summary of energy costs	$					
Costs of liquid fuels	$	848	531	911	911	531
Costs of pesticides[b/]	$	2,311	828	3,175	3,175	828
Costs of nitrogen purchased[c/]	$	3,987	3,786	5,031	4,082	2,837
Total costs of energy inputs[d/]	$	7,145	5,145	9,116	8,167	4,196
Summary of energy quantities[e/]						
Kilocalories liquid fuels	Kcal.	96,801,463	75,884,398	101,962,268	101,962,268	75,884,398
Kilocalories pesticides[b/]	Kcal.	4,880,371	2,431,000	5,741,566	5,741,566	2,431,000
Kilocalories nitrogen purchased[c/]	Kcal.	124,037,056	117,794,317	156,528,661	126,994,261	88,259,917
Kilocalories total	Kcal.	225,718,891	196,109,714	264,232,494	234,698,094	166,575,314
Gasoline equivalents total	Gal.	6,235	5,417	7,299	6,483	4,601

[a/] Liquid and solid refer to the type of manure system. Ct and RT refer to conventional and reduced tillage of corn respectively.

[b/] The cost and kilocalories associated with 2, 4, D is included in these figures. However the cost of 2, 4, D was not varied and the quantity available of 2, 4, D was not restricted.

[c/] Quantity and value of manure nitrogen were not included in this table.

[d/] This figure does not include increases in lubrication costs.

[e/] Conversion factors used to convert the energy inputs to kilocalories are: gasoline - 36,200 kcal./gal., diesel fuel - 51,700 kcal./gal., liquid petroleum gas - 30,200 kcal./gal., nitrogen - 8,400 kcal./lb., pesticides - 11,000 kcal./lb. These values are found in Walker, J. N. "Energy Usage in Crop Systems," Energy in Agriculture, Proceedings of conference - workshop in Atlanta, Georgia, October 1-3, 1975, Southern Regional Education Board, 130 Sixth Street, N. W., Atlanta, Georgia 30313, pp. 42-50.

Table 3. Returns to Fixed Resources Per Dollar of Energy Costs and Per Gallon of Gasoline Equivalent, for Initial Analysis of Hundred Cow Dairy Farms Using Different Combinations of Manure and Tillage Systems.

Farm organizations	Returns[a] per dollars of energy costs	Returns per gallon of gasoline equivalent
	(dollars)	(dollars)
LMRT[b]	10.71	13.50
SMRT	9.28	11.59
LMCT	20.00	18.59
SMCT	16.07	15.26
LMRT and CT	12.34	14.14

[a] Returns are returns to fixed resources.

[b] LM and SM refer to the liquid and solid manure systems. CT and RT refer to conventional and reduced corn tillage.

Table 3). Farms using conventional corn tillage did not use any liquid petroleum gas,[1/] paraquat, furadan, or sevin.[2/]

Energy usage levels for the farm organization which used both methods of tillage were generally in between the levels of farms using conventional or reduced corn tillage only. One exception to this is that the amount of atrazine was higher when both methods of tillage were used than when either conventional or reduced corn tillage only was used.[3/]

Since use of a solid or liquid manure system did not affect the crops grown, it did not affect the amounts of liquid fuels and pesticides used. Substantial differences existed in the amount of nitrogen purchased by farms using solid or liquid manure systems because the liquid manure system made available 3,516 pounds more nitrogen from the dairy herd than the solid manure system. This 3,516 pounds of nitrogen represented a value of 949 dollars (at 27 cents per pound for nitrogen) and a quantity of 816 GEQ.

[1/] In this research, liquid petroleum gas was used only for drying corn grain, and no corn for grain was grown on farms using conventional corn tillage.

[2/] Paraquat, furadan, or sevin were not included in the conventional corn tillage budgets.

[3/] Atrazine was used in both conventional and reduced corn tillage budgets.

Increases In Energy Costs

Crops

An optimum combination of crops was determined for farms using each of the five combinations of manure systems and corn tillage methods with prices of the energy inputs increased by 25, 50, 75, and 100 percent. Results of this analysis in the crop systems are summarized in Appendix G, Tables 1, 2, and 3. There were no differences in the optimum combinations of crops between the two manure systems. However, there were differences between the two methods of tillage (see Table 4).

With the farm organization using reduced corn tillage, the largest crop system differences between consecutive energy price increases occurred between the 50 and 75 percent increases. Corn grain produced dropped from 4,876 to 2,489 bushels, corn silage produced dropped from 1,205 to 370 tons, and alfalfa silage produced increased from 27 to 451 tons (see Appendix G, Table 1). Differences in purchased feed between 50 and 75 percent energy price increases were, soybean meal purchased dropped from 1,833 to 429 hundredweights and corn grain purchased increased from none to 7,836 bushels.

There were smaller changes in the crops between the initial model and the 25 and 50 percent increases in energy input prices. Results of these first two price increases included decreases in the amount of corn grain, barley silage, and alfalfa silage produced; and increases in the amount of corn silage produced and soybean meal purchased.

Table 4. Crops Produced on Hundred-Cow Dairy Farms Using Reduced and Conventional Corn Tillage,[a] as Costs of Energy Inputs are Increased.[b]

Item	Units	Initial model[c]	Increase in energy costs 25%	50%	75%	100%
Crops[d] produced using reduced corn tillage:						
Corn grain	Bu.	5,790	5,290	4,876	2,489	2,489
Corn silage	Ton	918	1,076	1,205	370	370
Barley silage[e]	Ton	206	92	--	--	--
Alfalfa silage	Ton	50	37	27	451	451
Alfalfa hay	Ton	46	46	46	46	46
Pasture[f]	Acre	130	130	130	130	130
Crops[d] produced using conventional corn tillage:						
Corn grain	Bu.	--	698	2,526	2,526	2,526
Wheat grain	Bu.	1,869	952	--	--	--
Corn silage	Ton	922	921	669	669	669
Barley silage[e]	Ton	206	--	--	--	--
Alfalfa silage	Ton	46	170	299	299	299
Alfalfa hay	Ton	46	46	46	46	46
Pasture[f]	Acre	130	130	130	130	130

[a]Crops were the same for both liquid and solid manure system.

[b]Costs were increased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen. Lubrication costs are also increased because lubrication cost are calculated as 15 percent of fuel costs.

[c]Costs of inputs in the initial model were considered to be at 1976 price levels. A detailed list of these prices is included in Appendix A, Table 1.

[d]Detailed budgets for these crops can be found in Appendix D.

[e]Barley silage was only produced when double cropping was used.

[f]Pasture was restricted to land not suitable for crops and used for replacements and dry cows only.

The optimum combinations of crops for the farm organization using reduced corn tillage were identical at 75 and 100 percent energy input price increases.

On farms using conventional corn tillage only, differences between the optimum combinations of crops produced in the initial model and when energy input prices were increased by 25 percent are as follows: corn grain increased from none to 698 bushels, wheat grain decreased from 1,869 to 952 bushels, corn silage production dropped 1 ton, barley silage dropped from 206 tons to none, and alfalfa silage increased from 46 to 170 tons (see Appendix G, Table 2). Changes in feed purchased included a decrease in the amount of soybean meal and an increase in the amount of corn grain.

For farms with conventional corn tillage, the changes in optimum combinations of crops with the second 25 percent increase in energy prices were similar in direction to the differences between the initial model and the first 25 percent energy price increases.

On farms using conventional corn tillage, increases in energy input prices of 75 and 100 percent resulted in the same optimum combination of crops as the 50 percent increase in energy prices.

On farms using both conventional and reduced corn tillage, differences in the crops between the initial model and the model with a 25 percent increase in energy prices included a decrease in corn grain produced from 1,100 to 1,258 tons, a decrease in barley silage produced from 135 tons to none, an increase in soybean meal purchased from 1,864 to 1,023 tons and an increase in corn grain purchased from none to 318 bushels (see Appendix G, Table 3).

A fifty percent increase in energy input prices when both methods of corn tillage were used resulted in an optimum combination of crops which was identical to the optimum combination of crops with 25 percent energy price increases.

When energy input prices were increased by 75 and 100 percent, the farm organization which had been using both conventional and reduced corn tillage shifted to using all conventional corn tillage. Therefore, the optimum combination of crops were the same as reported for the optimum combination on the farm using conventional corn tillage at 50 percent energy price increases.

Returns

At 25, 50, and 75 percent energy price increases, farms using reduced corn tillage experienced higher reductions in returns than similar farms which used conventional tillage (see Table 5). In these cases the reductions in returns for the farm which used both methods of tillage fell between the reductions experienced by farms using one method of corn tillage only. At 100 percent increases in energy prices, farms using reduced corn tillage experienced lower reductions in returns than similar farms which used conventional corn tillage.

As compared to farms using conventional corn tillage, farms using reduced corn tillage had higher returns to fixed resources in the initial analysis and at the 25 percent increase in energy input prices, and

Table 5. Reductions in Returns Associated with Energy Price Increases.[a]

Farm organization	Initial model[b] returns	Increase in energy price 25%	50%	75%	100%
	$	$	$	$	$
LMRT[c]	87,498	2,183	2,119	1,367	560
SMRT	84,602	2,429	2,365	1,585	802
LMCT	85,553	1,054	777	719	719
SMCT	82,657	1,300	1,023	965	965
LMCT and RT	88,160	1,922	1,816	1,419	719

[a] Prices were increased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen. Lubrication costs are also increased because lubrication costs are calculated as 15% of fuel costs.

[b] Costs of inputs in the initial model were considered to be at 1976 price levels. A detailed list of these prices is included in Appendix A, Table 1.

[c] LM and SM refer to the liquid and solid manure systems. CT and RT refer to conventional and reduced corn tillage.

lower returns to fixed resources with 50, 75, and 100 percent energy price increases (see Appendix G, Table 4).

As energy prices were increased the farms using a solid manure system consistently had lower returns and higher reductions in returns than farms using a liquid manure system.

In terms of returns to fixed resources per dollar of energy costs, farms using conventional corn tillage were more efficient energy users than farms using reduced corn tillage at 25 and 50 percent energy price increases. However, farms using reduced corn tillage were more efficient at 75 and 100 percent energy price increases (see Appendix G, Table 19).

Energy Use

Farms which used conventional corn tillage had lower total energy costs and gasoline equivalents than farms using reduced corn tillage at 25 and 50 percent increases in energy prices. But farms using conventional corn tillage had higher total energy costs and GEQ at 75 and 100 percent energy price increases (see Table 6 and Appendix G, Tables 5-9).

On farms using reduced corn tillage (see Appendix G, Tables 5 and 6) the quantities of energy used, measured in gasoline equivalents (GEQ), decreased slightly with 25 and 50 percent increases in energy costs and decreased drastically with a 75 percent increase in energy costs. Total costs of energy inputs were higher than the initial model at 25 and 50 percent energy price increases and lower than the initial model at 75 and 100 percent energy price increases. The big reduction in GEQ and

Table 6. Energy Costs on Hundred-Cow Dairy Farms using Different Manure/Tillage Combinations with Increases in Energy Input Prices.[a]

Farm organizations	Initial[b] energy costs	Increases in energy prices			
		25%	50%	75%	100%
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
LMRT[c]	8,167	9,946	11,695	3,367	3,827
SMRT	9,116	11,132	13,119	4,999	5,693
LMCT	4,196	3,799	3,782	4,388	4,995
SMCT	5,145	4,985	5,206	6,049	6,893
LMCT and RT	7,145	8,334	9,972	4,388	4,995

[a] Energy inputs included in these costs figures are gasoline, liquid petroleum gas, diesel fuel, paraquat, furadan, sevin, nitrogen, and 2, 4, D. Costs were increased for all of these inputs except 2, 4, D.

[b] Costs of inputs in the initial analysis were considered to be at 1976 price levels. A detailed list of these prices is included in Appendix A, Table 1.

[c] LM and SM refer to the liquid and solid manure systems. CT and RT refer to conventional and reduced corn tillage.

energy costs when energy prices were increased by 75 percent was caused by shifts in the crop systems from corn silage to alfalfa silage and from farm produced to purchased corn grain. Quantities used of individual energy inputs generally decreased as costs of these inputs were increased except that the quantity of diesel fuel increased when energy prices were increased by 75 percent due to increased acreage of alfalfa silage, and quantities of pesticides used on corn increased slightly at 25 and 50 percent energy price increases due to increases in the total amount of land used for corn.

Liquid petroleum gas usage increased and nitrogen usage decreased at 25 and 50 percent increases in energy prices on the farm using conventional corn tillage (see Appendix G, Tables 7 and 8). These changes were primarily caused by decreases in wheat, corn silage, and double crop acreage and increases in corn grain and alfalfa silage acreages.

The energy usage on the farm operation which used a liquid manure system and both conventional and reduced corn tillage (see Appendix G, Table 9) was most like the farm with a liquid manure system and reduced corn tillage at 25 and 50 percent energy price increases. When both methods of corn tillage could be used on a farm, the liquid manure system and conventional corn tillage were used at 75 and 100 percent energy price increases, and energy use was as reported previously.

As in the initial analysis, since use of a solid or liquid manure system did not affect the crops grown as energy input prices were increased, the manure system also did not affect the amounts of liquid fuels and pesticides used. However, the impact of the greater amount of nitrogen furnished by the liquid manure system resulted in lower total energy costs and lower GEQ on farms using a liquid manure system relative to farms using a solid manure system.

Reductions in Quantities Available of Energy Inputs

Crops

The optimum combination of crops was determined for farms with each of the five manure system and tillage combinations, and with quantities available of the energy inputs reduced by 20, 40, 60, and 80 percent (see Table 7 and Appendix G, Tables 10-12).

Farms using reduced corn tillage (see Appendix G, Table 10), produced less corn grain, purchased less soybean meal, and purchased more corn grain as a result of each of the reductions in the quantities available of the energy inputs. Other differences on the farms using reduced corn tillage between the initial model and the model with a 20 percent reduction in the availability of energy inputs included an increase in production of wheat grain, a decrease in corn silage produced, and an increase in alfalfa silage produced. No barley silage or alfalfa silage was produced when the quantities available of the energy inputs were reduced by 40 percent. Other differences between the 20 and 40 percent reductions in available energy were an increase in wheat grain, an increase in corn silage, and an increase in alfalfa hay production. Other changes which occurred when available energy was reduced by 60 and 80 percent were: no wheat grain was produced; production of corn silage and alfalfa hay was decreased; and alfalfa hay was purchased.

Table 7. Crops Produced on Hundred-Cow Dairy Farms using Reduced and Conventional Corn Tillage,[a] as Quantities Available of Energy Inputs are Decreased.[b]

Item	Units	Initial model[c]	Reductions in availability of energy inputs[d] 20%	40%	60%	80%
Crops[e] produced using reduced corn tillage:						
Corn grain	Bu.	5,790	5,287	2,707	2,194	1,189
Wheat grain	Bu.	--	28	409	--	--
Corn silage	Ton	918	765	843	546	273
Barley silage[f]	Ton	206	206	--	--	--
Alfalfa silage	Ton	50	127	--	--	--
Alfalfa hay	Ton	46	46	187	137	47
Pasture[g]	Acre	130	130	131	191	247
Crops[e] produced using conventional corn tillage:						
Corn grain	Bu.	--	694	20	2,157	1,164
Wheat grain	Bu.	1,869	1,507	785	--	--
Corn silage	Ton	922	826	1,015	528	267
Barley silage[f]	Ton	206	206	--	--	--
Alfalfa silage	Ton	46	95	--	--	--
Alfalfa hay	Ton	46	46	111	94	25
Pasture[g]	Acre	130	130	155	199	251

[a] Crops were the same for both liquid and solid manure systems.

[b] Quantities available were decreased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen.

[c] Quantities of energy inputs available in the initial model are at levels which are not restrictive.

[d] Each 20 percent reduction in available energy inputs was accompanied by a 25 percent increase in purchased feed costs.

[e] Detailed budgets for these crops can be found in Appendix D.

[f] Barley silage was only produced when double cropping was used.

[g] The amount of land used for pasture was allowed to vary, pasture was allowed on cropland, and pasture was allowed to be used by lactating cows as energy quantities were reduced.

On farms using conventional corn tillage (see Table 7 and Appendix G, Table 11) the majority of the changes in the optimum combinations of crops moved in the same direction as the changes which occurred when reduced corn tillage was used. However, there are two notable exceptions to this statement: on farms using conventional corn tillage the quantity of corn grain produced was lower at the 20 and 40 percent levels of energy availability reductions than at the 60 and 80 percent levels, and wheat grain produced was much higher at the 20 percent than at the 40 percent level of decreases in energy quantities available.

Even though other changes in the crops moved in the same direction when farms using reduced corn tillage were compared with farms using conventional corn tillage, there were some differences in the amounts of individual crops produced and purchased.

As available quantities of the energy inputs were reduced, levels of crops produced and purchased on the farm which could use both methods of corn tillage (see Appendix G, Table 12) were very similar to the crop levels on the farm using reduced corn tillage. Where differences did occur between the two models the farm using both methods of corn tillage produced more corn grain, wheat grain, and corn silage; produced less barley silage, alfalfa silage, and alfalfa hay; purchased more soybean meal; and purchased less corn grain and alfalfa hay.

Returns

Reductions in returns associated with energy quantity restrictions of 20, 40, 60, and 80 percent were much more severe than reductions in returns associated with 25, 50, 75, and 100 percent increases in energy prices (see Table 8 and Table 5).

Reductions in returns with energy quantity decreases on farms using reduced corn tillage were lower than reductions on farms using conventional corn tillage at the 20 and 60 percent levels but higher at the 40 and 80 percent levels. The farm using both methods of tillage experienced reductions in returns very close to the reductions found when reduced corn tillage was used.

In terms of total returns to fixed resources as energy supplies were restricted, (see Appendix G, Table 13) farms using reduced corn tillage always had higher returns than similar farms which used conventional corn tillage; and the farm which used both methods of corn tillage always had higher returns than similar farms using only one method of corn tillage.

Energy Use

On farms using reduced corn tillage (see Table 9 and Appendix G, Tables 14 and 15) the total costs of energy inputs, total quantity of energy inputs, and the quantities used of individual energy inputs all decreased with each reduction in the quantities of energy inputs available. (The quantity of 2, 4, D was not restricted in this analysis so the amount of 2, 4, D used increased at the 40, 60, and 80 percent levels of reduced availability of the energy inputs that were restricted, because pasture acreage increased in these situations.) The cause of these decreases seems to be substitution of pastures and purchased feed for farm produced harvested crop feed. The decrease in energy inputs

Table 8. Reductions in Returns Associated with Energy Quantity Restrictions.[a]

Farm organization	Initial model[b] returns	Energy quantity restrictions[c] 20%	40%	60%	80%
	$	$	$	$	$
LMRT[d]	87,498	5,005	9,323	19,080	29,289[e]
SMRT	84,602	5,005	9,323	19,080	28,109
LMCT	85,553	6,149	9,197	19,177	28,437[e]
SMCT	82,657	6,149	9,197	19,177	26,967
LMCT and RT	88,160	4,893	9,254	19,254	29,363[e]

[a] Quantities available were decreased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen.

[b] Quantities of energy inputs available in the initial model are at levels which are not restrictive.

[c] Each 20 percent reduction in available energy inputs was accompanied by a 25 percent increase in purchased feed costs.

[d] LM and SM refer to the liquid and solid manure systems. CT and RT refer to conventional and reduced corn, tillage.

[e] In this case excess fertilizer was furnished by the manure system and considered unused.

Table 9. Energy Costs on Hundred-Cow Dairy Farms using Different Manure/Tillage Combinations with Reductions in Energy Input[a] Quantities Available.

Farm organizations	Initial[b] energy costs	Decreases in energy quantities			
		20%	40%	50%	80%
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
LMRT[c]	8,167	7,053	4,686	2,468	1,166
SMRT	9,116	8,002	5,635	3,417	1,318
LMCT	4,196	4,007	2,904	1,607	782
SMCT	5,145	4,956	3,853	2,556	908
LMCT and RT	7,145	7,096	5,096	2,717	1,192

[a] Energy inputs included in these costs figures are gasoline, liquid petroleum gas, diesel fuel, paraquat, furadan, sevin, nitrogen, and 2, 4, D. Quantities available were reduced for all of these inputs except 2, 4, D.

[b] Quantities of energy inputs available in the initial analysis are at levels which are not restrictive.

[c] LM and SM refer to the liquid and solid manure systems. CT and RT refer to conventional and reduced corn tillage.

used relative to the initial model when energy quantities were reduced by 20 percent was also caused by an increase in alfalfa silage and a decrease in corn silage produced.

The results on farms using conventional corn tillage (see Appendix G, Tables 16 and 17) were similar to the results on farms using reduced corn tillage in that total costs and total quantities of energy used decreased with each reduction in the quantities of the energy inputs available. However, there was more variation in the amounts of gasoline and liquid petroleum gas used, because there were greater variations in the amount of corn grain produced on farms using conventional corn tillage.

In comparing farms using conventional and reduced corn tillage as quantities available of the energy inputs were decreased, farms using reduced corn tillage consistently used higher total quantities of pesticides, liquid fuels, and nitrogen. Thus farming with reduced corn tillage consistently had higher total energy costs and higher total quantities of energy used per farm. In terms of returns to fixed resources per dollar of energy costs, farms using conventional corn tillage consistently had less energy costs than farms using reduced corn tillage (see Appendix G, Table 20).

As quantities available of the energy inputs were reduced, energy usage on the farm using both methods of corn tillage (see Appendix G, Table 18) was very much like the energy usage of the farms using reduced corn tillage.

There were no differences in liquid fuels and pesticides used caused by differences in the two manure systems. However, differences previously mentioned in purchased nitrogen between the solid and liquid manure system also existed when quantities of energy inputs were restricted. Another difference was that when quantities available of the energy inputs were restricted by 80 percent, all nitrogen furnished by the dairy herd--when the liquid manure system was used--could not be used by the crop activities because crops that could utilize nitrogen were restricted by non-nitrogen energy supplies.

Something else that perhaps should be mentioned in this chapter about results is that there were six crop producing activities which were not produced in any of the 45 L. P. variations used in this analysis. These six activities were orchard grass/red clover hay on land B and C, two corn silage activities (one using reduced and the other using conventional tillage) which used reduced quantities of nitrogen and pesticides and had reduced yields, and the two barley silage/corn silage double crop activities on land A (one using reduced and the other using conventional corn tillage).[1/]

Although reducing the quantities of nitrogen and pesticides used for corn silage on land A did not prove profitable with any of the energy price or quantity conditions, there were considerable differences in the reductions in returns which would have occurred if an acre of these crop alternative had been forced into the optimum combinations of crops (see Appendix G, Table 21).

[1/] It should be noted that the yields for corn silage in the double crop alternatives were reduced by 25 percent from normally expected yields to reflect the risk associated with planting the corn later than normal.

CHAPTER VI

DISCUSSION

This chapter will be a discussion of questions of "why?" and "so what?" which have been raised by the information in Chapter V.

The only difference in energy usage between farms using a liquid manure system and farms using a solid manure system was that 3,516 pounds more nitrogen were made available from the dairy herd by the liquid system. This 3,516 pounds of nitrogen represented a value of 949 dollars (at 27 cents per pound for nitrogen) and a quantity of 816 GEQ.[1/]

In cases footnoted in Table 4 and Table 13 of Appendix G, a greater amount of fertilizer nutrients were furnished by the liquid manure system than was required by the crops grown. These excess fertilizer nutrients were considered unused. In an actual farm situation these excess nutrients would most likely be spread on the crop or pasture land resulting in slightly higher yields and thus slightly higher returns to fixed resources.

Results of this study revealed that the type of manure system did not have any effect on which crops were grown or purchased.

Farms with a liquid manure system consistently had higher returns than farms using a solid manure system due to the greater amount of fertilizer nutrients made available by the liquid system.

[1/]There was a total difference of 3,185.70 dollars between the two manure systems in the value of nitrogen, phosphate, and potash made available from the dairy herd. See Appendix B, Table 4.

Some of the assumptions about the liquid and solid manure systems that went into this study were: (1) both systems require the same amount of labor and incur the same costs of spreading, (2) investment costs and repair costs are greater for the liquid manure system (see Appendix B, Table 6), and (3) timeliness of manure incorporation into the soil was not specified.

The importance of timeliness of incorporation has been discussed by both Holter[1/] and McCart.[2/] Timeliness of incorporation is important because much of the nitrogen in manure is volatilized shortly after the manure is spread.

Further research is needed into the realtionship between costs and nitrogen savings associated with different manure systems and timeliness of manure handling.

Returns evaluated in this study are returns to fixed resources. Net income for a particular farm would be determined by such factors as the costs of fixed resources and the farm debt situation.

Estimates of annual fixed costs for the farms using the five different manure/tillage combinations are as follows: (1) a farm with a solid manure system which used conventional corn tillage - 61,204

[1/] Holter, J. B., "Revolutionary Concepts in Energy Management - Dairy Cattle," Paper presented at 30th Virginia Feed Convention and Nutrition Conference, Williamsburg, Virginia, February 20, 1976.

[2/] McCart, G. D., "Manure Management: Efficient Use of An Important Source of Plant Nutrients," Grain News (Blacksburg, Va.: Virginia Polytechnic Institute and State University, Extension Division, 1976).

dollars, (2) a farm with a solid manure system which used reduced corn tillage - 61,209 dollars, (3) a farm with a liquid manure system which used conventional corn tillage - 62,675 dollars, (4) a farm with a liquid manure system which used reduced corn tillage - 62,680 dollars, and (5) a farm which could use either a solid or liquid manure system and could use either or both conventional or reduced corn tillage - 63,300 dollars (see Appendix A, Table 5).

A look at these estimated annual fixed costs indicates that farms using reduced corn tillage have annual fixed costs 5 dollars greater than farms using conventional corn tillage, farms using both methods of corn tillage have annual fixed costs 620 dollars greater than farms using reduced corn tillage, and farms using liquid manure systems have annual fixed costs 1,471 dollars greater than farms using solid manure systems.

In the initial analysis farms using both methods of corn tillage had returns to fixed resources 662 dollars higher than farms using reduced corn tillage only, and farms using a liquid manure system had returns to fixed resources 2,896 dollars higher than farms using a solid manure system. When annual fixed costs are considered these differences in returns are decreased by 620 and 1,471 dollars respectively.

It should be noted that with these estimated annual fixed costs, all of the farm situations considered in this analysis would be experiencing yearly losses rather than profits when quantities available of the energy inputs are reduced by 60 percent or greater (see Appendix G, Table 14).

As the prices of energy inputs were increased or the quantities available of energy inputs were restricted, there were a variety of differences in crops grown, returns, and energy use associated with which corn tillage method was used.

Reductions in returns to fixed resources were not extremely severe when prices of the energy inputs were increased by 100 percent. There are two main reasons for this result. First, as energy costs are increased, the optimum combinations of crops grown shifted toward crops whose energy input costs were a relatively small percent of total variable costs. Second, since the price of purchased feed was held constant, more feed was purchased as the energy cost increased. In a real life situation it would be expected that increasing energy costs would cause subsequent increases in purchased feed costs. For example, a 25 percent increase in energy input prices used in the initial analysis caused an increase of approximately 16 percent in the cost of producing corn grain on land A using reduced tillage. Feed transportation costs would also increase. As energy prices increase, increases in purchased feed costs would cause reductions in returns to fixed resources to be more severe than shown in this study.

At energy price increases of 50 percent or greater, farms using conventional corn tillage had higher returns to fixed resources than farms using reduced corn tillage, because energy costs per unit of feed produced was higher for reduced corn tillages than for conventional corn tillage.

The direction of the changes in the penalty prices for corn silage using reduced quantities of energy inputs (see Appendix G, Table 21) suggests that this alternative would have become profitable if energy costs had been increased to a level higher than the 100 percent level. This alternative was not profitable up to 100 percent energy price increases because the reduced yield had a greater effect on the ratio of costs per unit of feed produced, than the impact on this ratio of the dollar savings due to reducing the quantities of energy inputs used.

Note that in this analysis the prices of all the energy inputs increased at the same rate. The impact of increasing prices of these inputs could be entirely different if prices of different inputs did not all increase at the same rate.

There was a direct relationship between the crops which were grown and purchased and the quantity and types of energy inputs used.

For example, when reduced corn tillage was used and energy input prices were increased by 75 and 100 percent, drastic reductions in energy use were associated with shifts to purchased corn grain and higher acreage of alfalfa silage. Alfalfa silage production uses no nitrogen but uses high quantities of diesel fuel. The impact of these energy using characteristics of alfalfa silage on farms using reduced corn tillage is shown by increases in liquid fuel costs and drastic decreases in purchased nitrogen costs at energy price increases of 75 and 100 percent (see Appendix G, Table 5).

Changes in the optimum combinations of crops in this study confirm the hypothesis suggested by Eidman, _et al_, "that relatively little change in tillage practices will occur unless fuel prices increase by about fifty percent."[1/]

Reductions in returns resulting from decreasing the quantities available of energy inputs were considerably more severe than the reductions in returns occurring when energy costs were increased. This result occurred because the amount of feed which could be grown on the farm was severely limited by energy quantity restrictions and the costs of purchased feed were increased in this analysis.

Changes in the crop activities which all the models had in common as energy inputs were restricted were: (1) increases in the amount of land being used for pasture and decreases in the amount used for crops with energy quantity reductions of 40 percent or greater, (2) shifts toward use of the best land available for the row crops and hay, (3) increases in the amount of feed purchased and decreases in the amount of feed produced on the farm, (4) increasing similarity between the optimum combination of crops using different methods of corn tillage, as the energy input restrictions become more severe.

Trends toward using the best land available for crops and the fact that activities set up with reduced quantities of energy inputs and reduced yields were not included in any optimum farm organizations, suggests that if quantities available of energy inputs become limited,

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[1/] Eidman, Vernon; Dobbins, Craig; and Schwartz, Harold, "The Impact of Changing Energy Prices on Net Returns, Production Methods and Kilocalories of Output for Representative Irrigated Farms," Paper presented at the American Agricultural Economics Association meetings at Columbus, Ohio, August 1975.

energy inputs should be used in higher quantities on the best land to try to achieve higher yields per acre as opposed to using lower levels of energy inputs and getting lower yields per acre. As quantities available of the energy inputs were reduced, there was not a consistent trend in the loss of returns that would occur if an acre of corn silage using reduced amounts of nitrogen and pesticides had been included in the farm plan. This result occurred because the impact of the increases in purchased feed costs and the impact of decreases in available energy inputs resulted not only in changes in the marginal value products of certain energy inputs, but also variations in the marginal value product of land A and the amount of labor hired.

The increase in pasture acreage and use of cropland for pasture as quantities of energy available become more restrictive, suggests that cropland not utilized for crops could profitably be used for pasture, if energy inputs become restrictive.

Shifts to pasture could cause increases in the amount of labor required to manage the cow herd. However, if energy availability restrictions caused shifts from crops to pasture, on-farm labor requirements for crops would be reduced. There might also be a reduction in milk production if shifts to pasture occurred.

Even though the prices of purchased feed were increased by 25 percent with each 20 percent decrease in the quantities available of energy inputs, quantities of feed purchased still increased drastically at 60 and 80 percent energy reductions. Under energy crisis conditions these amounts of purchased feed might not be available.

The five different farm organizations became increasingly similar as energy inputs became increasingly restrictive. This suggests that alternative methods of tillage will have limited potential to improve the farm situation if energy restrictions become severe.

In the analysis in which quantities available of the energy inputs were restricted, hundred-cow dairy farms using reduced corn tillage consistently used higher total quantities of pesticides, liquid fuels, and nitrogen than similar farms which used conventional corn tillage. However, farms using reduced corn tillage consistently had higher returns to fixed resources than farms using conventional corn tillage. Farms using both methods of corn tillage consistently had the highest returns to fixed resources when compared to farms using only one method of corn tillage. Thus, a farm operator desiring to maximize returns to fixed resources would use both methods of corn tillage under restricted availability of energy inputs, although his costs and quantities of energy inputs would be higher than if he used conventional corn tillage only. That is, the farm operator would chose the alternative which results in the greatest economic efficiency (the highest possible income for his farm situation); even though this alternative may not be the most technically efficient in terms of energy use per farm.

Comparisons of energy usage between the two corn tillage methods might have been different if the energy used to produce purchased feed had been considered. For example, comparing the initial models of hundred cow dairy farms, farms using reduced corn tillage appeared to be the higher energy users as energy costs and gasoline equivalents

(GEQ) were higher for these farms. However, farms using conventional corn tillage purchased 4,002 bushels of corn grain. (See Table 1 of Chapter V). The costs and quantity of GEQ which might have been used to produce this purchased corn grain were not included in the energy costs and GEQ totals for farms using conventional corn tillage. The average GEQ required to produce a bushel of corn grain in the initial analysis of this study is .5716 GEQ. The average costs of energy inputs per bushel in the initial analysis is .6317 dollars. Thus, the 4,002 bushels of purchased corn grain would represent a total use of 2,287.5 GEQ of energy and 2,528 dollars of energy costs.[1/] Adding these figures to the totals for farms using conventional corn tillage would make farms using conventional corn tillage the larger energy users in terms of GEQ, but total energy costs would still be higher for farms using reduced corn tillage.

In an energy related study of representative irrigated farms in Oklahoma, Eidman, et al[2/] found that "adaption of certain reduced tillage cropping programs will increase the level of fossil fuel inputs used" but also "result in relatively greater increases in net returns." With reductions in availability of energy inputs the results of this

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[1/] Note that these figures do not include energy used for transportation of the purchased corn grain.

[2/] Eidman, Vernon; Dobbins, Craig; and Schwartz, Harold, "The Impact of Changing Energy Prices on Net Returns, Production Methods and Kilocalories of Output for Representative Irrigated Farms", Paper presented at the American Agricultural Economics Association meetings at Columbus, Ohio, August, 1975.

present study appear to agree with Eidman's higher income finding, and to agree with his energy use finding. However, the inclusion of the purchasing feed alternative in the present Virginia research makes it difficult to compare the energy usage finding of these two studies. The results of this study do not agree with Eidman's findings at 50, 75, and 100 percent energy price increases.

Two recent agricultural engineering studies[1&2] have shown potential for fuel savings using reduced tillage. At first glance their conclusion appears to conflict with the result of generally higher energy quantities and costs on a dairy farm when reduced corn tillage is used. Actually there is no conflict, as the two agricultural engineering studies are showing differences in liquid fuel used on individual crops as a result of differences in preharvest practices between the two methods of tillage. Lower liquid fuel requirements in the preharvest stage of corn production with reduced tillage were also used for this study.

The study by Vaughn, et al[3] found "better labor efficiency" to be an advantage of reduced corn tillage. Better labor efficiency in the

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[1] Wittmuss, H.; Olson, L.; and Lane, D.; "Energy Requirements for Conventional Versus Minimum Tillage," Journal of Soil and Water Conservation, March-April 1975, pp. 72-75.

[2] Vaughn, D. H.; Hughes, H. A.; and Smith, E. S., "Effects of No-Tillage Practices on the Energy Requirements for Corn Productions in Virginia," Paper presented at the 1976 Southeast Region Meeting American Society of Agricultural Engineers, Civic Auditorium, Mobile, Alabama, February 1-4, 1976.

[3] Ibid.

corn planting season was generally an advantage of reduced corn tillage in the present study, except at higher levels of energy quantity decreases where there was excess on-farm labor.

Areas in which further research is needed include: (1) an analysis in which the prices of energy related inputs are increased and the quantities available of energy related inputs are decreased simultaneously, (2) an analysis in which energy prices and quantities available are varied for pesticides, nitrogen, and liquid fuel individually rather than all together, (3) research which quantifies the relationship between the price of purchased feed and increasing energy prices; and the relationship between the price of purchased feed and decreasing quantities available of energy inputs, (4) an analysis minimizing annual costs subject to attaining a certain minimum level of returns as energy input prices are increased, (5) a study which includes energy input costs and energy quantities used for purchased feed and the dairy enterprise as well as the energy input costs and energy quantities used for growing crops, (6) an analysis which evaluates the long run profitability of different manure and tillage systems under energy crisis conditions, (7) an analysis in which the size of the cow herd and the level of milk production is allowed to vary under energy crisis conditions, (8) a study which evaluates the impact on returns of nitrogen savings associated with a legume followed by corn productions under energy crisis conditions,[1/] (9) a

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[1/] Pimentel, David, et al, "Food Production and the Energy Crisis," Science, Vol. 182, pp. 446-447, November 2, 1973.

study which compares the profitability of biological insect control with use of petroleum based pesticides under energy crisis conditions, and (10) a study of how altering speed and size of machinery will affect returns under energy crisis conditions.

CHAPTER VII

SUMMARY AND CONCLUSIONS

The objective of this study was to evaluate how a farm operator might adjust his farm business in response to circumstances which may occur as a result of an energy crisis.

Two distinguishing features of this research are that it will evaluate responses to the energy situation from the farm manager's point of view and that it will explore short run responses and adjustments.

An analysis was made of the impacts of energy crisis conditions on representative Virginia dairy farms using five different combinations of manure systems and corn tillage methods.

For each of the five manure and corn tillage combinations, a linear programming farm planning model was used to determine an initial optimum combination of crops under 1976 energy conditions. Linear programming procedures were then used to determine the impacts on returns to fixed resources, the optimum combination of crops, and energy use for an analysis in which energy input prices were increased and for an analysis in which quantities available of energy inputs were reduced.

The results of this study indicate that an energy crisis which causes energy input prices to increase or the supply of energy inputs to be restricted will cause a reduction in returns to livestock farmers. However the present research indicates that a farmer can make changes in his cropping plan which will help him to minimize losses that may occur.

With increasing energy prices it will be profitable for the farmer to produce less corn grain, a crop that requires large amounts of energy inputs per acre, and increase purchases of corn if the purchased corn prices have not increased (or increased at a slower rate than the energy inputs). Acreage that had previously been planted to a high energy using crop such as corn grain could be used to produce feed such as alfalfa silage which, for production, requires less energy per pound of dry matter. Since the yield of corn silage is reduced when it is produced as part of a double crop, the results indicate that double-cropping would not be profitable with 50 percent or greater increases in energy input prices.

Results of the study indicated that when energy input supplies were reduced 40 percent the reduction in returns to fixed resources were greater than reduction in returns associated with a 100 percent increase in energy input prices.[1/] In fact if the supply of energy inputs available to the farmer were reduced 60 percent or greater the farmers net income (including fixed cost) would be negative.

With 20 percent reductions in the quantities of energy inputs available, increased acreages of alfalfa silage were profitable. With 40 percent of greater reductions in energy input quantities, both alfalfa silage and the double crop alternative were not profitable; and it was profitable to use cropland for pasture. Increased quantities of alfalfa

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[1/] Purchased feed costs were increased in the analysis in which the quantities of energy inputs available were restricted, but purchased feed costs were not increased in the analysis in which energy input prices were increased.

hay were profitable at 40 and 60 percent energy quantity reductions. Some wheat grain was profitable at 20 and 40 percent energy quantity reductions.

Although purchased feed costs were increased as quantities available of the energy inputs were reduced, shifts from farm produced to purchased feed consistently occurred with energy quantity reductions of 40 percent or greater.

Comparing farms using different manure systems, farms using a liquid manure system consistently had higher returns to fixed resources than similar farms using a solid manure system. This result was due to the greater amount of nitrogen, phosphate, and potash made available from the dairy herd by the liquid manure system. The type of manure system used did not have any effect on the feed producing and purchasing activities.

Comparing farms using different corn tillage methods, farms using reduced corn tillage had higher returns to fixed resources than farms using conventional corn tillage in all cases, except when energy prices were increased by 50, 75, and 100 percent. At these higher energy price increases, since conventional corn tillage had lower energy costs per unit of feed produced, conventional corn tillage was more profitable. Quantities and costs of energy used to produce the feed for the cow herd were directly related to what crops were produced and what quantities of feed were purchased. Farms using reduced corn tillage were consistently the higher energy users compared with farms using conventional corn tillage, except when 75 and 100 percent energy price increases occurred; but this result might have been different if energy used to produce the purchased feed had been considered.

Reductions in returns to fixed resources, when energy quantities are restricted, are much more severe than reductions in returns to fixed resources with energy price increases.[1/] This result indicates that if government were faced with the choice of an energy conservation policy based on large energy price increases, or an energy conservation policy based on a strict rationing of energy inputs, the strict rationing policy would probably cause greater reductions in livestock farmer's income.

[1/] Note that purchased feed costs were increased in the analysis in which the quantities of energy inputs available were restricted, but purchased feed costs were not increased in the analysis in which energy input prices were increased. It appears that this result would hold, even if purchased feed costs had been increased in both analysis.

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APPENDIX A

Prices, Investment Costs, and Annual Fixed Costs

Table 1. Prices Used in Budgets and Linear Program.[a]

Item	Unit	Price Paid	Price Received
			$
Barley seed	Bu.	4.99	
Corn seed	Lb.	.50	
Rye seed	Bu.	5.95	
Wheat seed	Bu.	6.39	
Red clover seed	Lb.	1.03	
Nitrogen	Lb.	.27	
Phosphate	Lb.	.27	
Potash	Lb.	.10	
Boron	Lb.	.23	
Lime	Ton	13.50	
Atrazine	Lb.	3.50	
Paraquat	Pt.	7.00	
Furadan	Lb.	.67	
Sevin	Lb.	1.50	
2, 4, D	Lb.	2.24	
Twine	Ton[b]	1.15	
Corn grain	Bu.	2.50	
Alfalfa hay	Ton	65.97	
Mixed hay	Ton	58.40	
Soybean meal	Cwt.	9.56	
Labor	Hr.	2.25	
Gasoline[c]	Gal.	.505	
L. P. gas[c]	Gal.	.36	
Diesel[c]	Gal.	.345	
Wheat straw	Ton		22.00

[a]These prices represent a price level for early 1976.

[b]Cost of twine per ton of hay.

[c]Source of liquid fuel prices is: Statistical Reporting Service, "Agricultural Prices," United States Department of Agriculture, Washington, D. C. 20250, October 31, 1975.

Table 2. Investment Costs of Crop System Machinery and Equipment.[a]

Name of machine	Purchase price
	$
Tractor (35 H.P.)	6,600
Tractor (50 H.P.)	9,680
Tractor (75 H.P.)	13,200
Grain auger	1,106
Hay elevator	2,109
Truck (2 ton)	13,515
Dryer	8,855
Tandem disk, 10.5'	2,130
Chisel plow, 7'	1,000
Corn planter, no tillage, 4-row	4,100
Corn planter, conventional tillage, 4-row	1,925
Grain drill, fertilizer attachment	2,090
Spreader fertilizer and lime	848
Sprayer, 17 nozzle	767
Hay baler, PTO	4,310
Balewagon, PTO	5,793
Rake, side delivery 9'	1,300
Mower, 7', PTO	1,145
Mower-conditioner, 7'	4,365
Stalk shredder, 4-row	2,135
Forage wagon, 7 ton	5,670
Silage blower	1,810
Combine, self propelled with small grain head	23,375
Corn head	3,025
Field chopper, PTO with shear bar	4,810
2-row corn attachment	1,320

[a] These prices represent a price level for early 1976.

Table 3. Investments Costs of Buildings and Equipment (For Hundred-Cow Grade-A Dairy With Solid or Liquid Manure System).

Item	New costs
Common to both systems[a]	
Free stall barn structure, inc. concrete[d]	36,475
Feed manager or bunk	1,800
Feed cart or mech. feeder	2,700
Gutter cleaner or mech. scraper	4,700
Free stalls	5,000
Water, plumbing, wiring	4,000
Milk room or parlor[e]	25,400
Pipeline milking system[f]	8,000
Bulk tank	8,300
Silage storage (1,100 tons)[b]	16,500
Grain storage (4,250 bu.)	1,050
Silo unloader	3,400
Hay barn (100 tons)	2,082
TOTAL	119,407
Solid manure only[c]	
Manure platform[g]	4,000
Spreader (tank flail)	4,100
Manure loader	1,300
TOTAL, Solid manure only	9,400
TOTAL, Bldg. & equip. $ solid manure system	128,807
Liquid manure only[c]	
Storage tank[g]	14,825
Load out pump	3,000
Spreader tank (2,300 gal.)	5,000
TOTAL, Liquid manure only	22,825
TOTAL, Bldg. & equip. & liquid manure system	142,232

[a] Information for free stall housing and associated feeding, milking and cleaning equipment are taken from "Dairy Systems Analysis Handbook Progress Report for Dairy Chore Reduction Program," Paper presented at Dairy Chore Reduction Conferences at Kellogg Center, Michigan State University, March 16 and at Holiday Inn West, Syracuse, N. Y., March 19, 1976 by C. R. Hogland.

[b] Silage, grain and hay storage and silo unloader new costs are adapted from "An Economic Analysis for a 250 head, one-time capacity custom feed lot 1976" by Jim Moore, Virginia Polytechnic Institute and State University. To be published as an Extension Bulletin.

[c] Equipment and costs for manure handling systems are taken or adapted from "Considerations in Selecting Dairy Manure Handling Systems" AEN-7 Compiled by Berge, et al., Agricultural Engineering Department, 460 Henry Mall, University of Wisconsin-Madison, November 1975.

[d] Includes barn structure, all concrete, stalls, water system, plumbing, wiring, insulation and ventilation.

[e] Includes washing equipment, water heater, insulation of walls and ceiling.

[f] Milking system includes all milking equipment, condensors, pumps, pipelines, and other equipment.

[g] This new cost represents a storage capacity large enough to hold 90 days output of manure.

Table 4. Investment Costs of Land and Cows For Hundred-Cow Grade-A Dairy.

Type of land	Number of acres	Cost of land per acre[a]	Cost of land
Land A	46	570	26,220
Land B	95	370	35,150
Land C	19	320	6,080
Land D	130	265	34,450
Total costs of land			101,900

Investment Costs of Hundred Grade-A Dairy Cows

Number of cows	Cost per cow	Investment cost of cow herd[b]
100	506	50,600

a/ Use-value assessment values for a neighboring county used as a rough estiment. See Marshall, J. P. and Tsang, C. S., "Procedure Utilized to Determine Use-Value of Agricultural Land In Virginia With Estimated Use-Values For 21 Jurisdictions Authorizing Use-Value Taxation For the Tax-Year 1976," Methodology For Determining Ranges of Use-Values For Agriculture, Horticulture, Forest and Open Space Land in Virginia, State Land Evaluation Advisory Committee, P. O. Box 1-K, Richmond, Virginia 23201, September, 1975.

b/ This includes replacements.

Table 5. Annual Fixed Costs of Land, Cows, On-Farm Labor, Buildings, Equipment, and Machinery.[a/] For Hundred-Cow Grade-A Dairy Farm With Different Manure/Tillage Systems.

Annual fixed cost of land	9,171
Annual fixed cost of cows	4,554
Annual fixed costs of on-farm labor	14,625
Annual fixed costs of dairy building and equipment, 20 years life, no salvage value.	
A. With a solid manure system	14,110
B. With a liquid manure system	15,581
Annual fixed costs of crop equipment, 10 years life, 5 percent salvage value.	
A. Using conventional corn tillage only	18,744
B. Using reduced corn tillage only	18,749
C. Using both methods of corn tillage	19,369
Total annual fixed cost of farms with different manure/tillage combinations.	
A. Solid manure system/reduced corn tillage	61,209
B. Solid manure system/conventional corn tillage	61,204
C. Liquid manure system/reduced corn tillage	62,680
D. Liquid manure system/conventional corn tillage	62,675
E. Liquid manure system/both methods of corn tillage	63,300

[a/] Annual fixed costs were determined by the annuity method.

APPENDIX B

Grade-A Dairy Budgets

Table 1. Grade-A Dairy With Solid Manure System In Dry Lot the Year Around 15,000 Pounds Average Production[a,b] (Hundred Cows).

Item	Unit	Price	Quantity	Total
RECEIPTS:				
Milk (14,800 lbs. sold/cow)	cwt.	9.42[c]	14,800.00	139,416.0
25 cull cows[d]	cwt.	26.71	337.50	9,015.0
8 cull heifers (900 lbs.)[d]	cwt.	26.71	72.00	1,923.0
62 calves (1 week old)[d]	each	26.71	62.00	1,656.0
Manure credits				
Nitrogen	lb.	.27	4,369.00	1,179.6
P_2O_5	lb.	.27	3,277.00	884.8
K_2O	lb.	.10	8,738.00	873.8
	Total receipts			154,948.2
EXPENSES: (variable)				
Salt and minerals	cwt.	6.49	28.33	183.9
Milk replacer	cwt.	15.15	17.50	265.1
Calf starter	cwt.	10.82	22.50	243.4
Spray	each	.31	100.00	31.0
Buildings, equipment, etc., repair[e]				3,965.0
Vet. and medicine	each	10.82	100.00	1,082.0
Breeding	each	15.16	109.00	1,652.4
Milk hauling and marketing	cwt.	.80	14,800.00	11,840.0
Supplies	each	8.66	100.00	866.0
Machinery - Tractor, manure spreader, etc.	hours	2.13	850.00	1,810.5
D.H.I.A. and other records	each	10.83	100.00	1,083.0
Utilities	each	23.83	100.00	2,383.0
Bedding	ton	32.48	50.00	1,624.0
Interest on above cost	$	8%	27,029.40	2,162.4
Cow and heifer marketing	each	4.13	33.00	136.3
Haul cows and heifers to market	each	8.27	33.00	272.9
Calf marketing	each	2.48	62.00	153.8
Haul calves to market	each	3.30	62.00	204.6
Equipment (clippers, neck chains, etc.)	each	1.66	100.00	166.0
Total variable costs	Total variable costs			30,125.3
	Returns to fixed resources and feed			124,822.9

a/This budget is adapted from Moore, J. M., "Costs and Returns Guide for Dairy in Virginia," Extension Division, Virginia Polytechnic Institute Record Book 72, June 1970.

b/The milking herd will be in dry lot the year around. Heifers and dry cows will be on pasture. Cows are on a 12 month lactation period.

c/Source of milk price is Patterson, W. N., "Dairy Guidelines. Virginia Dairy Herd Improvement Association Program Summary, 1965-76," Extension Division Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

d/All calves except replacements will be sold at 3 days. Thirty-three heifer calves will be kept for replacements. Eight will be culled at breeding time and 25 will go into the herd. Twenty-five cows will leave the herd each year.

e/This is from Table 6.

Table 2. Grade-A Dairy With Liquid Manure System In Dry Lot The Year Around 15,000 Pounds Average Production[a,b] (Hundred Cows).

Item	Unit	Price	Quantity	Total
RECEIPTS:				
Milk (14,800 lbs. sold/cow)	cwt.	9.42[c]	14,800.00	139,416.0
25 cull cows[d]	cwt.	26.71	337.50	9,015.0
8 cull heifers (900 lbs.)[d]	cwt.	26.71	72.00	1,923.0
62 calves (1 week old)[d]	each	26.71	62.00	1,656.0
Manure credits				
Nitrogen	lb.	.27	7,885.00	2,129.0
P_2O_5	lb.	.27	9,199.00	2,483.7
K_2O	lb.	.10	15,112.00	1,511.2
	Total receipts			158,133.9
EXPENSES: (variable)				
Salt and minerals	cwt.	6.49	28.33	183.9
Milk replacer	cwt.	15.15	17.50	265.1
Calf starter	cwt.	10.82	22.50	243.4
Spray	each	.31	100.00	31.0
Buildings, equipment, etc., repair[e]				4,233.0
Vet. and medicine	each	10.82	100.00	1,082.0
Breeding	each	15.16	109.00	1,652.4
Milk hauling and marketing	cwt.	.80	14,800.00	11,840.0
Supplies	each	8.66	100.00	866.0
Machinery - tractor, manure spreader, etc.	hours	2.13	850.00	1,810.5
D.H.I.A. and other records	each	10.83	100.00	1,083.0
Utilities	each	23.83	100.00	2,383.0
Bedding	ton	32.48	50.00	1,624.0
Interest on above cost	$	8%	27,297.40	2,183.8
Cow and heifer marketing	each	4.13	33.00	136.3
Haul cows and heifers to market	each	8.27	33.00	272.9
Calf marketing	each	2.48	62.00	153.8
Haul calves to market	each	3.30	62.00	204.6
Equipment (clippers, neck chains, etc.)	each	1.66	100.00	166.0
	Total variable costs			30,414.7
	Returns to fixed resources and feed			127,719.2

[a]This budget is adapted from Moore, J. M., "Costs and Returns Guide for Dairy in Virginia," Extension Division, Virginia Polytechnic Institute Record Book 72, June 1970.

[b]The milking herd will be in dry lot the year around. Heifers and dry cows will be on pasture. Cows are on a 12 month lactation period.

[c]Source of milk price is Patterson, W. N., "Dairy Guidelines. Virginia Dairy Herd Improvement Association Program Summary, 1965-75," Extension Division Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

[d]All calves except replacements will be sold at 3 days. Thirty-three heifer calves will be kept for replacements. Eight will be culled at breeding time and 25 will go into the herd. Twenty-five cows will leave the herd each year.

[e]This is from Table 6.

Table 3. Manure Credit Calculations.

Solid Manure System:

	Lb/ton of manure[a]	Yearly[b] tons of manure produced per cow	Lbs. nutrients furnished per cow yearly	Number Lactating cows	Lbs. nutrients furnished yearly
Nitrogen	2	12.85	51.40	85	4,369
P_2O_5	3	12.85	38.55	85	3,277
K_2O	8	12.85	102.80	85	8,738

Liquid Manure System:

	Lb/1000 gal. of manure[a]	Yearly 1000 gals. units of manure per cow	Lbs. nutrients furnished per cow yearly	Number Lactating cows	Lbs. nutrients furnished yr.
Nitrogen	12	7.73	92.76	85	7,885
P_2O_5	14	7.73	108.22	85	9,199
K_2O	23	7.73	177.79	85	155,122

[a] G. D. McCart, "Manure Management: Efficient Use of An Important Source of Plant Nutrients," Grain News (Blacksburg, Va.: Virginia Polytechnic Institute and State University, Extension Division, 1976).

[b] Livestock Waste Facilities Handbook (Ames, Iowa: Iowa State University, Midwest Plan Service, 1975), p. 4. (Percent water of manure produced was adjusted to conform to percent water of the data from the McCart article.)

Table 4. Value of Manure Credit.

Solid Manure:

Nutrient	Amount furnished	Price per lb.	Value
	Pounds	$	$
Nitrogen	4,369	.27	1,179.60
P_2O_5	3,277	.27	884.80
K_2O	8,738	.10	873.80
		TOTAL -----	2,938.20

Liquid Manure:

Nutrient	Amount furnished	Price per lb.	Value
	Pounds	$	$
Nitrogen	7,885	.27	2,129.00
P_2O_5	9,199	.27	2,483.70
K_2O	15,112	.10	1,511.20
		TOTAL ----	6,123.90

Difference between liquid and solid = $3,185.70.

Table 5. Labor Requirements by Seasons.[a/]

MONTHS		HOURS
D-J-F-M		2,166
A-M		1,084
J-J-A		1,625
S-O-N		1,625
	Total	6,500

[a/]Labor requirements for this study are assumed to be the same for both liquid and solid manure systems. Substantial differences could exist between both total labor and seasonal distribution of labor depending on the managerial ability of the farm operator and how his individual system is set up. This same type of statement could be made about the amount of bedding required which, in this study, is also assumed to be the same for both systems.

Table 6. Repair Costs of Buildings and Equipment (For Hundred-Cow Grade-A Dairy With Solid or Liquid Manure System).

Item	New Costs	Repairs	
		% of new	$
Common to both systems[a]			
Free stall barn structure, inc. concrete[d]	36,475	2.0	730
Feed manager or bunk	1,800	3.0	54
Feed cart or mech. feeder	2,700	5.0	135
Gutter cleaner or mech. scraper	4,700	5.0	235
Free stalls	5,000	2.0	100
Water, plumbing, wiring	4,000	2.0	80
Milk room or parlor[e]	25,400	4.0	1,016
Pipeline milking system[f]	8,000	5.0	400
Bulk tank	8,300	4.0	332
Silage storage (1,100 tons)[b]	16,500	2.0	330
Grain storage (4,250 bu.)	1,050	2.0	21
Silo unloader	3,400	5.0	170
Hay barn (100 tons)	2,082	2.5	104
TOTAL	119,407		3,655
Solid manure only[c]			
Manure platform[g]	4,000	1.0	40
Spreader (tank flail)	4,100	5.0	205
Manure loader	1,300	5.0	65
TOTAL, Solid manure only	9,400		310
TOTAL, Bldg. & equip. & solid manure system	128,807		3,965
Liquid manure only[c]			
Storage tank[g]	14,825	1.0	148
Load out pump	3,000	6.0	180
Spreader tank (2,300 gal.)	5,000	5.0	250
TOTAL, Liquid manure only	22,825		578
TOTAL, Bldg. & equip. & liquid manure system	142,232		4,233

[a] Information for free stall housing and associated feeding, milking and cleaning equipment are taken from "Dairy Systems Analysis Handbook Progress Report for Dairy Chore Reduction Program," Paper presented at Dairy Chore Reduction Conferences at Kellogg Center, Michigan State University, March 16 and at Holiday Inn West, Syracuse, N. Y., March 19, 1976 by C. R. Hogland.

[b] Silage, grain and hay storage and silo unloader new costs are adapted from "An Economic Analysis for a 250 head, one-time capacity custom feed lot 1976" by Jim Moore, Virginia Polytechnic Institute and State University. To be published as an Extension Bulletin.

[c] Equipment and costs for manure handling systems are taken or adapted from "Considerations in Selecting Dairy Manure Handling Systems" AEN-7 Compiled by Berge, et al., Agricultural Engineering Department, 460 Henry Mall, University of Wisconsin-Madison, November 1975.

[d] Includes barn structure, all concrete, stalls, water system, plumbing, wiring, insulation and ventilation.

[e] Includes washing equipment, water heater, insulation of walls and ceiling.

[f] Milking system includes all milking equipment, condensors, pumps, pipelines, and other equipment.

[g] This new cost represents a storage capacity large enough to hold 90 days output of manure.

APPENDIX C

Dairy Herd Feeding Information

Table 1. Nutrients Furnished by One Unit of Various Feeds.[a/]

Crop	Unit	Dry matter pounds	Crude protein pounds	Crude fiber pounds
Corn grain	Bu.	49.84	4.98	1.10
Wheat grain	Bu.	53.40	7.64	1.82
Corn silage	Ton	760.00	53.20	202.92
Barley silage	Ton	782.00	68.82	237.73
Alfalfa silage	Ton	1,154.00	201.95	403.90
Alfalfa hay	Ton	1,690.00	283.92	598.26
Mixed hay	Ton	1,716.00	195.62	646.93
Pasture[b/]	Ton	634.00	93.83	181.96
Soybean oil meal	Cwt.	90.00	48.70	5.6

[a/] The major source used for the average composition of these feeds was Murley, W. R., "Feeding Guidelines for Dairy Cows," Virginia Polytechnic Institute and State University, Extension Division Publication 630, November 1974, p. 22.

[b/] Source used for composition of pasture was National Research Council, "Nutrient Requirements of Dairy Cattle," Nutrient Requirements of Domestic Animals, Number 3, Fourth Revised Edition, National Academy of Sciences, Washington, D. C., 1971.

Table 2. Yearly Nutrient Requirements for 100 Cow Grade-A Dairy Herd.[a,b]

Nutrient	Lactating cows	Dry cows	Replacements	Total herd
Dry matter	1,303,050	97,729	221,519	1,622,300
Crude protein	195,458	8,814	19,980	224,252
Crude fiber (high)	247,580	32,247	73,095	352,922
Crude fiber (low)	221,519	30,277	68,627	320,423

[a]These requirements are based on 15,000 pounds average yearly milk production, 85% lactating and 15% dry cows, and 68 replacements.

[b]Source of method of determining these requirements is Murley, W. R., "Feeding Guidelines for Dairy Cows," Virginia Polytechnic Institute and State University, Extension Division Publication 630, November 1974, and Conversations with Dr. Murley.

APPENDIX D

Crop Budgets

TABLE 1. CORN FOR GRAIN, CONVENTIONAL TILL, 100 BUSHEL YIELD.
BOTETOURT COUNTY, VIRGINIA, LAND A; L.P. ACTIVITY CGTA.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
CORN	BU.	0.0	100.00	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
CORN SEED	LBS.	0.50	13.44	6.72
NITROGEN	LBS.	0.27	135.00	36.45
PHOSPHATE	LBS.	0.27	50.00	13.50
POTASH	LBS.	0.10	50.00	5.00
LIME	TONS	13.50	0.50	6.75
ATRAZINE	LBS.	3.50	2.50	8.75
MACHINERY	ACRE	1.00	1.00	1.00
TRACTORS	ACRE	2.41	1.00	2.41
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	1.35	0.0
INTEREST ON OP. CAP.	DOL.	0.08	40.29	3.22
SUBTOTAL, PRE-HARVEST				83.81
HARVEST COSTS				
MACHINERY	ACRE	15.64	1.00	15.64
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	3.27	0.0
SUBTOTAL, HARVEST				15.64
TOTAL VARIABLE COST				99.45
3. INCOME ABOVE VARIABLE COSTS				-99.45
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	36.75	1.00	36.75
TRACTORS	ACRE	3.41	1.00	3.41
TOTAL FIXED COSTS				40.16
5. TOTAL VARIABLE & FIXED COSTS				139.61
6. RETURN OVER VARIABLE & FIXED COSTS				-139.61
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				139.61
9. NET RETURN TO LAND & RISK				-139.61

NOTE: CORN HARVESTED AT 25% MOISTURE-DRIED TO 15%; CORN HAULED 1 MILE
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 2. CORN FOR GRAIN, CONVENTIONAL TILL, 80 BUSHEL YIELD.
BOTETOURT COUNTY, VIRGINIA, LAND B; L.P. ACTIVITY CGTB.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
CORN	BU.	0.0	80.00	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
CORN SEED	LBS.	0.50	12.32	6.16
NITROGEN	LBS.	0.27	116.00	31.32
PHOSPHATE	LBS.	0.27	46.00	12.42
POTASH	LBS.	0.10	46.00	4.60
LIME	TONS	13.50	0.50	6.75
ATRAZINE	LBS.	3.50	2.50	8.75
MACHINERY	ACRE	1.00	1.00	1.00
TRACTORS	ACRE	2.41	1.00	2.41
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	1.35	0.0
INTEREST ON OP. CAP.	DOL.	0.08	36.71	2.94
SUBTOTAL, PRE-HARVEST				76.35
HARVEST COSTS				
MACHINERY	ACRE	13.19	1.00	13.19
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	2.72	0.0
SUBTOTAL, HARVEST				13.19
TOTAL VARIABLE COST				89.54
3. INCOME ABOVE VARIABLE COSTS				-89.54
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	33.64	1.00	33.64
TRACTORS	ACRE	3.41	1.00	3.41
TOTAL FIXED COSTS				37.05
5. TOTAL VARIABLE & FIXED COSTS				126.59
6. RETURN OVER VARIABLE & FIXED COSTS				-126.59
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				126.59
9. NET RETURN TO LAND & RISK				-126.59

NOTE: CORN HARVESTED AT 25% MOISTURE-DRIED TO 15%; CORN HAULED 1 MILE.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 3. CORN FOR GRAIN, REDUCED TILL, 115 BUSHEL YIELD.
BOTETOURT COUNTY, VIRGINIA; LAND A; L.P. ACTIVITY CGNA.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
CORN	BU.	0.0	115.00	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
CORN SEED	LBS.	0.50	14.05	7.02
NITROGEN	LBS.	0.27	150.00	40.50
PHOSPHATE	LBS.	0.27	60.00	16.20
POTASH	LBS.	0.10	60.00	6.00
LIME	TONS	13.50	0.50	6.75
ATRAZINE	LBS.	3.50	2.50	8.75
PARAQUAT	PT.	7.00	1.00	7.00
FURADAN	LBS.	0.67	10.00	6.70
SEVIN	LBS.	1.50	0.50	0.75
RYE SEED	BU.	5.95	1.00	5.95
MACHINERY	ACRE	0.59	1.00	0.59
TRACTORS	ACRE	1.24	1.00	1.24
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	0.88	0.0
INTEREST ON OP. CAP.	DOL.	0.08	39.18	3.13
SUBTOTAL, PRE-HARVEST				110.59
HARVEST COSTS				
MACHINERY	ACRE	17.48	1.00	17.48
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	3.68	0.0
SUBTOTAL, HARVEST				17.48
TOTAL VARIABLE COST				128.07
3. INCOME ABOVE VARIABLE COSTS				-128.07
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	39.08	1.00	39.08
TRACTORS	ACRE	1.78	1.00	1.78
TOTAL FIXED COSTS				40.86
5. TOTAL VARIABLE & FIXED COSTS				168.93
6. RETURN OVER VARIABLE & FIXED COSTS				-168.93
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				168.93
9. NET RETURN TO LAND & RISK				-168.93

NOTE: CORN HARVESTED AT 25% MOISTURE-DRIED TO 15%; CORN HAULED 1 MILE.
APPLY 2 LBS. SEVIN 50% WP EVERY 4 YEARS. SEED RYE WITH FERT.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 4. CORN FOR GRAIN, REDUCED TILL, 95 BUSHEL YIELD.
BOTETOURT COUNTY, VIRGINIA, LAND 8; L.P. ACTIVITY CGNB.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
CORN	BU.	0.0	95.00	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
CORN SEED	LBS.	0.50	12.50	6.25
NITROGEN	LBS.	0.27	133.00	35.91
PHOSPHATE	LBS.	0.27	52.00	14.04
POTASH	LBS.	0.10	52.00	5.20
LIME	TONS	13.50	0.50	6.75
ATRAZINE	LBS.	3.50	2.50	8.75
PARAQUAT	PT.	7.00	1.00	7.00
FURADAN	LBS.	0.67	10.00	6.70
SEVIN	LBS.	1.50	0.50	0.75
RYE SEED	BU.	5.95	1.00	5.95
MACHINERY	ACRE	0.44	1.00	0.44
TRACTORS	ACRE	0.58	1.00	0.58
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	0.49	0.0
INTEREST ON OP. CAP.	DOL.	0.08	36.50	2.92
SUBTOTAL, PRE-HARVEST				101.24
HARVEST COSTS				
MACHINERY	ACRE	15.19	1.00	15.19
TRACTORS	ACRE	0.66	1.00	0.66
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	3.53	0.0
SUBTOTAL, HARVEST				15.84
TOTAL VARIABLE COST				117.08
3. INCOME ABOVE VARIABLE CCSTS				-117.08
4. FIXED (CWNERSHIP) COSTS				
MACHINERY	ACRE	35.98	1.00	35.98
TRACTORS	ACRE	1.78	1.00	1.78
TOTAL FIXED CCSTS				37.76
5. TOTAL VARIABLE & FIXED COSTS				154.84
6. RETURN OVER VARIABLE & FIXED COSTS				-154.84
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				154.84
9. NET RETURN TO LAND & RISK				-154.84

NOTE: CORN HARVESTED AT 25% MOISTURE-DRIED TO 15%; CORN HAULED 1 MILE.
APPLY 2 LBS. SEVIN 50% WP EVERY 4 YEARS. SEED RYE WITH FERT.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 5. WHEAT FOR GRAIN, 35 BUSHEL YIELD.
BOTETOURT COUNTY, VIRGINIA, LAND A OR B; L.P. ACTIVITY WGCB.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
WHEAT	BU.	0.0	35.00	0.0
STRAW	TONS	22.00	1.00	22.00
TOTAL RECEIPTS				22.00
2. VARIABLE COSTS				
PREHARVEST				
WHEAT SEED	BU.	6.39	1.50	9.58
NITROGEN	LBS.	0.27	70.00	18.90
PHOSPHATE	LBS.	0.27	50.00	13.50
POTASH	LBS.	0.10	50.00	5.00
LIME	TONS	13.50	0.25	3.38
MACHINERY	ACRE	0.38	1.00	0.38
TRACTORS	ACRE	1.81	1.00	1.81
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	1.07	0.0
INTEREST ON OP. CAP.	DOL.	0.08	34.83	2.79
SUBTOTAL, PRE-HARVEST				55.33
HARVEST COSTS				
TWINE	TONS	1.15	1.00	1.15
MACHINERY	ACRE	3.02	1.00	3.02
TRACTORS	ACRE	0.86	1.00	0.86
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	1.07	0.0
SUBTOTAL, HARVEST				5.03
TOTAL VARIABLE COST				60.36
3. INCOME ABOVE VARIABLE COSTS				-38.36
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	16.95	1.00	16.95
TRACTORS	ACRE	3.76	1.00	3.76
TOTAL FIXED COSTS				20.71
5. TOTAL VARIABLE & FIXED COSTS				81.07
6. RETURN OVER VARIABLE & FIXED COSTS				-59.07
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				1.10
8. TOTAL OF ABOVE COSTS				82.17
9. NET RETURN TO LAND & RISK				-60.17

NOTE: WHEAT HAULED 1 MILE.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 6. CORN FOR SILAGE, CONVENTIONAL TILL, 13.8 TONS YIELD AS FED.
15.0 TONS FIELD YIELD LESS 8% STORAGE LOSS.
BOTETOURT COUNTY, VIRGINIA, LAND A; L.P. ACTIVITY CSTA.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
CORN SILAGE	TONS	0.0	13.80	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
CORN SEED	LBS.	0.50	13.44	6.72
NITROGEN	LBS.	0.27	169.00	45.63
PHOSPHATE	LBS.	0.27	67.00	18.09
POTASH	LBS.	0.10	100.00	10.00
LIME	TONS	13.50	0.50	6.75
ATRAZINE	LBS.	3.50	2.50	8.75
MACHINERY	ACRE	0.40	1.00	0.40
TRACTORS	ACRE	1.97	1.00	1.97
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	1.14	0.0
INTEREST ON OP. CAP.	DOL.	0.08	40.96	3.28
SUBTOTAL, PRE-HARVEST				101.59
HARVEST COSTS				
MACHINERY	ACRE	4.28	1.00	4.28
TRACTORS	ACRE	3.80	1.00	3.80
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	2.27	0.0
SUBTOTAL, HARVEST				8.07
TOTAL VARIABLE COST				109.66
3. INCOME ABOVE VARIABLE COSTS				-109.66
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	15.54	1.00	15.54
TRACTORS	ACRE	8.26	1.00	8.26
TOTAL FIXED COSTS				23.80
5. TOTAL VARIABLE & FIXED COSTS				133.47
6. RETURN OVER VARIABLE & FIXED COSTS				-133.47
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				133.47
9. NET RETURN TO LAND & RISK				-133.47

NOTE: SILAGE HAULED 1 MILE.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 7. CORN FOR SILAGE, CONVENTIONAL TILL, 8.28 TONS YIELD AS FED.
9.0 TONS FIELD YIELD LESS 8% STORAGE LOSS.
BOTETOURT COUNTY, VIRGINIA, LAND A; L.P. ACTIVITY CLTA.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
SILAGE	TONS	0.0	8.28	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
CORN SEED	LBS.	0.50	13.44	6.72
NITROGEN	LBS.	0.27	56.33	15.21
PHOSPHATE	LBS.	0.27	67.00	18.09
POTASH	LBS.	0.10	100.00	10.00
LIME	TONS	13.50	0.50	6.75
ATRAZINE	LBS.	3.50	0.83	2.90
MACHINERY	ACRE	0.40	1.00	0.40
TRACTORS	ACRE	1.97	1.00	1.97
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	1.14	0.0
INTEREST ON OP. CAP.	DOL.	0.08	25.85	2.07
SUBTOTAL, PRE-HARVEST				64.11
HARVEST COSTS				
MACHINERY	ACRE	3.62	1.00	3.62
TRACTORS	ACRE	2.94	1.00	2.94
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	1.68	0.0
SUBTOTAL, HARVEST				6.56
TOTAL VARIABLE COST				70.67
3. INCOME ABOVE VARIABLE COSTS				-70.67
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	13.69	1.00	13.69
TRACTORS	ACRE	7.00	1.00	7.00
TOTAL FIXED COSTS				20.69
5. TOTAL VARIABLE & FIXED COSTS				91.36
6. RETURN OVER VARIABLE & FIXED COSTS				-91.36
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				91.36
9. NET RETURN TO LAND & RISK				-91.36

NOTE: THIS BUDGET IS SAME AS CSTA EXCEPT ENERGY INPUTS REDUCED BY 2/3; YIELD BY 2/5.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 8. CORN FOR SILAGE, CONVENTIONAL TILL, 11.96 TONS YIELD AS FED.
13.0 TONS FIELD YIELD LESS 8% STORAGE LOSS.
BOTETOURT COUNTY, VIRGINIA; LAND B; L.P. ACTIVITY CSTB.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
CORN SILAGE	TONS	0.0	11.96	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
CORN SEED	LBS.	0.50	12.32	6.16
NITROGEN	LBS.	0.27	145.00	39.15
PHOSPHATE	LBS.	0.27	61.00	16.47
POTASH	LBS.	0.10	92.00	9.20
LIME	TONS	13.50	0.50	6.75
ATRAZINE	LBS.	3.50	2.50	8.75
MACHINERY	ACRE	0.40	1.00	0.40
TRACTORS	ACRE	1.97	1.00	1.97
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	1.14	0.0
INTEREST ON OP. CAP.	DOL.	0.08	37.02	2.96
SUBTOTAL, PRE-HARVEST				91.81
HARVEST COSTS				
MACHINERY	ACRE	4.06	1.00	4.06
TRACTORS	ACRE	3.51	1.00	3.51
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	2.07	0.0
SUBTOTAL, HARVEST				7.57
TOTAL VARIABLE COST				99.38
3. INCOME ABOVE VARIABLE COSTS				-99.38
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	14.93	1.00	14.93
TRACTORS	ACRE	7.84	1.00	7.84
TOTAL FIXED COSTS				22.77
5. TOTAL VARIABLE & FIXED COSTS				122.15
6. RETURN OVER VARIABLE & FIXED COSTS				-122.15
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				122.15
9. NET RETURN TO LAND & RISK				-122.15

NOTE: SILAGE HAULED 1 MILE.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 9. CORN FOR SILAGE, REDUCED TILL, 15.18 TONS YIELD AS FED.
16.5 TONS FIELD YIELD LESS 8% STORAGE LOSS.
BOTETOURT COUNTY, VIRGINIA, LAND A; L.P. ACTIVITY CSNA.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
CORN SILAGE	TONS	0.0	15.18	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
CORN SEED	LBS.	0.50	14.05	7.02
NITROGEN	LBS.	0.27	188.00	50.76
PHOSPHATE	LBS.	0.27	79.00	21.33
POTASH	LBS.	0.10	120.00	12.00
LIME	TONS	13.50	0.50	6.75
ATRAZINE	LBS.	3.50	2.50	8.75
PARAQUAT	PT.	7.00	1.00	7.00
FURADAN	LBS.	0.67	10.00	6.70
SEVIN	LBS.	1.50	0.50	0.75
RYE SEED	BU.	5.95	1.00	5.95
MACHINERY	ACRE	0.59	1.00	0.59
TRACTORS	ACRE	1.24	1.00	1.24
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	0.88	0.0
INTEREST ON OP. CAP.	DOL.	0.08	36.92	2.95
SUBTOTAL, PRE-HARVEST				131.80
HARVEST COSTS				
MACHINERY	ACRE	4.44	1.00	4.44
TRACTORS	ACRE	4.01	1.00	4.01
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	2.42	0.0
SUBTOTAL, HARVEST				8.45
TOTAL VARIABLE COST				140.25
3. INCOME ABOVE VARIABLE COSTS				-140.25
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	16.82	1.00	16.82
TRACTORS	ACRE	7.57	1.00	7.57
TOTAL FIXED COSTS				24.39
5. TOTAL VARIABLE & FIXED COSTS				164.64
6. RETURN OVER VARIABLE & FIXED COSTS				-164.64
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				164.64
9. NET RETURN TO LAND & RISK				-164.64

NOTE: SILAGE HAULED 1 MILE.
APPLY 2 LBS. SEVIN 50% WP EVERY 4 YEARS. SEED RYE WITH FERT.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 10. CORN FOR SILAGE, REDUCED TILL, 9.11 TONS YIELD AS FED.
9.9 TONS FIELD YIELD LESS 8% STORAGE LOSS.
BOTETOURT COUNTY, VIRGINIA, LAND A; L.P. ACTIVITY CLNA.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
SILAGE	TONS	0.0	9.11	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
CORN SEED	LBS.	0.50	14.05	7.02
NITROGEN	LBS.	0.27	62.67	16.92
PHOSPHATE	LBS.	0.27	79.00	21.33
POTASH	LBS.	0.10	120.00	12.00
LIME	TONS	13.50	0.50	6.75
ATRAZINE	LBS.	3.50	0.83	2.90
PARAQUAT	PT.	7.00	0.33	2.31
FURADAN	LBS.	0.67	3.30	2.21
SEVIN	LBS.	1.50	0.17	0.25
RYE SEED	BU.	5.95	1.00	5.95
MACHINERY	ACRE	0.59	1.00	0.59
TRACTORS	ACRE	1.24	1.00	1.24
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	0.88	0.0
INTEREST ON OP. CAP.	DOL.	0.08	16.39	1.31
SUBTOTAL, PRE-HARVEST				80.80
HARVEST COSTS				
MACHINERY	ACRE	3.72	1.00	3.72
TRACTORS	ACRE	3.08	1.00	3.08
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	1.77	0.0
SUBTOTAL, HARVEST				6.80
TOTAL VARIABLE COST				87.60
3. INCOME ABOVE VARIABLE COSTS				-87.60
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	14.80	1.00	14.80
TRACTORS	ACRE	6.19	1.00	6.19
TOTAL FIXED COSTS				20.99
5. TOTAL VARIABLE & FIXED COSTS				108.59
6. RETURN OVER VARIABLE & FIXED COSTS				-108.59
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				108.59
9. NET RETURN TO LAND & RISK				-108.59

NOTE: THIS BUDGET IS SAME AS CSNA EXCEPT ENERGY INPUTS REDUCED BY 2/3; YIELD BY 2/5.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 11. CORN FOR SILAGE, REDUCED TILL, 12.88 TONS AS FED.
14.0 TONS FIELD LESS 8% STORAGE LOSS.
BOTETOURT COUNTY, VIRGINIA; LAND B; L.P. ACTIVITY CSNB.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
CORN SILAGE	TONS	0.0	12.88	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
CORN SEED	LBS.	0.50	12.50	6.25
NITROGEN	LBS.	0.27	166.00	44.82
PHOSPHATE	LBS.	0.27	69.00	18.63
POTASH	LBS.	0.10	104.00	10.40
LIME	TONS	13.50	0.50	6.75
ATRAZINE	LBS.	3.50	2.50	8.75
PARAQUAT	PT.	7.00	1.00	7.00
FURADAN	LBS.	0.67	10.00	6.70
SEVIN	LBS.	1.50	0.50	0.75
RYE SEED	BU.	5.95	1.00	5.95
MACHINERY	ACRE	0.59	1.00	0.59
TRACTORS	ACRE	1.24	1.00	1.24
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	0.88	0.0
INTEREST ON OP. CAP.	DOL.	0.08	34.12	2.73
SUBTOTAL, PRE-HARVEST				120.56
HARVEST COSTS				
MACHINERY	ACRE	4.17	1.00	4.17
TRACTORS	ACRE	3.65	1.00	3.65
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	2.17	0.0
SUBTOTAL, HARVEST				7.82
TOTAL VARIABLE COST				128.38
3. INCOME ABOVE VARIABLE COSTS				-128.38
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	16.05	1.00	16.05
TRACTORS	ACRE	7.05	1.00	7.05
TOTAL FIXED COSTS				23.10
5. TOTAL VARIABLE & FIXED COSTS				151.48
6. RETURN OVER VARIABLE & FIXED COSTS				-151.48
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				151.48
9. NET RETURN TO LAND & RISK				-151.48

NOTE: SILAGE HAULED 1 MILE.
APPLY 2 LBS. SEVIN 50% WP EVERY 4 YEARS. SEED RYE WITH FERT.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 12. ALFALFA SILAGE, 4.75 TONS YIELD AS FED.
5.16 TONS FIELD LESS 8% STORAGE LOSS.
BOTETOURT COUNTY, VIRGINIA; LAND B; L.P. ACTIVITY ASCB.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
SILAGE	TONS	0.0	4.75	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
ESTAB. COSTS	ACRE	22.09	1.00	22.09
PHOSPHATE	LBS.	0.27	60.00	16.20
POTASH	LBS.	0.10	180.00	18.00
BORON	LBS.	0.23	3.00	0.69
LIME	TONS	13.50	0.50	6.75
MACHINERY	ACRE	0.08	1.00	0.08
TRACTORS	ACRE	0.16	1.00	0.16
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	0.16	0.0
INTEREST ON OP. CAP.	DOL.	0.08	41.19	3.29
SUBTOTAL, PRE-HARVEST				67.26
HARVEST COSTS				
MACHINERY	ACRE	10.05	1.00	10.05
TRACTORS	ACRE	7.88	1.00	7.88
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	4.66	0.0
INTEREST ON OP. CAP.	DOL.	0.08	3.01	0.24
SUBTOTAL, HARVEST				18.17
TOTAL VARIABLE COST				85.43
3. INCOME ABOVE VARIABLE COSTS				-85.43
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	35.17	1.00	35.17
TRACTORS	ACRE	11.47	1.00	11.47
TOTAL FIXED COSTS				46.64
5. TOTAL VARIABLE & FIXED COSTS				132.06
6. RETURN OVER VARIABLE & FIXED COSTS				-132.06
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				132.06
9. NET RETURN TO LAND & RISK				-132.06

NOTE: ESTAB. COSTS ARE NET RETURN TO LAND AND RISK FROM ESTAB. BUDGET PRORATED OVER 5 YEARS WITH 8% INTEREST. SILAGE HAULED 1 MILE. PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 13. ALFALFA HAY, 3.25 TONS YIELD.
BOTETOURT COUNTY, VIRGINIA; LAND B; L.P. ACTIVITY AHCB.
HAUL HAY 1 MILE.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
ALFALFA	TONS	0.0	3.25	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
ESTAB. COSTS	ACRE	22.09	1.00	22.09
PHOSPHATE	LBS.	0.27	60.00	16.20
POTASH	LBS.	0.10	180.00	18.00
BORON	LBS.	0.23	3.00	0.69
LIME	TONS	13.50	0.50	6.75
MACHINERY	ACRE	0.08	1.00	0.08
TRACTORS	ACRE	0.16	1.00	0.16
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	0.16	0.0
OTHER LABOR	HOUR	0.0	10.26	0.0
INTEREST ON OP. CAP.	DOL.	0.08	41.19	3.29
SUBTOTAL, PRE-HARVEST				67.26
HARVEST COSTS				
TWINE	TONS	1.15	3.25	3.74
MACHINERY	ACRE	7.73	1.00	7.73
TRACTORS	ACRE	4.84	1.00	4.84
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	5.11	0.0
INTEREST ON OP. CAP.	DOL.	0.08	2.86	0.23
SUBTOTAL, HARVEST				16.54
TOTAL VARIABLE COST				83.80
3. INCOME ABOVE VARIABLE COSTS				-83.80
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	30.86	1.00	30.86
TRACTORS	ACRE	7.19	1.00	7.19
TOTAL FIXED COSTS				38.04
5. TOTAL VARIABLE & FIXED COSTS				121.85
6. RETURN OVER VARIABLE & FIXED COSTS				-121.85
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				121.85
9. NET RETURN TO LAND & RISK				-121.85

NOTE: ESTAB. COSTS ARE NET RETURN TO LAND AND RISK FROM ESTAB. BUDGET PRORATED OVER 5 YEARS WITH 8% INTEREST.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 14. ALFALFA HAY, 2.42 TONS YIELD.
BOTETOURT COUNTY, VIRGINIA; LAND C; L.P. ACTIVITY AHCC.
HAUL HAY 1 MILE.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
ALFALFA	TONS	0.0	2.42	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
ESTAB. COSTS	ACRE	22.09	1.00	22.09
PHOSPHATE	LBS.	0.27	50.00	13.50
POTASH	LBS.	0.10	140.00	14.00
BORON	LBS.	0.23	3.00	0.69
LIME	TONS	13.50	0.50	6.75
MACHINERY	ACRE	0.08	1.00	0.08
TRACTORS	ACRE	0.16	1.00	0.16
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	0.16	0.0
OTHER LABOR	HOUR	0.0	9.14	0.0
INTEREST ON OP. CAP.	DOL.	0.08	37.84	3.03
SUBTOTAL, PRE-HARVEST				60.29
HARVEST COSTS				
TWINE	TONS	1.15	2.42	2.78
MACHINERY	ACRE	7.00	1.00	7.00
TRACTORS	ACRE	4.79	1.00	4.79
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	4.56	0.0
INTEREST ON OP. CAP.	DOL.	0.08	2.53	0.20
SUBTOTAL, HARVEST				14.78
TOTAL VARIABLE COST				75.07
3. INCOME ABOVE VARIABLE COSTS				-75.07
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	28.46	1.00	28.46
TRACTORS	ACRE	7.11	1.00	7.11
TOTAL FIXED COSTS				35.58
5. TOTAL VARIABLE & FIXED COSTS				110.64
6. RETURN OVER VARIABLE & FIXED COSTS				-110.64
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				110.64
9. NET RETURN TO LAND & RISK				-110.64

NOTE: ESTAB. COSTS ARE NET RETURN TO LAND AND RISK FROM ESTAB. BUDGET PRORATED OVER 5 YEARS WITH 8% INTEREST.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 15. ORCHARD GRASS/RED CLOVER HAY, 2.42 TONS YIELD.
BOTETOURT COUNTY, VIRGINIA; LAND 8; L.P. ACTIVITY MHC8.
HAUL HAY 1 MILE.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FRCM PRCDUCTION		($)		($)
HAY	TONS	0.0	2.42	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
ESTAB. COSTS	ACRE	11.12	1.00	11.12
CLOVER SEED	LBS.	1.03	2.50	2.57
PHOSPHATE	LBS.	0.27	70.00	18.90
POTASH	LBS.	0.10	150.00	15.00
LIME	TONS	13.50	0.50	6.75
MACHINERY	ACRE	0.12	1.00	0.12
TRACTORS	ACRE	0.20	1.00	0.20
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	0.20	0.0
OTHER LABOR	HOUR	0.0	7.16	0.0
INTEREST ON OP. CAP.	DOL.	0.08	18.30	1.46
SUBTOTAL, PRE-HARVEST				56.12
HARVEST COSTS				
TWINE	TONS	1.15	2.42	2.78
MACHINERY	ACRE	5.37	1.00	5.37
TRACTORS	ACRE	3.24	1.00	3.24
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	3.57	0.0
INTEREST ON OP. CAP.	DOL.	0.08	1.35	0.11
SUBTOTAL, HARVEST				11.51
TOTAL VARIABLE COST				67.63
3. INCOME ABOVE VARIABLE CCSTS				-67.63
4. FIXED (OWNERSHIP) CCSTS				
MACHINERY	ACRE	21.86	1.00	21.86
TRACTORS	ACRE	4.95	1.00	4.95
TOTAL FIXED COSTS				26.80
5. TOTAL VARIABLE & FIXED COSTS				94.44
6. RETURN OVER VARIABLE & FIXED COSTS				-94.44
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				94.44
9. NET RETURN TO LAND & RISK				-94.44

NOTE: ESTAB. COSTS ARE NET RETURN TO LAND AND RISK FROM ESTAB. BUDGET PRORATED OVER 5 YEARS WITH 8% INTEREST. SEED CLOVER BIANNUALLY. PREPARED BY BOB BURTCN FOR M.S. RESEARCH, 1976.

TABLE 16. ORCHARD GRASS/RED CLOVER HAY, 1.84 TONS YIELD.
BOTETOURT COUNTY, VIRGINIA; LAND C; L.P. ACTIVITY MHCC.
HAUL HAY 1 MILE.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
HAY	TONS	0.0	1.84	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
ESTAB. COSTS	ACRE	11.12	1.00	11.12
CLOVER SEED	LBS.	1.03	2.50	2.57
PHOSPHATE	LBS.	0.27	50.00	13.50
POTASH	LBS.	0.10	130.00	13.00
LIME	TONS	13.50	0.50	6.75
MACHINERY	ACRE	0.12	1.00	0.12
TRACTORS	ACRE	0.20	1.00	0.20
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	0.20	0.0
OTHER LABOR	HOUR	0.0	6.40	0.0
INTEREST ON OP. CAP.	DOL.	0.08	16.45	1.32
SUBTOTAL, PRE-HARVEST				48.57
HARVEST COSTS				
TWINE	TONS	1.15	1.84	2.12
MACHINERY	ACRE	4.86	1.00	4.86
TRACTORS	ACRE	3.21	1.00	3.21
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	3.19	0.0
INTEREST ON OP. CAP.	DOL.	0.08	1.22	0.10
SUBTOTAL, HARVEST				10.29
TOTAL VARIABLE COST				58.86
3. INCOME ABOVE VARIABLE COSTS				-58.86
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	20.20	1.00	20.20
TRACTORS	ACRE	4.90	1.00	4.90
TOTAL FIXED COSTS				25.10
5. TOTAL VARIABLE & FIXED COSTS				83.96
6. RETURN OVER VARIABLE & FIXED COSTS				-83.96
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				83.96
9. NET RETURN TO LAND & RISK				-83.96

NOTE: ESTAB. COSTS ARE NET RETURN TO LAND AND RISK FROM ESTAB. BUDGET PRORATED OVER 5 YEARS WITH 8% INTEREST. SEED CLOVER BIANNUALLY. PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 17. BLUE GRASS/WHITE CLOVER PASTURE, 2.3 TONS YIELD.
BOTETOURT COUNTY, VIRGINIA; LAND D; L.P. ACTIVITY PTCD.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
NATIVE PASTURE	TONS	0.0	2.30	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
PHOSPHATE	LBS.	0.27	25.00	6.75
POTASH	LBS.	0.10	25.00	2.50
LIME	TONS	13.50	0.17	2.29
2-4-D	LBS.	2.24	0.50	1.12
MACHINERY	ACRE	0.08	1.00	0.08
TRACTORS	ACRE	0.23	1.00	0.23
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	0.23	0.0
INTEREST ON OP. CAP.	DOL.	0.08	7.63	0.61
SUBTOTAL, PRE-HARVEST				13.58
HARVEST COSTS				
SUBTOTAL, HARVEST				0.0
TOTAL VARIABLE COST				13.58
3. INCOME ABOVE VARIABLE COSTS				-13.58
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	0.89	1.00	0.89
TRACTORS	ACRE	0.34	1.00	0.34
TOTAL FIXED COSTS				1.23
5. TOTAL VARIABLE & FIXED COSTS				14.81
6. RETURN OVER VARIABLE & FIXED COSTS				-14.81
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				14.81
9. NET RETURN TO LAND & RISK				-14.81

NOTE: 75 LBS. P2O5; 75 LBS. K2O; 1/2 TON LIME; 1.5 LBS. 2,4,D; APPLIED EVERY 3 YEARS. CLIP EVERY 2 YEARS.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 18. BARLEY SILAGE/CORN SILAGE, CONVENTIONAL TILL, B-6.44;C-10.35 TONS AS FED. FIELD YIELD B-7 AND C-11.25 TONS, 8% STOR. LOSS. BOTETOURT COUNTY, VIRGINIA; LAND A; L.P. ACTIVITY DCTA.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
CORN SILAGE	TONS	0.0	10.35	0.0
S. G. SILAGE	TONS	0.0	6.44	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
CORN SEED	LBS.	0.50	13.44	6.72
NITROGEN	LBS.	0.27	239.00	64.53
PHOSPHATE	LBS.	0.27	117.00	31.59
POTASH	LBS.	0.10	150.00	15.00
LIME	TONS	13.50	0.50	6.75
ATRAZINE	LBS.	3.50	2.50	8.75
BARLEY SEED	BU.	4.99	2.00	9.98
MACHINERY	ACRE	0.78	1.00	0.78
TRACTORS	ACRE	3.77	1.00	3.77
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	2.21	0.0
INTEREST ON OP. CAP.	DOL.	0.08	40.78	3.26
SUBTOTAL, PRE-HARVEST				151.13
HARVEST COSTS				
MACHINERY	ACRE	6.50	1.00	6.50
TRACTORS	ACRE	5.77	1.00	5.77
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	3.31	0.0
INTEREST ON OP. CAP.	DOL.	0.08	1.71	0.14
SUBTOTAL, HARVEST				12.41
TOTAL VARIABLE COST				163.54
3. INCOME ABOVE VARIABLE COSTS				-163.54
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	25.27	1.00	25.27
TRACTORS	ACRE	13.59	1.00	13.59
TOTAL FIXED COSTS				38.86
5. TOTAL VARIABLE & FIXED COSTS				202.40
6. RETURN OVER VARIABLE & FIXED COSTS				-202.40
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				202.40
9. NET RETURN TO LAND & RISK				-202.40

NOTE: USE BARSOY BARLEY, CORN YIELD CUT 25% DUE TO RISK.
SILAGE HAULED 1 MILE.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 19. BARLEY SILAGE/CORN SILAGE, CONVENTIONAL TILL, B-6.44;C-8.97 TONS AS FED. FIELD YIELD B-7 AND C-9.75 TONS, 8% STOR. LOSS. BOTETOURT COUNTY, VIRGINIA; LAND B; L.P. ACTIVITY OCTB.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
CORN SILAGE	TONS	0.0	8.97	0.0
S. G. SILAGE	TONS	0.0	6.44	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
CORN SEED	LBS.	0.50	12.32	6.16
NITROGEN	LBS.	0.27	215.00	58.05
PHOSPHATE	LBS.	0.27	111.00	29.97
POTASH	LBS.	0.10	142.00	14.20
LIME	TONS	13.50	0.50	6.75
ATRAZINE	LBS.	3.50	2.50	8.75
BARLEY SEED	BU.	4.99	2.00	9.98
MACHINERY	ACRE	0.78	1.00	0.78
TRACTORS	ACRE	3.77	1.00	3.77
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	2.21	0.0
INTEREST ON OP. CAP.	DOL.	0.08	37.63	3.01
SUBTOTAL, PRE-HARVEST				141.42
HARVEST COSTS				
MACHINERY	ACRE	6.34	1.00	6.34
TRACTORS	ACRE	5.56	1.00	5.56
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	3.16	0.0
INTEREST ON OP. CAP.	DOL.	0.08	1.71	0.14
SUBTOTAL, HARVEST				12.03
TOTAL VARIABLE COST				153.45
3. INCOME ABOVE VARIABLE COSTS				-153.45
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	24.81	1.00	24.81
TRACTORS	ACRE	13.28	1.00	13.28
TOTAL FIXED COSTS				38.08
5. TOTAL VARIABLE & FIXED COSTS				191.54
6. RETURN OVER VARIABLE & FIXED COSTS				-191.54
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				191.54
9. NET RETURN TO LAND & RISK				-191.54

NOTE: USE BARSOY BARLEY, CORN YIELD CUT 25% DUE TO RISK.
SILAGE HAULED 1 MILE.
PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 20. BARLEY SILAGE/CORN SILAGE, REDUCED TILL, B-6.44; C-11.39 TONS AS FED. FIELD YIELD B-7 AND C-12.38 TONS, 8% STOR. LOSS. BOTETOURT COUNTY, VIRGINIA; LAND A; L.P. ACTIVITY DCNA.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
CORN SILAGE	TONS	0.0	11.39	0.0
S. G. SILAGE	TONS	0.0	6.44	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
CORN SEED	LBS.	0.50	14.05	7.02
NITROGEN	LBS.	0.27	258.00	69.66
PHOSPHATE	LBS.	0.27	129.00	34.83
POTASH	LBS.	0.10	170.00	17.00
LIME	TONS	13.50	0.50	6.75
ATRAZINE	LBS.	3.50	2.50	8.75
PARAQUAT	PT.	7.00	1.00	7.00
FURADAN	LBS.	0.67	10.00	6.70
SEVIN	LBS.	1.50	0.50	0.75
BARLEY SEED	BU.	4.99	2.00	9.98
MACHINERY	ACRE	0.81	1.00	0.81
TRACTORS	ACRE	2.39	1.00	2.39
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	1.56	0.0
INTEREST ON OP. CAP.	DOL.	0.08	48.64	3.89
SUBTOTAL, PRE-HARVEST				175.54
HARVEST COSTS				
MACHINERY	ACRE	6.62	1.00	6.62
TRACTORS	ACRE	5.92	1.00	5.92
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	3.42	0.0
INTEREST ON OP. CAP.	DOL.	0.08	1.71	0.14
SUBTOTAL, HARVEST				12.68
TOTAL VARIABLE COST				188.22
3. INCOME ABOVE VARIABLE COSTS				-188.22
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	25.43	1.00	25.43
TRACTORS	ACRE	11.89	1.00	11.89
TOTAL FIXED COSTS				37.32
5. TOTAL VARIABLE & FIXED COSTS				225.54
6. RETURN OVER VARIABLE & FIXED COSTS				-225.54
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				225.54
9. NET RETURN TO LAND & RISK				-225.54

NOTE: USE BARSOY BARLEY, CORN YIELD CUT 25% DUE TO RISK. HAUL 1 MILE. APPLY 2 LBS. SEVIN 50% WP EVERY 4 YEARS. SEED RYE WITH FERT. PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

TABLE 21. BARLEY SILAGE/CORN SILAGE, REDUCED TILL, B-6.44;C-9.66 TONS AS FED. FIELD YIELD B-7 AND C-10.5 TONS, 8% STOR. LOSS. BOTETOURT COUNTY, VIRGINIA; LAND B; L.P. ACTIVITY DCNB.

CATEGORY	UNIT	PRICE	QUANTITY PER ACRE	VALUE OR COST
1. GROSS RECEIPTS FROM PRODUCTION		($)		($)
CORN SILAGE	TONS	0.0	9.66	0.0
S. G. SILAGE	TONS	0.0	6.44	0.0
TOTAL RECEIPTS				0.0
2. VARIABLE COSTS				
PREHARVEST				
CORN SEED	LBS.	0.50	12.50	6.25
NITROGEN	LBS.	0.27	236.00	63.72
PHOSPHATE	LBS.	0.27	119.00	32.13
POTASH	LBS.	0.10	154.00	15.40
LIME	TONS	13.50	0.50	6.75
ATRAZINE	LBS.	3.50	2.50	8.75
PARAQUAT	PT.	7.00	1.00	7.00
FURADAN	LBS.	0.67	10.00	6.70
SEVIN	LBS.	1.50	0.50	0.75
BARLEY SEED	BU.	4.99	2.00	9.98
MACHINERY	ACRE	0.81	1.00	0.81
TRACTORS	ACRE	2.39	1.00	2.39
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	1.56	0.0
INTEREST ON OP. CAP.	DOL.	0.08	44.97	3.60
SUBTOTAL, PRE-HARVEST				164.23
HARVEST COSTS				
MACHINERY	ACRE	6.42	1.00	6.42
TRACTORS	ACRE	5.66	1.00	5.66
LABOR(TRACTOR & MACHINERY)	HOUR	0.0	3.24	0.0
INTEREST ON OP. CAP.	DOL.	0.08	1.71	0.14
SUBTOTAL, HARVEST				12.22
TOTAL VARIABLE COST				176.45
3. INCOME ABOVE VARIABLE COSTS				-176.45
4. FIXED (OWNERSHIP) COSTS				
MACHINERY	ACRE	24.86	1.00	24.86
TRACTORS	ACRE	11.50	1.00	11.50
TOTAL FIXED COSTS				36.37
5. TOTAL VARIABLE & FIXED COSTS				212.81
6. RETURN OVER VARIABLE & FIXED COSTS				-212.81
7. MANAGEMENT & OVERHEAD CHARGE (5% OF GROSS)				0.0
8. TOTAL OF ABOVE COSTS				212.81
9. NET RETURN TO LAND & RISK				-212.81

NOTE: USE BARSOY BARLEY, CORN YIELD CUT 25% DUE TO RISK. HAUL 1 MILE. APPLY 2 LBS. SEVIN 50% WP EVERY 4 YEARS. SEED RYE WITH FERT. PREPARED BY BOB BURTON FOR M.S. RESEARCH, 1976.

APPENDIX E

Liquid Fuel Use Information

Table 1. Summary of Liquid Fuel Use Associated With Each Crop Budget.

Crop budget[a] identification	Gasoline (gallons)	Diesel (gallons)	Liquid petroleum gas (gallons)
1. CGTA	3.25	3.75	20.02
2. CGTB	3.06	3.75	16.02
3. CGNA	3.39	1.91	23.02
4. CGNB	3.20	1.91	19.02
5. WGCB	1.69	4.15	
6. CSTA		8.87	
7. CLTA		7.59	
8. CSTB		8.45	
9. CSNA		8.05	
10. CLNA		6.64	
11. CSNB		7.51	
12. ASCB		12.41	
13. AHCB	.41	7.69	
14. AHCC	.30	7.61	
15. MHCB	.30	5.29	
16. MHCC	.23	5.24	
17. PTCD		.35	
18. DCTA		14.75	
19. DCTB		14.43	
20. DCNA		12.81	
21. DCNB		12.42	

[a] These budget identifications are listed in the same order as the budgets appear in Appendix D.

Table 2. Quantities of Fuel Charged to Fuel Using Operations in Crop Budgets[a]

Fuel using operation	Size of operation	Type of fuel	Quantity of fuel (gallons)
Shred corn stalks	1 acre[b]	Diesel	.700
Plow, 7' chisel plow	1 acre	Diesel	1.423
Spread fertilizer	1 acre	Diesel	.242
Disk, 10.5' tandem	1 acre	Diesel	.781
Plant corn, conventional	1 acre	Diesel	.464
Spray pesticides	1 acre	Diesel	.141
Combine corn	1 acre	Gasoline	2.309
Haul corn 1 mile[c]	100 bu.	Gasoline	.540
Dry corn[d]	100 bu.	L. P. gas	20.020
Plant corn, no tillage	1 acre	Diesel	.464
Plant small grain (drill)	1 acre	Diesel	.365
Combine small grain	1 acre	Gasoline	1.484
Haul wheat 1 mile[c]	35 bu.	Gasoline	.203
Store corn (grain auger)	100 bu.	Gasoline	.400
Rake hay or straw	1 acre	Diesel	.369
Bale straw	1 acre	Diesel	.877
Haul hay or straw 1 mile[c]	1 ton	Diesel	.091
Harvest corn silage	1 acre	Diesel	2.618
Store silage (blower)	15 tons	Diesel	1.476
Haul silage 1 mile[c]	15 tons	Diesel	1.729
Mow and condition hay	1 acre	Diesel	.854
Harvest alfalfa silage	1 acre	Diesel	2.466
Bale hay	1 acre	Diesel	1.161
Store hay (elevator)	1 ton	Gasoline	.124
Clip pasture	1 acre	Diesel	.454
Harvest small grain silage	1 acre	Diesel	2.367

[a] There is much variability in the amount of fuel used for similar operations in different farm situations. Where possible the information in this table was checked and adjusted for reasonableness using Walker, J. N., "Energy Usage in Crop Systems," Energy in Agriculture, Proceedings of Conference-Workshop in Atlanta, Georgia, October 1-3, 1975, Southern Regional Education Board, 130 Sixth Street, N. W. Atlanta, Georgia 30313, pp. 48-50.

[b] One acre here means that the operation is completed only once. Note that alfalfa is harvested 3 times and mixed hay 2 times each year.

[c] This 1 mile represents field to farmstead hauling. Hauling additional miles on hard surface roads would require less fuel per mile.

[d] Corn is dried from 25 to 15 percent moisture.

APPENDIX F

Overview of Linear Programming Model

TABLE 1. SUMMARY OF THE LINEAR PROGRAMMING MODEL USING A PICTURE OF THE LINEAR PROGRAMMING MATRIX.

		DAIRYS	DAIRYL	CGTA	CGTB	GRIDMIX	WGCB	CSTA	CLTA	CSTB	ASHCB	AHCB	AHCC	MHCB	MHCC	PTCD	CTPXFER	DCTA	DCTB	LABORDM	LABORAM	LABORJA	LABORSON	CGNA	CGNB	CSNA	CLNA	CSNB	DCNA	DCNB	SBMLCWT	BUYCORN	BUYAHAY	BYMIXHAY	RHS1	RHSP	CHG1
RETURNS	N	D	D	-B	-B	-T	-B	-C	-B	-B	-B	-B	-B	-B	-B	-B	-B	-C	-C	-A	-A	-A	-A	-C	-C	-C	-B	-C	-C	-C	-A	-A	-B	-B			
CHRETRNS	N	A	A	-B	-B		-A	-B	-A	-B	-A	-T	-T	-T	-T	-T		-B	-B					-B	-B	-B	-A	-B	-B	-B							
CHBYFEED	N																														-A	-T	-B	-B			
DMLOW	L	E	E	-D	-D		-D	-E	-D	-C	-C	-C	-D	-C	-D	-D		-E	-E					-D	-D	-E	-D	-D	-E	-E	-B	-B	-D	-D			
CPLOW	L	D	D	-C	-C		-C	-C	-C	-C	-C	-C	-C	-C	-C	-C		-C	-C					-C	-C	-C	-C	-C	-D	-C	-B	-A	-C	-C			
CFHIGH	G	D	D	-C	-B		-B	-D	-D	-C	-D	-D	-D	-D	-C	-C		-D	-D					-C	-C	-C	-D	-D	-D	-D	-A	-A	-C	-C			
CFLOW	L	D	D	-C	-B		-B	-C	-D	-D	-C	-D	-D	-D	-C	-C		-D	-D					-C	-C	-C	-C	-D	-D	-D	-A	-A	-C	-C			
COWS	E	1	1																																B	B	
PASTRAC	L															1																			C	C	
NITRO	L	-B	-B	C	C		B	C	B	C								C	C					C	C	C	B	C	C	C					E	E	-D
P2O5	N	-B	-B	B	B		B	B	B	B	B	B	B	B	B	B		C	C					B	B	B	B	B	C	C							
K2O	N	-B	-C	B	B		B	B	B	B	C	C	C	C	C	B		C	C					B	B	C	C	C	C	C							
LANDA	L			1				1	1									1						1		1	1		1						B	B	
LANDAB	L			1	1		1	1	1	1	1	1		1				1	1					1	1	1	1	1	1	1					C	C	
LANDABC	L			1	1		1	1	1	1	1	1	1	1	1		1	1	1					1	1	1	1	1	1	1					C	C	
LANDD	L															1	-1																		C	C	
BRCWCROP	L				1					1									1											1					B	B	
LABDJFM	L	B	B				T				T	T	T	T	T			T	T	-1									T	T					D	D	
LABAM	L	A	A	A	A			A	A	A	A	A	A	A	A			A	A		-1			T	T	T	T	T	A	A					D	D	
LABJJA	L	B	B				A				A	A	A	A	A	T						-1							U	U					D	D	
LABSON	L	B	B	A	A		T	A	A	A	A	A	A			U		A	A				-1	A	A	A	A	A	A	A					D	D	
MIXGRND	L			B	B	-1																		C	B							1					
GASOLINE	L			A	A		A					T	T	T	T									A	A										C	C	-B
LP	L			B	B																			B	B										D	D	-C
DIESEL	L			A	A		A	A	A	A	B	A	A	A	A	T		B	B					A	A	A	A	A	B	B					D	D	-C
ATRAZINE	L			A	A			A	T	A								A	A					A	A	A	T	A	A	A					C	C	-B
PARAQUAT	L																							1	1	1	T	1	1	1					C	C	-B
FURADAN	L																							A	A	A	A	A	A	A					D	D	-C
SEVIN	L																							T	T	T	T	T	T	T					B	B	-B
QTWOF	N															T																					
QNITR	N			C	C		B	C	B	C								C	C					C	C	C	B	C	C	C							
KFUEL	N			F	F		F	F	F	F	F	F	F	F	F	E		F	F					F	F	F	F	F	F	F							
KPEST	N			E	E			E	D	E						D		E	E					E	E	E	E	E	E	E							
KNITR	N	-F	-F	G	F		F	G	F	G								G	G					G	G	G	F	G	G	G							
CFUEL	N			B	A		A	A	A	A	A	A	A	A	A	T		A	A					B	A	A	A	A	A	A							
CPEST	N			A	A			A	A	A						A		A	A					B	B	B	A	B	B	B							
CNITR	N	-B	-B	B	B		B	B	B	B								B	B					B	B	B	B	B	B	B							
CTENG	N	-B	-B	B	B		B	B	B	B	A	A	A	A	A	A		B	B					B	B	B	B	B	B	B							
TQKCL	N	-F	-F	G	G		F	G	F	G	F	F	F	F	F	E		G	G					G	G	G	F	G	G	G							
TGSEQ	N	-B	-B	B	B		B	B	B	B	B	B	B	A	A	T		B	B					B	B	B	B	B	B	B							
ACOST	N	C	C	B	B	T	B	C	B	B	B	B	B	B	B	B	B	C	C	A	A	A	A	C	C	C	B	C	C	C	A	A	B	B			
BUCGN	N			B	B																			C	B												
BUWGN	N						B																														
TNCST	N							B	A	B								B	A							B	A	B	B	A							
TNDCB	N																	A	A										A	A							
TNAHN	N											A	A																								
TNMHN	N													A	A																						

TABLE 2. SUMMARY OF SIZE OF NUMBERS USED IN TABLE 1.

SYMBOL	FROM	TO	TIMES USED
U	.010000	.099999	3
T	.100000	.999999	43
1	1.000000	1.000000	68
A	1.000001	10.000000	149
B	10.000001	100.000000	190
C	100.000001	1,000.000000	114
D	1,000.000001	10,000.000000	73
E	10,000.000001	100,000.000000	25
F	100,000.000001	1,000,000.000000	36
G	GREATER THAN	1,000,000.000000	23

Table 3. Explanation of Linear Programming Rows.

RETURNS	- Returns to fixed resources
CHRETRNS	- Changes in returns due to a 25 percent increase in energy input prices.
CHBYFEED	- Changes in returns due to a 25 percent increase in purchased feed costs.
DMLOW, CPLOW, CFHIGH, and CFLOW	- Dairy feed restrictions described in Appendix C.
COWS	- Restricts the size of the dairy activity to a 100 cow herd.
PASTRAC	- Restricts pasture acreage to the amount needed to feed replacements and dry cows in initial model and model in which prices are increased.
NITRO	- Transfers nitrogen from the dairy herd to the crop activities and sets the restriction level on the amount of nitrogen available.
P_2O_5 and K_2O	- Transfer phosphate and potash from the dairy herd to the crop activities.
LANDA, LANDAB, LANDABC, and LANDD	- Set restrictions on the amounts of different types of land available.
BROWCROP	- Prohibits conventional tilled corn and conventional and reduce tilled double crop activities from being grown on the same land more often than one out of every three years when using land B.
LABDJFM, LABAM, LABJJA, LABSON	- Set restrictions on the amounts of seasonal labor available on the farm.
MIXGRND	- Ensures that mixing and grinding costs are charged whenever corn grain is fed.
GASOLINE, LP, DIESEL, ATRAZINE, PARAQUAT, FURADAN, SEVIN	- Set the restriction levels on the amounts available of liquid fuels and corn pesticides when quantities of these inputs are restricted.
QTWOF	- Sums the amount of 2, 4, D used.
QNITR	- Sums the amount of nitrogen used by the crops including nitrogen furnished by the dairy cows.
KFUEL, KPEST, KNITR	- Sum of number of kilocalories associated with fuel, pesticides, and nitrogen.
CFUEL, CPEST, CNITR	- Sum the cost of fuel, pesticides, and nitrogen.
CTENG	- Sums the total cost of fuel, pesticides, and nitrogen.
TQKCL	- Sums the total quantity of kilocalories associated with fuel, pesticides and nitrogen.

Table 3. Continued.

TGSEQ	- Sums the total gasoline equivalents associated with fuel, pesticides and nitrogen.
ACOST	- Annual costs, sums the variable costs of the farm operation.
BUCGN	- Sums the bushels of corn grain produced.
BUWGN	- Sums the bushels of wheat grain produced.
TNCST	- Sums the tons of corn silage produced.
TNDCB	- Sums the tons of barley silage produced.
TNAHN	- Sums the tons of alfalfa hay produced.
TNMHN	- Sums the tons of mixed hay produced.

Table 4. Explanation of Linear Programming Columns.

CONSTRAINT COLUMN	- Column of N's, L's, E's, and G's identifies the type of constraint which each row represents. The meaning of these letters is: N--non-constraining row, L--less than or equal to, E--equal to, and G--greater than or equal to.
DAIRYS	- Dairy enterprise with a solid manure system.
DAIRYL	- Dairy enterprise with a liquid manure system.
CGTA	- Corn grain, conventional tillage, on land A.
CGTB	- Corn grain, conventional tillage, on land B.
GRINDMIX	- Sets costs of grinding and mixing to be charged when corn grain is fed.
WGCB	- Wheat grain on land B.
CSTA	- Corn silage, conventional tillage, on land A.
CLTA	- Corn silage, conventional tillage, with limited energy inputs on land A.
CSTB	- Corn silage, conventional tillage, on land B.
ASCB	- Alfalfa silage, on land B.
AHCB	- Alfalfa hay, on land B.
AHCC	- Alfalfa hay, on land C.
MHCB	- Orchard grass/red clover hay on land B.
MHCC	- Orchard grass/red clover hay on land C.
PTCD	- Pasture on land D.
CTPXFER	- Transfers cropland to pasture use when energy inputs are restricted.
DCTA	- Barley silage/corn silage double crop, using conventional tillage for corn, on land A.
DCTB	- Barley silage/corn silage double crop, using conventional tillage for corn, on land B.
LABORDM, LABORAM, LABORJA, LABOROSN	- Provide for hiring of seasonal labor alternative.
CGNA	- Corn grain, reduced tillage, on land A.
CGNB	- Corn grain, reduced tillage, on land B.
CSNA	- Corn silage, reduced tillage, on land A.
CLNA	- Corn silage, reduced tillage, with limited energy inputs, on land A.
CSNB	- Corn silage, reduced tillage, on land B.
DCNA	- Barley silage/corn silage double crop, using reduced tillage for corn, on land A.
DCNB	- Barley silage/corn silage double crop, using reduced tillage for corn, on land B.
SBMLCWT	- Purchase soybean meal.
BUYCORN	- Purchase corn grain.
BUYAHAY	- Purchase alfalfa hay.
BYMIXHAY	- Purchase orchard grass/red clover hay.
RHS1	- Level of restrictions used for initial model and model in which energy costs were increased.

Table 4. Continued.

RHSP	- Level of restrictions used for model in which energy quantities were decreased.[a]
CH61	- Amounts by which energy input levels of RHSP are reduced when these energy input levels are decreased by 20 percent.

[a] The only difference between RHS1 and RHSP is the pastrac row is 130 acres for RHS1 and 290 acres for RHSP.

APPENDIX G

Results

Table 1. Hundred-Cow Dairy with a Solid or Liquid[a] Manure System and Reduced Corn Tillage - Summary of Crops with Increase in Costs of Energy Inputs.[a]

Item	Units	Initial model[c]	Increase in energy costs			
			25%	50%	75%	100%
Crops produced (types)						
Corn grain	Bu.	5,790	5,290	4,876	2,489	2,489
Corn silage	Ton	918	1,076	1,205	370	370
Barley silage	Ton	206	92	--	--	--
Alfalfa silage	Ton	50	37	27	451	451
Alfalfa hay	Ton	46	46	46	46	46
Crops produced (activities)[d]						
Corn grain, land A[e]	Acre	46	46	42	22	22
Corn grain, land B	Acre	5	--	--	--	--
Corn silage, land A	Acre	--	--	4	24	24
Corn silage, land B	Acre	47	73	89	--	--
Alfalfa silage, land B	Acre	11	8	6	95	95
Alfalfa hay, land C	Acre	19	19	19	19	19
Pasture, land D[f]	Acre	130	130	130	130	130
Double crop,[g] land B	Acre	32	14	--	--	--
Crops purchased						
Soybean meal	Cwt.	1,668	1,758	1,833	429	429
Corn grain	Bu.	--	--	--	7,836	7,836

[a] Crops were the same for both manure system.

[b] Costs were increased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen. Lubrication costs are also increased because lubrication cost are calculated as 15% of fuel costs.

[c] Costs of inputs in the initial model were considered to be at 1976 price levels. A detailed list of these prices is included in Appendix A, Table 1.

[d] Detailed budgets for these activities can be found in Appendix D.

[e] Types of land are defined as follows:
Land A - land suitable for continuous row crops using conventional tillage.
Land B - land suitable for rotational row crops using conventional tillage.
Land C - land suitable for hay crops but not for row crops.
Land D - land suitable for pasture only.

[f] Pasture was restricted to land D and used for replacements and dry cows only.

[g] Double crop refers to barley silage followed by corn silage grown on the same land during a one year period.

Table 2. Hundred-Cow Dairy with a Solid or Liquid[a] Manure System and Conventional Corn Tillage - Summary of Crops with Increases in Costs of Energy Inputs.[b]

Item	Units	Initial model[c]	Increase in energy costs 25%	50%	75%	100%
Crops produced (types)						
Corn grain	Bu.	--	698	2,526		
Wheat grain	Bu.	1,869	952	--		
Corn silage	Ton	922	921	669		
Barley silage	Ton	206	--	--		
Alfalfa silage	Ton	46	170	299		
Alfalfa hay	Ton	46	46	46		
Crops produced (activities)[d]						
Corn grain, land A[e]	Acre	--	7	25		
Wheat grain, land B	Acre	53	27	--		
Corn silage, land A	Acre	46	39	21		
Corn silage, land B	Acre	--	32	32	Crops same as 50%	
Alfalfa silage, land B	Acre	10	36	63		
Alfalfa hay, land C	Acre	19	19	19		
Pasture, land D[f]	Acre	130	130	130		
Double crop,[g] land B	Acre	32	--	--		
Crops purchased						
Soybean meal	Cwt.	1,571	1,304	933		
Corn grain	Bu.	4,002	5,130	5,847		

[a] Crops were the same for both manure systems.

[b] Costs were increased for gasoline, liquid petroleum gas, diesel fuel, atrazine, and nitrogen. Lubrication costs are also increased because lubrication cost are calculated as 15% of fuel costs.

[c] Costs of inputs in the initial model were considered to be at 1976 price levels. A detailed list of these prices is included in Appendix A, Table 1.

[d] Detailed budgets for these activities can be found in Appendix A.

[e] Types of land are defined as follows:
Land A - land suitable for continuous row crops using conventional tillage.
Land B - land suitable for rotational row crops using conventional tillage.
Land C - land suitable for hay crops but not for row crops.
Land D - land suitable for pasture only.

[f] Pasture was restricted to land D and used for replacements and dry cows only.

[g] Double crop refers to barley silage followed by corn silage grown on the same land during a one year period.

Table 3. Hundred-Cow Dairy With a Liquid Manure System and Both Conventional and Reduced Corn Tillage - Summary of Crops with Increases in Costs of Energy Inputs[a]

Item	Units	Initial model[b]	Increase in energy costs 25%	50%	75%	100%
Crops produced (types)						
Corn grain	Bu.	984	4,209		2,526	
Corn silage	Ton	1,100	1,258		669	
Barley silage	Ton	135	--		--	
Alfalfa silage	Ton	--	--		299	
Alfalfa hay	Ton	46	46		46	
Crops produced (activities)[c]						
Corn grain, CT,[d] land A[e]	Acre	--	--		25	
Corn silage, CT, land A	Acre	45	46		21	
Corn silage, CT, land B	Acre	11	32		32	
Alfalfa silage, land B	Acre	--	--	Crops same as 25%	63	Crops same as 75%
Alfalfa hay, land C	Acre	19	19		19	
Pasture, land D[f]	Acre	130	130		130	
Double crop,[g] CT, land B	Acre	21	--		--	
Corn grain, RT, land A	Acre	1	--		--	
Corn grain, RT, land B	Acre	50	44		--	
Corn silage, RT, land B	Acre	13	19		--	
Crops purchased						
Soybean meal	Cwt.	1,864	1,923		933	
Corn grain	Bu.	--	318		5,847	

[a] Costs were increased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen. Lubrication costs are also increased because lubrication cost are calculated as 15% of fuel costs.

[b] Costs of inputs in the initial model were considered to be at 1976 price levels. A detailed list of these prices is included in Appendix A, Table 1.

[c] Detailed budgets for these activities can be found in Appendix D.

[d] CT and RT refer respectively to conventional and reduced corn tillage.

[e] Types of land are defined as follows:
Land A - land suitable for continuous row crops using conventional tillage.
Land B - land suitable for rotational row crops using conventional tillage.
Land C - land suitable for hay crops but not for row crops.
Land D - land suitable for pasture only.

[f] Pasture was restricted to land D and used for replacements and dry cows only.

[g] Double crop refers to barley silage followed by corn silage grown on the same land during a one year period.

Table 4. Summary of Returns to Fixed Resources for a Hundred-Cow Dairy with Alternative Manure and Corn Tillage Systems as Costs of Energy Inputs are Increased.[a/]

Item	Liquid[b/] CT & RT	Solid CT	Liquid CT	Solid RT	Liquid RT
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
Initial model[c/]	88,160	82,657	85,553	84,602	87,498
25% increase in costs	86,238	81,357	84,499	82,173	85,315
50% increase in costs	84,422	80,334	83,722	79,808	83,196
75% increase in costs	83,003	79,369	83,003	78,223	81,829[d/]
100% increase in costs	82,284	78,404	82,284	77,421	81,269[d/]

[a/] Costs were increased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen. Lubrication costs are also increased because lubrication cost are calculated as 15% of fuel costs.

[b/] Liquid and solid refer to type of manure system, and CT and RT refer respectively to conventional and reduced corn tillage.

[c/] Costs of inputs in the initial model were considered to be at 1976 price levels. A detailed list of these prices is included in Appendix A, Table 1.

[d/] In this case excess nitrogen was furnished by the manure system and considered unused.

Table 5. Hundred-Cow Dairy with a Solid Manure System and Reduced Corn Tillage - Summary of Energy Inputs used When Energy Costs are Increased.[a]

Item	Units	Initial model[b]	Increase in energy costs[e]			
			25%	50%	75%	100%
Energy inputs						
Gasoline	Gal.	178	162	149	79	
Liquid petroleum gas	Gal.	1,159	1,059	976	498	
Diesel	Gal.	1,170	1,100	1,041	1,606	
Atrazine	Lb.	326	333	338	115	Same as 75%
Paraquat	Pt.	131	133	135	46	
Furadan	Lb.	1,306	1,331	1,353	460	
Sevin	Lb.	65	67	68	23	
2, 4, D[c]	Lb.	65	65	65	65	
Nitrogen purchased[d]	Lb.	18,634	17,997	17,495	3,456	
Summary of energy costs	$					
Costs of liquid fuels	$	911	1,053	1,179	1,354	1,547
Costs of pesticides[c]	$	3,175	4,006	4,855	2,013	2,280
Costs of nitrogen purchased[d]	$	5,031	6,073	7,085	1,633	1,866
Total costs of energy inputs[e]	$	9,116	11,132	13,119	4,999	5,693
Summary of energy quantities[f]						
Kilocalories liquid fuels	Kcal.	101,962,268	94,722,270	88,724,723	100,963,173	
Kilocalories pesticides[c]	Kcal.	5,741,566	5,840,099	5,924,882	2,486,000	Same as 75%
Kilocalories nitrogen purchased[d]	Kcal.	156,528,661	151,170,763	146,958,393	29,034,530	
Kilocalories total	Kcal.	264,232,494	251,733,132	241,607,998	132,483,702	
Gasoline equivalents total	Gal.	7,299	6,953	6,674	3,659	

[a]Costs were increased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen. Lubrication costs are also increased because lubrication cost are calculated as 15% of fuel costs.

[b]Costs of inputs in the initial model were considered to be at 1976 price levels. A detailed list of these prices is included in Appendix A, Table 1.

[c]The cost and kilocalories associated with 2, 4, D is included in these figures. However the cost of 2, 4, D was not varied.

[d]Quantity and value of manure nitrogen were not included in this table.

[e]This figure does not include increases in lubrication costs.

[f]Conversion factors used to convert the energy inputs to kilocalories are: gasoline - 36,200 kcal./gal., diesel fuel - 51,700 kcal./gal., liquid petroleum gas - 30,200 kcal./gal., nitrogen - 8,400 kcal./lb., pesticides - 11,000 kcal./lb. These values are found in Walker, J. N., "Energy Usage in Crop Systems," Energy in Agriculture, Proceedings of conference - workshop in Atlanta, Georgia, October 1-3, 1975, Southern Regional Education Board, 130 Sixth Street, N. W., Atlanta, Georgia 30313, pp. 42-50.

Table 6. Hundred-Cow Dairy with a Liquid Manure System and Reduced Corn Tillage - Summary of Energy Inputs used When Energy Costs are Increased.[a]

Item	Units	Initial model[b]	Increase in energy costs[c] 25%	50%	75%	100%
Energy inputs						
Gasoline	Gal.					
Liquid petroleum gas	Gal.					
Diesel	Gal.	NOTE: Liquid fuels and pesticides are identical to solid manure system with reduced tillage.				
Atrazine	Lb.					
Paraquat	Pt.					
Furadan	Lb.					
Sevin	Lb.					
2, 4, D[c]	Lb.					
Nitrogen purchased[d]	Lb.	15,118	14,481	13,979	0	0
Summary of energy costs	$					
Costs of liquid fuels	$		See above note.			
Costs of pesticides[c]	$					
Costs of nitrogen purchased[d]	$	4,082	4,887	5,661	0	0
Total costs of energy inputs[e]	$	8,167	9,946	11,695	3,367	3,827
Summary of energy quantities[f]						
Kilocalories liquid fuels	Kcal.		See above note.			
Kilocalories pesticides[c]	Kcal.					
Kilocalories nitrogen purchased[d]	Kcal.	126,994,261	121,636,363	117,423,993	0	0
Kilocalories total	Kcal.	234,698,094	222,198,732	212,073,598	103,449,173	103,449,173
Gasoline equivalents total	Gal.	6,483	6,137	5,858	2,858	2,858

[a] Costs were increased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen. Lubrication costs are also increased because lubrication cost are calculated as 15% of fuel costs.

[b] Costs of inputs in the initial model were considered to be at 1976 price levels. A detailed list of these prices is included in Appendix A, Table 1.

[c] The cost and kilocalories associated with 2, 4, D is included in these figures. However the cost of 2, 4, D was not varied.

[d] Quantity and value of manure nitrogen were not included in this table.

[e] This figure does not include increases in lubrication costs.

[f] Conversion factors used to convert the energy inputs to kilocalories are: gasoline - 36,200 kcal./gal., diesel fuel - 51,700 kcal./gal., liquid petroleum gas - 30,200 kcal./gal., nitrogen - 8,400 kcal./lb., pesticides - 11,000 kcal./lb. These values are found in Walker, J. N., "Energy Usage in Crop Systems," Energy in Agriculture, Proceedings of conference - workshop in Atlanta, Georgia, October 1-3, 1975, Southern Regional Education Board, 130 Sixth Street, N. W., Atlanta, Georgia 30313, pp. 42-50.

Table 7. Hundred-Cow Dairy with a Solid Manure System and Conventional Corn Tillage - Summary of Energy Inputs used When Energy Costs are Increased.[a]

Item	Units	Initial model[b]	Increases in energy costs[c]			
			25%	50%	75%	100%
Energy inputs						
Gasoline	Gal.	96	74	88		
Liquid petroleum gas	Gal.	---	140	506		
Diesel	Gal.	1,401	1,390	1,521	Same as 50%	
Atrazine	Lb.	195	195	195		
2, 4, D[c]	Lb.	65	65	65		
Nitrogen purchased[d]	Lb.	14,023	9,711	7,186		
Summary of energy costs	$					
Costs of liquid fuels	$	531	709	1,127	1,314	1,502
Costs of pesticides[c]	$	828	999	1,169	1,340	1,511
Costs of nitrogen purchased[d]	$	3,786	3,277	2,910	3,395	3,880
Total costs of energy inputs[e]	$	5,145	4,985	5,206	6,049	6,893
Summary of energy quantities[f]						
Kilocalories liquid fuels	Kcal.	75,884,398	78,773,411	97,086,177		
Kilocalories pesticides[c]	Kcal.	2,431,000	2,431,000	2,431,000		
Kilocalories nitrogen purchased[d]	Kcal.	117,794,317	81,575,890	60,364,027	Same as 50%	
Kilocalories total	Kcal.	196,109,714	162,780,300	159,881,204		
Gasoline equivalents total	Gal.	5,417	4,496	4,416		

a/ Costs were increased for gasoline, liquid petroleum gas, diesel fuel, atrazine, and nitrogen. Lubrication costs are also increased because lubrication costs are calculated as 15% of fuel costs.

b/ Costs of inputs in the initial model were considered to be at 1976 price levels. A detailed list of these prices is included in Appendix A, Table 1.

c/ The cost and kilocalories associated with 2, 4, D is included in these figures. However the cost of 2, 4, D was not varied.

d/ Quantity and value of manure nitrogen were not included in this table.

e/ This figure does not include increases in lubrication costs.

f/ Conversion factors used to convert the energy inputs to kilocalories are: gasoline - 36,200 kcal./gal., diesel fuel - 51,700 kcal./gal., liquid petroleum gas - 30,200 kcal./gal., nitrogen - 8,400 kcal./lb., pesticides - 11,000 kcal./lb. These values are found in Walker, J. N., "Energy Usage in Crop Systems," Energy in Agriculture, Proceedings of conference - workshop in Atlanta, Georgia, October 1-3, 1975, Southern Regional Education Board, 130 Sixth Street, N. W., Atlanta, Georgia 30313, pp. 42-50.

Table 8. Hundred-Cow Dairy with a Liquid Manure System and Conventional Corn Tillage - Summary of Energy Inputs Used When Energy Costs are Increased.[a]

Item	Units	Initial model[b]	Increase in energy costs[c] 25%	50%	75%	100%
Energy inputs						
Gasoline	Gal.	NOTE: Liquid fuels and pesticides are identical to solid manure system with conventional tillage.				
Liquid petroleum gas	Gal.					
Diesel	Gal.					
Atrazine	Lb.					
2, 4, D[c]	Lb.					
Nitrogen purchased[d]	Lb.	10,507	6,195	3,670	3,670	3,670
Summary of energy costs	$					
Costs of liquid fuels	$		See above note.			
Costs of pesticides[c]	$					
Costs of nitrogen purchased[d]	$	2,837	2,091	1,486	1,734	1,982
Total costs of energy inputs[e]	$	4,196	3,799	3,782	4,388	4,995
Summary of energy quantities[f]						
Kilocalories liquid fuels	Kcal.		See above note.			
Kilocalories pesticides[c]	Kcal.					
Kilocalories nitrogen purchased[d]	Kcal.	88,259,917	52,041,490	30,829,627	Same	Same
Kilocalories total	Kcal.	166,575,314	133,245,900	130,346,804	as	as
Gasoline equivalents total	Gal.	4,601	3,680	3,600	50%	50%

[a]Costs were increased for gasoline, liquid petroleum gas, diesel fuel, atrazine, and nitrogen. Lubrication costs are also increased because lubrication cost are calculated as 15% of fuel costs.

[b]Costs of inputs in the initial model were considered to be at 1976 price levels. A detailed list of these prices is included in Appendix A, Table 1.

[c]The cost and kilocalories associated with 2, 4, D is included in these figures. However the cost of 2, 4, D was not varied.

[d]Quantity and value of manure nitrogen were not included in this table.

[e]This figure does not include increases in lubrication costs.

[f]Conversion factors used to convert the energy inputs to kilocalories are: gasoline - 36,200 kcal./gal., diesel fuel - 51,700 kcal./gal., liquid petroleum gas - 30,200 kcal./gal., nitrogen - 8,400 kcal./lb., pesticides - 11,000 kcal./lb. These values are found in Walker, J. N., "Energy Usage in Crop Systems," Energy in Agriculture, Proceedings of conference - workshop in Atlanta, Georgia, October 1-3, 1975, Southern Regional Education Board, 130 Sixth Street, N. W., Atlanta, Georgia 30313, pp. 42-50.

Table 9. Hundred-Cow Dairy with a Liquid Manure System and Both Conventional and Reduced Corn Tillage - Summary of Energy Inputs used When Energy Costs are Increased.[a]

Item	Units	Initial model[b]	Increase in energy costs[c] 25%	50%	75%	100%
Energy inputs						
Gasoline	Gal.	171	147		88	
Liquid petroleum gas	Gal.	988	843		506	
Diesel	Gal.	1,176	1,094	Inputs same as 25%	1,521	Inputs same as 75%
Atrazine	Lb.	353	353		195	
Paraquat	Pt.	64	63		---	
Furadan	Lb.	644	630		---	
Sevin	Lb.	32	32		---	
2, 4, D[c]	Lb.	65	65		65	
Nitrogen purchased[d]	Lb.	14,766	13,525		3,670	
Summary of energy costs	$					
Costs of liquid fuels	$	848	944	1,133	1,314	1,502
Costs of pesticides[c]	$	2,311	2,826	3,362	1,340	1,511
Costs of nitrogen purchased[d]	$	3,987	4,565	5,478	1,734	1,982
Total costs of energy inputs[e]	$	7,145	8,334	9,972	4,388	4,995
Summary of energy quantities[f]						
Kilocalories liquid fuels	Kcal.	96,801,463	87,321,528	Quantities same as 25%	97,086,177	Quantities same as 75%
Kilocalories pesticides[c]	Kcal.	4,880,371	4,856,500		2,431,000	
Kilocalories nitrogen purchased[d]	Kcal.	124,037,056	113,610,614		30,829,627	
Kilocalories total	Kcal.	225,718,891	205,788,642		130,346,804	
Gasoline equivalents total	Gal.	6,235	5,684		3,600	

[a] Costs were increased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen. Lubrication costs are also increased because lubrication cost are calculated as 15% of fuel costs.

[b] Costs of inputs in the initial model were considered to be at 1976 price levels. A detailed list of these prices is included in Appendix A, Table 1.

[c] The cost and kilocalories associated with 2, 4, D is included in these figures. However the cost of 2, 4, D was not varied.

[d] Quantity and value of manure nitrogen were not included in this table.

[e] This figure does not include increases in lubrication costs.

[f] Conversion factors used to convert the energy inputs to kilocalories are: gasoline - 36,200 kcal./gal., diesel fuel- 51,700 kcal./gal., liquid petroleum gas - 30,200 kcal./gal., nitrogen - 8,400 kcal./lb., pesticides - 11,000 kcal./lb. These values are found in Walker, J. N. "Energy Usage in Crop Systems," Energy in Agriculture, Proceedings of conference - workshop in Atlanta, Georgia, October 1-3, 1975, Southern Regional Education Board, 130 Sixth Street, N. W., Atlanta, Georgia 30313, pp. 42-50.

Table 10. Hundred-Cow Dairy with Solid or Liquid[a/] Manure System and Reduced Corn Tillage - Summary of Crops with Reductions in Availability of Energy Inputs.[a/]

Item	Units	Initial model[c/]	Reductions in availability of energy inputs[d/]			
			20%	40%	60%	80%
Crops produced (types)						
Corn grain	Bu.	5,790	5,287	2,707	2,194	1,189
Wheat grain	Bu.	--	28	409	--	--
Corn silage	Ton	918	765	843	546	273
Barley silage	Ton	206	206	--	--	--
Alfalfa silage	Ton	50	127	--	--	--
Alfalfa hay	Ton	46	46	187	137	47
Crops produced (activities)[e/]						
Corn grain, land A[f/]	Acre	46	46	24	19	10
Corn grain, land B	Acre	5	--	--	--	--
Wheat grain, land B	Acre	--	1	12	--	--
Corn silage, land A	Acre	--	--	22	27	18
Corn silage, land B	Acre	47	35	39	11	--
Alfalfa silage, land B	Acre	11	27	--	--	--
Alfalfa hay, land B	Acre	--	--	44	42	15
Alfalfa hay, land C	Acre	19	19	18	--	--
Pasture, land D[g/]	Acre	130	130	131	191	247
Double crop,[h/] land B	Acre	32	32	--	--	--
Crops purchased						
Soybean meal	Cwt.	1,668	1,409	1,251	822	409
Corn grain	Bu.	--	1,476	4,113	6,563	8,985
Alfalfa hay	Ton	--			110	255

[a/] Crops were the same for both manure systems.

[b/] Quantities available were decreased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen.

[c/] Quantities of energy inputs available in the initial model were at levels which were not restrictive.

[d/] Each 20% reduction in available energy inputs was accompanied by a 25% increase in purchased feed costs.

[e/] Detailed budgets for these activities can be found in Appendix D.

[f/] Types of land are defined as follows:
Land A - land suitable for continuous row crops using conventional tillage.
Land B - land suitable for rotational row crops using conventional tillage.
Land C - land suitable for hay crops but not for row crops.
Land D - land suitable for pasture only.

[g/] The amount of land used for pasture was allowed to vary and pasture was allowed on land A, B, and C as energy quantities were reduced.

[h/] Double crop refers to barley silage followed by corn silage grown on the same land during a one year period.

Table 11. Hundred-Cow Dairy with Solid or Liquid[a] Manure System and Conventional Corn Tillage - Summary of Crops with Reductions in Availability of Energy Inputs.[b]

Item	Units	Initial model[c]	Reductions in availability of energy inputs[d] 20%	40%	60%	80%
Crops produced (types)						
Corn grain	Bu.	--	694	20	2,157	1,164
Wheat grain	Bu.	1,869	1,507	785	--	--
Corn silage	Ton	922	826	1,015	528	267
Barley silage	Ton	206	206	--	--	--
Alfalfa silage	Ton	46	95	--	--	--
Alfalfa hay	Ton	46	46	111	94	25
Crops produced (activities)[e]						
Corn grain, land A[f]	Acre	--	7	--	22	12
Wheat grain, land B	Acre	53	43	23	--	--
Corn silage, land A	Acre	46	39	46	24	19
Corn silage, land B	Acre	--	--	32	16	--
Alfalfa silage, land B	Acre	10	20	--	--	--
Alfalfa hay, land B	Acre	--	--	34	29	8
Alfalfa hay, land C	Acre	19	19	--	--	--
Pasture, land D[g]	Acre	130	130	155	199	251
Double crop, land B	Acre	32	32	--	--	--
Crops purchased						
Soybean meal	Cwt.	1,571	1,430	1,504	796	400
Corn grain	Bu.	4,002	4,274	5,184	6,671	9,027
Alfalfa hay	Ton	--	--	--	154	276

[a] Crops were the same for both manure systems.

[b] Quantities available were decreased for gasoline, liquid petroleum gas, diesel fuel, atrazine, and nitrogen.

[c] Quantities of energy inputs available in the initial model were at levels which were not restrictive.

[d] Each 20% reduction in available energy inputs was accompanied by a 25% increase in purchased feed costs.

[e] Detailed budgets for these activities can be found in Appendix D.

[f] Types of land are defined as follows:
Land A - land suitable for continuous row crops using conventional tillage.
Land B - land suitable for rotational row crops using conventional tillage.
Land C - land suitable for hay crops but not for row crops.
Land D - land suitable for pasture only.

[g] The amount of land used for pasutre was allowed to vary, pasture was allowed on land A, B, and C, and pasture was allowed to be used by lactating cows as energy quantities were reduced.

Table 12. Hundred-Cow Dairy with a Liquid Manure System and Both Conventional and Reduced Corn Tillage - Summary of Crops with Reductions in Availability of Energy Inputs.[a]

Item	Units	Initial model[b]	Reductions in availability of energy inputs[c]			
			20%	40%	60%	80%
Crops produced (types)						
Corn grain	Bu.	4,934	5,287	2,737	2,267	1,228
Wheat grain	Bu.	--	50	471	--	--
Corn silage	Ton	1,100	884	934	599	304
Barley silage	Ton	135	193	--	--	--
Alfalfa silage	Ton	--	75	--	--	--
Alfalfa hay	Ton	46	46	156	120	38
Crops produced (activities)[d/,f/]						
Wheat grain, CT,[e] land B[f]	Acre	--	1	13	--	--
Corn silage, CT, land A	Acre	45	--	--	--	2
Corn silage, CT, land B	Acre	11	2	8	5	--
Double crop,[h] CT, land B	Acre	--	30	--	--	--
Alfalfa silage, land B	Acre	--	16	--	--	--
Alfalfa hay, land B	Acre	--	--	35	37	12
Alfalfa hay, land C	Acre	19	19	18	--	--
Pasture, land D[g]	Acre	130	130	131	191	247
Double crop,[h] RT, land B	Acre	21	--	--	--	--
Corn grain, RT, land A	Acre	1	46	24	20	11
Corn grain, RT, land B	Acre	50	--	--	--	--
Corn silage, RT, land A	Acre	--	--	22	26	18
Corn silage, RT, land B	Acre	13	46	39	11	--
Crops purchased						
Soybean meal	Cwt.	1,864	1,588	1,389	905	457
Corn grain	Bu.	--	740	3,443	6,147	8,744
Alfalfa hay	Ton	--	--	--	109	253

[a] Quantities available were decreased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen.

[b] Quantities of energy inputs available in the initial model were at levels which were not restrictive.

[c] Each 20% reduction in available energy inputs was accompanied by a 25% increase in purchased feed costs.

[d] Detailed budgets for these activities can be found in Appendix D.

[e] CT and RT refer respectively to conventional and reduced corn tillage.

[f] Types of land are defined as follows:
Land A - land suitable for continuous row crops using conventional tillage.
Land B - land suitable for rotational row crops using conventional tillage.
Land C - land suitable for hay crops but not for row crops.
Land D - land suitable for pasture only.

[g] The amount of land used for pasture was allowed to vary, pasture was allowed on land A, B, and C, and pasture was allowed to be used by lactating cows as energy quantities were reduced.

[h] Double crop refers to barley silage followed by corn silage grown on the same land during a one year period.

Table 13. Summary of Returns to Fixed Resources for a Hundred-Cow Dairy with Alternative Manure and Corn Tillage Systems as Quantities Available of Energy Inputs are Decreased.[a]

Item	Liquid[b] CT & RT	Solid CT	Liquid CT	Solid RT	Liquid RT
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
Initial model[c]	88,160	82,657	85,553	84,602	87,498
20% decrease in quantities	83,267	76,508	79,404	79,597	82,493
40% decrease in quantities	74,013	67,311	70,207	70,274	73,170
60% decrease in quantities	54,759	48,134	51,030	51,194	54,090
80% decrease in quantities	25,396[d]	21,167	22,593[d]	23,085	24,001[d]

[a] Quantities available were decreased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen.

[b] Liquid and solid refer to type of manure system, and CT and RT refer respectively to conventional and reduced tillage corn.

[c] Quantities of energy inputs available in the initial model were at levels which were not restrictive.

[d] In this case excess fertilizer was furnished by the manure system and considered unused.

Table 14. Hundred-Cow Dairy with a Solid Manure System and Reduced Corn Tillage - Summary of Energy Inputs used with Reductions in Availability of Energy Inputs.[a]

Item	Units	Initial model[b]	Reductions in availability of energy inputs[c] 20%	40%	60%	80%
Energy inputs						
Gasoline	Gal.	178	163	123	82	41
Liquid petroleum gas	Gal.	1,159	1,058	542	439	238
Diesel	Gal.	1,170	1,277	1,088	725	363
Atrazine	Lb.	326	283	213	142	71
Paraquat	Pt.	131	113	85	57	28
Furadan	Lb.	1,306	1,134	850	567	283
Sevin	Lb.	65	57	43	28	14
2, 4, D[c]	Lb.	65	65	66	96	124
Nitrogen purchased[d]	Lb.	18,634	16,012	10,680	5,327	566
Summary of energy costs	$					
Costs of liquid fuels	$	911	904	632	450	231
Costs of pesticides[c]	$	3,175	2,776	2,120	1,529	934
Costs of nitrogen purchased[d]	$	5,031	4,323	2,883	1,438	152
Total costs of energy inputs[e]	$	9,116	8,002	5,635	3,417	1,318
Summary of energy quantities[f]						
Kilocalories liquid fuels	Kcal.	101,962,268	103,908,225	77,058,206	53,724,342	27,420,105
Kilocalories pesticides[c]	Kcal.	5,741,566	5,079,360	3,995,989	3,233,024	2,450,508
Kilocalories nitrogen purchased[d]	Kcal.	156,528,661	134,501,493	89,711,979	44,746,094	4,753,906
Kilocalories total	Kcal.	264,232,494	243,489,078	170,766,174	101,703,460	34,624,519
Gasoline equivalent total	Gal.	7,299	6,726	4,717	2,809	956

a/ Quantities available were decreased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen.

b/ Quantities of energy inputs available in the initial model were at levels which were not restrictive.

c/ The cost and kilocalories associated with 2, 4, D is included in these figures. However the quantity available of 2, 4, D was not restricted.

d/ Quantity and value of manure nitrogen were not included in this table.

e/ This figure does not include increases in lubrication costs.

f/ Conversion factors used to convert the energy inputs to kilocalories are: gasoline - 36,200 kcal./gal., diesel fuel -51,700 kcal./gal., liquid petroleum gas - 30,200 kcal./gal., nitrogen - 8,400 kcal./lb., pesticides - 11,000 kcal./lb. These values are found in Walker, J. N., "Energy Usage in Crop Systems," Energy in Agriculture, Proceedings of conference - workshop in Atlanta, Georgia, October 1-3, 1975, Southern Regional Education Board, 130 Sixth Street, N. W., Atlanta, Georgia 30313, pp. 42-50.

Table 15. Hundred-Cow Dairy with a Liquid Manure System and Reduced Corn Tillage - Summary of Energy Inputs used with Reductions in Availability of Energy Inputs.[a]

Item	Units	Initial model[b]	Reductions in availability of energy inputs[e] 20%	40%	60%	80%
Energy inputs						
Gasoline	Gal.					
Liquid petroleum gas	Gal.					
Diesel	Gal.					
Atrazine	Lb.	NOTE: Liquid fuels and pesticides are identical to solid manure system with reduced tillage.				
Paraquat	Pt.					
Furadan	Lb.					
Sevin	Lb.					
2, 4, D[c]	Lb.					
Nitrogen purchased[d]	Lb.	15,118	12,496	7,163	1,810	0
Summary of energy costs	$					
Costs of liquid fuels	$			See above note.		
Costs of pesticides[c]	$					
Costs of nitrogen purchased[d]	$	4,082	3,374	1,934	489	0
Total costs of energy inputs[e]	$	8,167	7,053	4,686	2,468	1,166
Summary of energy quantities[f]						
Kilocalories liquid fuels	Kcal.			See above note.		
Kilocalories pesticides[c]	Kcal.					
Kilocalories nitrogen purchased[d]	Kcal.	126,994,261	104,967,093	60,177,579	15,211,694	0
Kilocalories total	Kcal.	234,698,094	213,954,678	141,231,774	72,169,060	29,870,613
Gasoline equivalents total	Gal.	6,483	5,910	3,901	1,993	825

[a] Quantities available were decreased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen.

[b] Quantities of energy inputs available in the initial model were at levels which were not restrictive.

[c] The cost and kilocalories associated with 2, 4, D is included in these figures. However the quantity available of 2, 4, D was not restricted.

[d] Quantity and value of manure nitrogen were not included in this table.

[e] This figure does not include increases in lubrication costs.

[f] Conversion factors used to convert the energy inputs to kilocalories are: gasoline - 36,200 kcal./gal., diesel fuel - 51,700 kcal./gal., liquid petroleum gas - 30,200 kcal./gal., nitrogen - 8,400 kcal./lb., pesticides - 11,000 kcal./lb. These values are found in Walker, J. N., "Energy Usage in Crop Systems," Energy in Agriculture, Proceedings of conference - workshop in Atlanta, Georgia, October 1-3, 1975, Southern Regional Education Board, 130 Sixth Street, N. W., Atlanta, Georgia 30313, pp. 42-50.

Table 16. Hundred-Cow Dairy with a Solid Manure System and Conventional Corn Tillage - Summary of Energy Inputs used with Reductions in Availability of Energy Inputs.[a]

Item	Units	Initial model[b]	Reductions in availability of energy inputs[c]			
			20%	40%	60%	80%
Energy inputs						
Gasoline	Gal.	96	101	53	82	41
Liquid petroleum gas	Gal.	---	139	4	432	233
Diesel	Gal.	1,401	1,450	1,088	725	363
Atrazine	Lb.	195	195	195	155	77
2, 4, D[c]	Lb.	65	65	78	100	126
Nitrogen purchased[d]	Lb.	14,023	13,064	9,608	4,980	468
Summary of energy costs	$					
Costs of liquid fuels	$	531	601	403	447	299
Costs of pesticides[c]	$	828	828	857	765	552
Costs of nitrogen purchased[d]	$	3,786	3,527	2,594	1,344	126
Total costs of energy inputs[e]	$	5,145	4,956	3,853	2,556	908
Summary of energy quantities[f]						
Kilocalories liquid fuels	Kcal.	75,884,398	82,841,646	58,259,650	53,499,949	27,266,617
Kilocalories pesticides[c]	Kcal.	2,431,000	2,431,000	2,570,618	2,456,892	2,063,201
Kilocalories nitrogen purchased[d]	Kcal.	117,794,317	109,735,666	80,706,159	41,833,396	3,927,585
Kilocalories total	Kcal.	196,109,714	195,008,312	141,536,427	97,790,237	33,257,402
Gasoline equivalents total	Gal.	5,417	5,387	3,909	2,701	918

[a] Quantities available were decreased for gasoline, liquid petroleum gas, diesel fuel, atrazine, and nitrogen.

[b] Quantities of energy inputs available in the initial model were at levels which were not restrictive.

[c] The cost and kilocalories associated with 2, 4, D is included in these figures. However the quantity available of 2, 4, D was not restricted.

[d] Quantity and value of manure nitrogen were not included in this table.

[e] This figure does not include increases in lubrication costs.

[f] Conversion factors used to convert the energy inputs to kilocalories are: gasoline - 36,200 kcal./gal., diesel fuel - 51,700 kcal./gal., liquid petroleum gas - 30,200 kcal./gal., nitrogen - 8,400 kcal./lb., pesticides - 11,000 kcal./lb. These values are found in Walker, J. N., "Energy Usage in Crop Systems," Energy in Agriculture, Proceedings of conference - workshop in Atlanta, Georgia, October 1-3, 1975, Southern Regional Education Board, 130 Sixth Street, N. W., Atlanta, Georgia 30313, pp. 42-50.

Table 17. Hundred-Cow Dairy with a Liquid Manure System and Conventional Corn Tillage - Summary of Energy Inputs Used with Reductions in Availability of Energy Inputs.[a/]

Item	Units	Initial model[b/]	Reductions in availability of energy inputs[e/] 20%	40%	60%	80%
Energy inputs						
Gasoline	Gal.					
Liquid petroleum gas	Gal.					
Diesel	Gal.	NOTE: Liquid fuels and pesticides are identical to solid manure system with conventional tillage.				
Atrazine	Lb.					
2, 4, D[c/]	Lb.					
Nitrogen purchased[d/]	Lb.	10,507	9,548	6,092	1,464	0
Summary of energy costs	$					
Costs of liquid fuels	$		See above note.			
Costs of pesticides[c/]	$					
Costs of nitrogen purchased[d/]	$	2,837	2,578	1,645	395	0
Total costs of energy inputs[e/]	$	4,196	4,007	2,904	1,607	782
Summary of energy quantities[f/]						
Kilocalories liquid fuels	Kcal.		See above note.			
Kilocalories pesticides[c/]	Kcal.					
Kilocalories nitrogen purchased[d/]	Kcal.	88,259,917	80,201,266	51,171,759	12,298,996	0
Kilocalories total	Kcal.	166,575,314	165,473,912	112,002,027	68,255,837	29,329,817
Gasoline equivalents total	Gal.	4,601	4,571	3,093	1,885	810

[a/] Quantities available were decreased for gasoline, liquid petroleum gas, diesel fuel, atrazine, and nitrogen.

[b/] Quantities of energy inputs available in the initial model were at levels which were not restrictive.

[c/] The cost and kilocalories associated with 2, 4, D is included in these figures. However the quantity available of 2, 4, D was not restricted.

[d/] Quantity and value of manure nitrogen were not included in this table.

[e/] This figure does not include increases in lubrication costs.

[f/] Conversion factors used to convert the energy inputs to kilocaloires are: gasoline - 36,200 kcal./gal., diesel fuel - 51,700 kcal./gal., liquid petroleum gas - 30,200 kcal./gal., nitrogen - 8,400 kcal./lb., pesticides - 11,000 kcal./lb. These values are found in Walker, J. N. "Energy Usage in Crop Systems," Energy in Agriculture, Proceedings of conference - workshop in Atlanta, Georgia, October 1-3, 1975, Southern Regional Education Board, 130 Sixth Street, N. W., Atlanta, Georgia 30313, pp. 42-50.

Table 18. Hundred-Cow Dairy with a Liquid Manure System and Both Conventional and Reduced Corn Tillage - Summary of Energy Inputs Used with Reductions in Availability of Energy Input.[a]

Item	Units	Initial model[b]	Reductions in availability of energy inputs 20%	40%	60%	80%
Energy inputs						
Gasoline	Gal.	171	164	123	82	41
Liquid petroleum gas	Gal.	988	1,058	548	454	246
Diesel	Gal.	1,176	1,273	1,088	725	363
Atrazine	Lb.	353	310	232	155	77
Paraquat	Pt.	64	92	85	57	28
Furadan	Lb.	644	918	850	567	283
Sevin	Lb.	32	46	43	28	14
2, 4, D[c]	Lb.	65	65	66	96	124
Nitrogen purchased[d]	Lb.	14,766	13,469	8,418	2,547	0
Summary of energy costs	$					
Costs of liquid fuels	$	848	903	635	455	234
Costs of pesticides[c]	$	2,311	2,556	2,188	1,575	957
Costs of nitrogen purchased[d]	$	3,987	3,637	2,273	688	0
Total costs of energy inputs[e]	$	7,145	7,096	5,096	2,717	1,192
Summary of energy quantities[f]						
Kilocalories liquid fuels	Kcal.	96,801,463	103,739,736	77,237,159	54,165,874	27,652,318
Kilocalories pesticides[c]	Kcal.	4,880,371	4,954,467	4,167,477	3,348,366	2,508,928
Kilocalories nitrogen purchased[d]	Kcal.	124,037,056	113,139,629	70,712,536	21,391,287	0
Kilocalories total	Kcal.	225,718,891	221,833,832	152,117,172	78,905,526	30,161,246
Gasoline equivalents total	Gal.	6,235	6,127	4,201	2,179	833

[a]Quantities available were decreased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen.

[b]Quantities of energy inputs available in the initial model were at levels which were not restrictive.

[c]The cost and kilocalories associated with 2, 4, D is included in these figures. However, the quantity available of 2, 4, D was not restricted.

[d]Quantity and value of manure nitrogen were not included in this table.

[e]This figure does not include increases in lubrication costs.

[f]Conversion factors used to convert the energy inputs to kilocalories are: gasoline - 36,200 kcal./gal., diesel fuel - 51,700 kcal./gal., liquid petroleum gas - 30,200 kcal./gal., nitrogen - 8,400 kcal./lb., pesticides - 11,000 kcal./lb. These values are found in Walker, J. N., "Energy Usage in Crop Systems," Energy in Agriculture, Proceedings of conference - workshop in Atlanta, Georgia, October 1-3, 1975, Southern Regional Education Board, 130 Sixth Street, N. W., Atlanta, Georgia 30313, pp. 42-50.

Table 19. Returns to Fixed Resources Per Dollar of Energy Costs for Hundred-Cow Dairy Farms using Different Combinations of Manure and Corn Tillage Systems, as Energy Input Prices are Increased.[a]

Farm organization	Initial analysis[b]	Increases in energy costs			
		25%	50%	75%	100%
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
LMRT[c]	10.71	8.58	7.11	24.30	21.24
SMRT	9.28	7.38	6.08	15.65	13.60
LMCT	20.00	22.24	22.14	18.92	16.47
SMCT	16.07	16.32	15.43	13.12	11.37
LMCT & RT	12.34	10.35	8.47	18.92	16.47

[a] Prices were increased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen. Lubrication costs are also increased because lubrication costs are calculated as 15 percent of fuel costs.

[b] Costs of inputs in the initial model were considered to be at 1976 price levels (see Appendix A, Table 1).

[c] LM and SM refer to the liquid and solid manure systems. CT and RT refer to conventional and reduced corn tillage.

Table 20. Returns to Fixed Resources Per Dollar of Energy Costs, for Hundred-Cow Dairy Farms using Different Combinations of Manure and Corn Tillage Systems, as Quantities Available of Energy Inputs are Decreased.[a]

Farm organization	Initial analysis[b]	Decreases in energy quantities			
		20%	40%	60%	80%
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
LMRT[c]	10.71	11.70	15.61	21.92	21.27
SMRT	9.28	9.95	12.47	14.98	17.52
LMCT	20.00	19.82	24.18	31.75	28.89
SMCT	16.07	15.44	17.47	18.83	23.31
LMCT & RT	12.34	11.73	14.52	20.15	21.31

[a] Quantities available were decreased for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen.

[b] Quantities available of the energy inputs in the initial model are at levels which are not restrictive.

[c] LM and SM refer to the liquid and solid manure systems. CT and RT refer to conventional and reduced corn tillage.

Table 21. Penalty Prices[a/] of an Acre of Corn Silage[b/] with Limited Nitrogen and Pesticides Under Different Energy Conditions.

Farm organization	Method of tillage	Initial analysis[c/]	Increases in energy costs 25%	50%	75%	100%
		$	$	$	$	$
RT[d/]	Reduced	45.41	38.74	34.24	25.40	12.31
CT	Conventional	68.36	55.33	43.38	33.72	24.05
Both CT & RT	Conventional	59.10	55.84	46.22	33.72	24.05
	Reduced	60.81	59.50	51.45	34.47	31.38
			Decreases in energy quantities[e/] 20%	40%	60%	80%
			$	$	$	$
RT	Reduced	45.41	46.68	34.93	58.99	22.57
CT	Conventional	68.36	91.61	130.59	89.40	62.43
Both CT & RT	Conventional	59.10	38.08	47.80	93.28	59.41
	Reduced	60.81	38.02	35.15	59.25	22.95

[a/] The penalty price is defined as the reductions in returns associated with forcing one unit of an unprofitable activity into the optimum combination of the activities of a linear programming model.

[b/] Detailed budgets for these crop activities are found in Appendix D, Tables 7 and 10.

[c/] Costs of inputs in the initial analysis were considered to be at 1976 price levels. A detailed list of these prices is included in Appendix A, Table 1. Quantities of inputs available in the initial analysis were at levels which were not restrictive.

[d/] RT and CT refer to farm organizations which used only reduced or conventional corn tillage. "Both CT and RT" refers to a farm organization which had the option of using both methods of corn tillage.

[e/] Each 20 percent reduction in available energy inputs was accompanied by a 25 percent increase in purchased feed costs.

VITA

Robert Oliver Burton, Jr., the son of Mr. and Mrs. Robert O. Burton, of Earlysville, Virginia, was born February 8, 1947, in Charlottesville, Virginia. In June 1975 he was married to the former Margaret Lambert of Blacksburg, Virginia.

He attended elementary and high school in the Albemarle County Public School System and was graduated from Albemarle High School in June, 1965.

Between September, 1965 and June, 1969 he attended Virginia Polytechnic Institute, graduating with a B.S. in Agricultural Economics.

After graduation he spent a year in Blacksburg, Virginia, doing volunteer work with a campus Christian organization. He then served four years in the Navy, most of which was spent on a ship home ported in San Diego, California.

In June, 1974 he entered Virginia Polytechnic Institute and State University and completed graduate requirements for a Master of Science Degree in Agricultural Economics in July, 1976.

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Robert O. Burton, Jr.

ADJUSTMENTS IN A FARM BUSINESS IN RESPONSE
TO AN ENERGY CRISIS

by

Robert Oliver Burton, Jr.

(ABSTRACT)

The objective of this study was to evaluate how a farm operator might adjust his farm business in response to circumstances which may occur as a result of an energy crisis.

Two distinguishing features of this research are that it will evaluate responses to the energy situation from the farm manager's point of view and that it will explore short run responses and adjustments.

For representative Virginia dairy farms using five different combinations of manure systems and corn tillage methods, linear programming procedures were used to determine the impacts on returns to fixed resources, crops grown and purchased, and energy use under conditions of increasing energy costs and decreasing quantities of energy available.

Results of this study indicate that: (1) although energy crisis conditions can be expected to cause reduced returns, there are adjustments in the optimum combinations of crops which can be made in order to maximum returns to fixed resources subject to given energy conditions, (2) reductions in returns are more severe with energy quantity restrictions than with energy price increases, (3) differences in the amount of fertilizer nutrients made available by a liquid and solid

manure system do not affect the optimum combination of crops; but there are dollar and energy savings associated with the greater amount of nitrogen made available from the dairy herd by the liquid system, (4) farms using reduced corn tillage are more profitable than farms using conventional corn tillage except at energy price increases of 50, 75, and 100 percent, (5) farms using reduced corn tillage have higher energy costs and quantities used per farm than farms using conventional corn tillage except at energy price increases of 75 and 100 percent.