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Effects of Livestock Enterprises on the Economics of Soil and Water Conservation Practices in Iowa

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EFFECTS OF LIVESTOCK ENTERPRISES ON THE ECONOMICS OF SOIL AND WATER CONSERVATION PRACTICES IN IOWA*

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PREFACE

The magnitude of the soil erosion problem and the important role that economic factors play in the adoption of conservation practices has led to an extensive research effort to examine the economics of soil and water conservation practices in Iowa. The research was conducted by the Center for Agricultural and Rural Development (CARD) in the Iowa Agricultural and Home Economics Experiment Station in cooperation with the Iowa Department of Soil Conservation and the Cooperative Extension Service in order to provide guidance in planning and implementing cost-effective control for Iowa's soil erosion and nonpoint water pollution problems. Various related studies have been completed and related reports have been written. These are being published as a series of five CARD Reports. These reports are listed as folows:

I. The Economics of Soil and Water Conservation Practices in Iowa: Model and Data Documentation (Pope, Bhide and Heady, 1982a).

II. The Economics of Soil and Water Conservation Practices in Iowa: Results and Discussion (Pope, Bhide and Heady, 1982b).

III. A Dynamic Analysis of Economics of Soil Conservation: An Application of Optimal Control Theory (Bhide, Pope and Heady, 1982).

IV. Effects of Tenure Arrangements, Capital Constraints, and Farm Size on the Economics of Soil and Water Conservation Practices in Iowa (Banks, Bhide, Pope and Heady, 1982).

V. Effects of Livestock Enterprises on the Economics of Soil and Water Conservation Practices in Iowa (Krog, Bhide, Pope and Heady, 1982).

The first report of this series describes and documents the basic methodology, data and assumptions used in these related studies. Methodology, data, and assumptions specific to an individual study are given in the corresponding report.

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CHAPTER I. INTRODUCTION

Soil erosion from water runoff is a concern in Iowa and elsewhere because of the costs which it creates. Costs associated with soil loss can generally be thought of in terms of temporal and spacial externalities. Depletion of soil resources over time reduces the ability of farms to produce agricultural products. Sheet and rill erosion transport nutrients and developed topsoil from farms, and gully erosion takes land out of production. Not only does excessive soil loss reduce the income-generating potential of farms and their capitalized value but also, the long-run availability of worldwide food supplies is jeopardized. Soil loss also results in spacial or "down-stream" costs. These costs result from sedimentation and contamination of water resources. Society must assume these costs either through clean-up operations or through loss of use of the water resource. Because of these temporal and spacial externalities, more soil loss is generated by farmers than is desirable from the perspective of both farmers and society (Walker, 1977).

Soil and water conservation practices such as reduced tillage practices, crop rotations of various types, and supporting practices such as contour planting, strip cropping, and terracing are available and need to be used on farms where soil erosion occurs. To date, adoption of these practices has been minimal in Iowa, even though soil loss continues to be a problem. One of the most important factors in determining the adoption or nonadoption of soil-conserving practices by farmers is the adverse or perceived adverse economic consequences of these practices on the farming operation.

Farmers make production decisions based upon the resources and information available to them. Decisions are made which are thought to optimize one or more objectives over a given planning period. Central of farmers objectives, and not surprisingly so, is that of profit maximization. From the farmer's perspective, profit maximization results in economic efficiency and is, therefore, a desirable end. The means through which the farmer achieves this end is through allocation of resources--land, labor, capital, and managerial ability--to the most profitable combination of production alternative available. Resource allocation problems are widespread in agriculture. A major factor is a lack of useful information.

Farmers need information concerning production and price relationships to make decisions and achieve maximum profits. Faced with insufficient or erroneous information, appropriate marginalities from product and factor markets cannot be "derived" by farmers, and conditions for profit maximization will not be met. Farm planning is not static and, therefore, farmers need flows of information. As improved technologies become available, farmers are able to either (a) produce more output from a given stock of resources, (b) use a smaller amount of resources in the production of the same output, or (c) do a combination of both. Improvements in technology, therefore, change production and price relationships and increase the level of attainable profit by increasing revenues and/or decreasing costs.

Specification and adoption of profit-maximizing farm plans may solve the resource allocation problem and the soil loss problem from the farmer's point of view, but society may not be satisfied with these levels of soil loss. If such is the case, policies will be needed which bring soil loss to acceptable levels from society's point of view. The appropriate formulation and successful implementation of policy will come about only when policy makers have a full understanding of the effects of various soil conserving practices on soil loss and farm profits.

The Center for Agricultural and Rural Development (CARD) in the study entitled "The Economics of Soil and Water Conservation Practices: results and discussion" (Pope, Bhide, and Heady, 1982b) addressed issues concerning the economics of adopting conservation practices in Iowa. In a normative framework, the study evaluated the economic profitability and soil loss impacts of several soil and water conservation practices used in Iowa under various economic environments and across various farm situations with differing soil resources and economic characteristics. The analysis was conducted on 18 representative farms in Iowa. The study by Pope, Bhide, and Heady made this study possible.

This study examines the unique role which livestock enterprises play in determining the economic profitability and the resulting soil loss impacts of conservation pratices used on farms in Iowa. Decisions are simultaneously made by farmers with respect to selecting appropriate livestock enterprises, choosing the levels of production of each enterprise, and selecting the least-cost method of raising animals in each enterprise. Decisions relating to production in the livestock sector have a direct effect on production in the crop sector and, therefore, also on soil loss. Just how the livestock sector influences the crop sector and soil loss will vary for different livestock enterprises and across various farm situations faced with different economic conditions and varying stocks of resources.

Objectives

Realizing that soil erosion imposes costs on both farmers and the rest of society, steps need to be taken in order to combat soil loss. Farming practices are available which can help to reduce soil erosion. Information relating to the profitability of adopting these practices and their impacts on soil loss is limited. The aim of this study is to remove some of the uncertainty associated with the adoption of soil and water conservation practices in Iowa.

In general, the objective of this study is to evaluate livestock's role in determining the adoption of soil and water conservation practices. Specifically, the objectives are to:

(a) Develop profit maximizing farm plans for five representative farms in Iowa under various livestock situations and under various restrictions on the use of farming practices;

(b) Estimate the impact of selected livestock enterprises on the profitabilty of adopting soil and water conservation practices; and

(c) Estimate the impact of selected livestock enterprise on soil loss.

The restrictions on the use of farming practices are used in order to generate farm plans in which (1) the farmer is unwilling or unable to use conservation practices, (2) the farmer is willing and able to use conservation practices, and (3) the farmer is allowed to use only those farming practices which restrict soil loss to below tolerance (T-value) levels.

Organization of the Report

The material in this report is contained in five chapters. Chapter I provides an introduction to the problem of soil loss and its control and specifies the objectives of the study. Chapter II explains the analytical approach used and discusses the data needed. Chapter III presents the results of the study and provides a discussion. Chapter IV suggests some policy implications and notes some limitations to the model. Chapter V gives the summary of and conclusions drawn from the study.

CHAPTER II. ANALYTICAL APPROACH AND DATA

This chapter focuses on the development of the analytical approach used in reaching the objectives of the study. Specifically discussed are the programming technique used and the data needed. Also included is a description of the scenarios used in this analysis.

Mathematical programming techniques are quite useful in analyzing and solving allocative decision making problems in agriculture. Decision making problems arise on farms because farmers are faced with an array of production alternatives and limited resources with which to optimize objectives. Farmers also face other restrictions on production. Commitments in tenure agreements, participation in government programs, contracts with processors, and subjective considerations related to personal preferences all are restrictions which influence decisions. Programming techniques combine, in a mathematical sense, production alternatives, resource constraints, and other restrictions in order to derive a farm plan which optimizes a specific objective. With a properly specified objective and a relevant set of data, programming methods can aid the farmer in deciding (1) which enterprises to adopt on the farm, (2) what method of production to use in each enterprise, and (3) what amount of resources to allocate to each production alternative (Anderson, Dillon, and Hardaker, 1977). The most widely used of the mathematical programming tools is linear programming.

Linear programming is used in this study as the framework for analysis. Linear programming contends with the problem of optimizing a linear objective function given set of activities and subject to a set of linear constraints. Activities are the means through which the objective is achieved. They are the processes which convert resources and other restrictions on planning into products (Agrawal and Heady, 1972). The set of linear constraints includes the limitations on land, labor, capital, and other restrictions on production. A thorough discussion of linear programming and its conditions and assumptions can be found in several qualified texts (Agrawal and Heady, 1972; Heady and Candler, 1973; Sposito, 1975). A description of the linear programming models used in this study is given below.

A single-year, linear programming model is constructed for each of the five representative Iowa farms. The optimization problem for each model is expressed in matrix notation as

$$\text{Maximize } Z = C'X \quad \text{subject to}$$

$$AX\ [\leq\ =\ \geq]\ B, \qquad X \geq 0$$

where $Z = C'X$ is the objective function,

Z is net returns,

C is the vector of prices,

X is the vector of activities,

A is the matrix of technical coefficients,

B is the vector of constraints, and

where one and only one of the signs ($\leq$, =, or $\geq$) holds for each of the constraints. The restriction that activity levels be greater than or equal to zero is imposed because crop and livestock production cannot take on negative values. The coefficients of the A matrix and the elements of the B and C vectors are constants assumed to be known with certainty.

The Objective Function

The objective of each of the study farms is to maximize net returns. Net returns are defined in this study as before-tax returns to land, family labor, management, and permanent livestock facilities, minus all crop and livestock enterprise ownership and operating costs excluding costs associated with depreciation and interest on livestock buildings. Prices received for crops and livestock are included in the objective function. All costs and prices are specified in 1980 dollars. Each farm's objective is reached through selection of optimal levels of crop and livestock activities given the input-output coefficients and subject to the resource constraints and other restrictions.

Activities

Activities are the processes needed in producing products. Activities are representative of several possible enterprises that can be included in the farm plans and many possible ways of undertaking these enterprises (Anderson, Dillon, and Hardaker, 1977). Each farm model contains a crop sector and a livestock sector. Activities included in the crop sector are production activities, purchasing activities, and selling activities. The livestock sector includes production activities, feeding activities, purchasing activities, and selling activities.

Crop sector

Crop production activities compose the largest portion of activities included in the crop sector. Crop production activities are developed with respect to crop management systems and soil type. Crop management systems are derived from various combinations of selected crop rotations, tillage systems, and supporting practices. Each management system on each soil has its own unique characteristics in terms of resources required, production generated, and soil loss created.

Six crops are chosen to be included in the models. They are corn grain (C), corn silage (S), soybeans (B), oats (O), meadow (M), and permanent pasture (P). From these six crops are constructed 15 crop rotations which are considered to be practical for Iowa farming and also useful in terms of the study's objectives. The rotations are shown in Table 1.

Table 1. Crop rotations selected for the farm models

1	C	6	SSSOM	11	SB
2	CCCOM	7	SSOMM	12	SSB
3	CCOMM	8	SOMMM	13	CBCOMM
4	COMMM	9	CB	14	SBSOMM
5	S	10	CCB	15	P

Five tillage systems are defined for use in the study. They are called conventional, fall chisel plow, spring disk, till-plant, and slot-plant tillage systems. Each system is differentiated by the types or degrees of tillage performed and, therefore, the amount of residue left on the soil surface. Residue left on the soil surface ranges from nearly none left under the conventional system to nearly all left under the slot-plant system. The tillage systems selected represent realistic practices and represent the full range of tillage systems used in Iowa.

Three supporting practices are selected for use in the study. These practices include contour farming, strip cropping, and terracing. Contour farming involves planting row crops perpendicular to the flow of water. Compared to straight-row farming, contour farming is assumed to have a 7 percent higher labor requirement and a 5 percent higher fuel requirement. Strip cropping, which plants alternative strips of row crops, small grains, and meadow on the contour, is also assumed to have a 7 percent higher labor requirement and a 5 percent higher fuel requirement. Appropriate types of terraces are determined for each soil type and annualized installation and maintenance costs are derived.

Crop management systems used in this study include all practical combinations of the above crop rotations, tillage systems, and supporting practices. Strip cropping is used only on the COMMM, CCOMM, SOMMM, and SSOMM rotations. Pasture uses only conventional tillage methods with no contouring or strip cropping. In addition, till-plant and slot-plant systems, which are used on slope class C or steeper soils, are done on the contour, and the till-plant tillage system is not used on the COMMM or SOMMM rotations.

Crop production activities use inputs and generate outputs. Each activity contains a set of requirements for land, labor, capital, pesticides, fuel, and fertilizer. Objective function coefficients represent per acre costs for seed, depreciation, taxes, insurance housing, nonenergy costs for drying, repairs, and custom charges. Crop requirements and costs are derived from the Firm Enterprise Data System (FEDS) (Economic Research Service, 1980) and various Iowa State University Extension sources. Crop production activities generate output which can be either sold off the farm (with the exception of corn silage) or used in the livestock sector. Crop production is based on 1985 yield projections determined from historical Iowa yield data and information provided by the Iowa State University Agronomy Extension Service (Fenton, Duncan, Shrader, and Dumenil, 1971). Crop yields are determined for individual soils. No yield adjustments are made across the different tillage systems, supporting practices, or crop rotations with one exception; first-year corn grain and first-year corn silage yields are assumed to be 7 percent higher than yields in other years. Crop yield estimates are provided in Table 2.

Table 2. Estimated 1985 crop yields for soils on the five representative Iowa farms

Farm	SMU number	Crop: Corn grain (bu./A)	Corn silage (ton/A)	Soybeans (bu./A)	Oats (bu./A)	Meadow (tons/A)	Pasture (AUM)
Boone County	107A1	136	18.2	48	96	5.4	7.6
	55A1	147	19.6	51	103	6.1	8.6
	138B1	136	18.2	48	96	5.7	7.9
	138C2	126	16.8	45	88	5.2	7.3
Van Buren County	65E2	0	0.0	0	0	2.5	2.6
	131B1	125	16.9	44	68	5.1	7.2
	132C2	106	14.5	37	58	4.4	5.7
Jasper County	120C2	145	19.3	50	101	6.0	8.4
	162D2	126	16.8	45	88	5.2	7.3
	119A1	164	21.7	58	114	6.7	9.4
	24E2	82	12.1	28	58	3.4	4.7
Ida County	1D3	85	12.5	30	60	3.2	4.5
	1E3	68	10.6	24	47	2.6	3.6
	10C2	112	15.1	40	78	4.2	6.5
	10D2	94	13.2	33	65	3.5	5.5
	12C1	124	16.5	44	87	4.6	7.2
Allamakee County	163C1	134	17.9	47	93	5.6	7.8
	163D2	119	16.3	42	83	4.9	6.8
	163E2	100	13.8	35	70	4.2	5.8
	478B1	0	0.0	0	0	0.0	2.4
	162C1	142	18.9	50	99	5.9	8.5

Each crop production activity creates a unique level of soil loss which corresponds to the characteristics of the given management system and soil type. Soil loss accounted for in the models is only that which results from water erosion. The Universal Soil Loss Equation (USLE) is used to estimate average annual per acre soil loss for each management system on each soil. This soil loss represents soil which is transported along the slope in question but not necessarily soil which is deposited in streams or bodies of water. The USLE is written as

$$A = R \times K \times L \times S \times C \times P$$

where A is the average annual soil loss in tons per acre,

R is the rainfall factor,

K is the soil erodibility factor,

L is the slope length factor,

S is the slope gradient factor,

C is the cropping and management factor, and

P is the conservation practice factor.

Estimates of these factors are made for all crop production activities.

Purchasing activities supply off-farm inputs to the production activities. Inputs such as hired labor, capital, fertilizer herbicides, insecticides, and fuel are purchased as they are needed by the production activities. Selling activities provide the flow of income for the crop sector. All crops can be sold off the farm with the exception of corn silage. Input and output prices are all in 1980 dollars. Table 3 provides these prices.

For a complete description and documentation of the LP models, as they relate to the cropping sector and data used, see Pope, Bhide, and Heady (1982a).

Table 3. Crop sector prices paid and received

Item	Unit	Price paid ($/unit)	Price received ($/unit)
Fertilizer			
Nitrogen (anhydrous ammonia: 82% N)	lb.	0.14	----
Phosphorus (super phosphate: 45% P_2O_5)	lb.	0.27	----
Potassium (muriate of potash: 60% K_2O)	lb.	0.12	----
Fuel			
Diesel fuel	gal.	1.29	----
LP gas	gal.	0.686	
Crops			
Corn grain	bu.	----	2.56
Soybeans	bu.	----	7.30
Oats	bu.	----	1.56
Straw	ton	----	50.00
Alfalfa	ton	----	57.73
Pasture	AUM	----	8.00
Other			
Hired labor	hrs.	4.50	----
Capital	dollars	0.15	----

Livestock sector

The livestock sector contains four livestock enterprises. Included are a feeder steer finishing enterprise, a cow-calf enterprise, a farrow-to-finish hog enterprise, and a dairy enterprise. Livestock are assumed to be produced in facilities already on the farm. Depreciation costs on assets with an estimated life of greater than ten years are not included in the models. Also, no means for investment in new facilities is made available in the model. Rations fed to livestock come from crops grown on the farm and protein supplement purchased off the farm. Hogs are fed a predetermined ration. Feeder steer, cow-calf, and dairy rations are determined endogenously within the models given the minimum nutritional requirements of the animals. Thus, a least-cost feed ration problem is solved within the larger net return maximization problem.

Activities are developed which correspond to key processes within the livestock sector. Production activities, purchasing activities, and selling activities are developed for each of the four enterprises. In addition, feeding activities are developed for the feeder steer, cow-calf, and dairy enterprises.

Livestock production activities each have an objective function coefficient, a set of input requirements, and a vector of outputs. The objective function coefficient represents the annualized fixed and variable costs of machinery and equipment not associated with feeding activities, hauling costs, salt and mineral costs, and veterinarian and medical expenses. Input requirements are included in each activity for labor, capital, and straw. In addition, the hog enterprise has requirements for corn grain, pasture, and energy, and the feeder steer enterprise has requirements for feeder steer calves. Also, minimum requirements for nutrients are specified for the feeder steer, cow-calf and dairy enterprises. Nutrient requirements are shown in Table 4 while other input requirements are provided in Table 5. Output is unique for each of the

Table 4. Annual nutrient requirements for feeder steer, cow-calf, and dairy enterprises

Livestock enterprise	Dry matter (lbs./unit)	Protein (lbs./unit)	Net energy for maintenance (Mcal./unit)	Net energy for gain (Mcal./unit)	Net energy for lactation (Mcal./unit)
Feeder steer (per head)[a]	3,997.20	447.44	3,610.08	2,326.39	----
Cow-calf (per unit)[a]	8,247.37	675.56	4,290.34	516.88	----
Dairy (per head)[b]	13,773.10	1,823.50	1,039.50	467.80	7,507.60

[a] Source: (National Academy of Sciences, 1976).

[b] Source: (National Academy of Sciences, 1978).

Table 5. Input requirements for livestock production activities

Input	Units	Livestock enterprise			
		Hog (per litter)	Feeder steer (per head)	Cow-calf (per unit)	Dairy (per milking cow)
Labor[a]					
Spring	hours	1.67	0.41	0.47	9.80
Fall	hours	1.37	0.09	0.35	7.35
Other	hours	6.01	0.96	1.52	32.85
Capital[a]					
Short-term	dollars	250.84	40.54	32.95	336.57
Medium-term	dollars	46.74	5.07	8.72	71.12
Energy[a]					
Diesel fuel	gallons	16.91	b	b	b
LP gas	gallons	13.99	b	b	b
Electricity	kilowatts	306.06	b	b	b
Corn grain[c]	bushels	98.00	---	---	---
Pasture[c]	animal unit months	0.48	---	---	---
Straw[c]	tons	0.27	---	---	---
Feeder steer calves	head	---	1	---	---

[a]Source: (Economic Research Service, 1980; and James, 1979).

[b]Energy costs for feeder steer, cow-calf, and dairy enterprises are included in respective objective coefficients.

[c]Source: (Economic Research Service, 1980).

production activities and is discussed below along with some other characteristics of the livestock enterprises.

The feeder steer enterprise generates fed steers and supplies nutrients to the crop sector in the form of manure. Feeder steer calves are acquired at 450 pounds in late fall. Calves can be be purchased from outside the farm or acquired from a cow-calf enterprise within the farm. Steers are fed 253 days to an average weight of 1,113 pounds. Six percent shrinkage is assumed in transportation to market in mid summer, and steers are, therefore, sold at an average weight of 1,050 pounds. Each animal inputs 24.74 pounds of nitrogen, 24.74 pounds of phosphorus, and 49.48 pounds of potassium into the crop sector. Annual capacity of finishing facilities is assumed to be 600 head.

The cow-calf enterprise generates feeder calves and cull cows. Fourteen percent of the breeding herd is culled annually, and 2 percent is lost due to death. Mature cows are bred in June with calving occurring in early April. A net calving rate of 86 percent is assumed. Calves are weaned and sold in October, nonreplacement heifers at 425 pounds and steers not entering the feeder steer enterprise at 450 pounds. Culled cows are sold at 960 pounds. Facilities are assumed to handle a capacity of 100 cow-calf units annually.

The dairy enterprise generates production of milk, culled dairy cows, dairy bull calves, dairy heifer calves, dairy springers, and crop nutrients in the form of manure. Equipment and facilities large enough to accommodate a maximum 60-cow herd are assumed to exist. Thirty percent of the milking herd is assumed to be replaced annually. A 98 percent calving rate is assumed. An average of 0.49 dairy bull calves, 0.04 dairy heifers, 0.02 dairy springers, 0.30 culled cows, and 12,000 pounds of milk are marketed annually per dairy cow. The dairy enterprise is developed from Oklahoma State University dairy budgets (Voelker, 1981).

Farrowing capacity in the farrow-to-finish hog enterprise is assumed to be 100 litters annually. Farrowing occurs quarterly in a solid floor farrowing house. Each litter produces an average of 6.2 market hogs and 0.3 cull sows per year. Pigs are finished in a dry lot to an average wieght of 227 pounds. Culled sows are sold at 360 pounds.

Feeding activities are developed which supply the required nutrients to the feeder steer, cow-calf, and dairy enterprises. Least-cost rations are derived. Animals can be fed corn grain, corn silage, alfalfa, and pasture which has been raised on the farm. In addition, cow-calf and dairy animals are allowed to graze corn stalks in the fall. Soybean meal can be purchased and fed as a supplemental source of protein. Likewise, urea can be purchased and fed to steers. Nutrients supplied by individual feed inputs are reported in Table 6. It is assumed that corn grain, corn silage, and alfalfa hay incur .5, 6, and 8 percent storage losses, respectively. Objective function coefficients for feeding activities represent costs for crop storage, handling, and grinding (Economic Research Service, 1980; Stoneberg and Anderson, 1979). In addition, fencing costs are determined for grazed corn stalks. Labor requirements are derived from FEDS budgets.

Table 6. Composition of feed inputs used in feeder steer, cow-calf, and dairy diets[a]

Feed type	Percentage dry matter	As fed basis				
		Percentage protein	Net energy for maintenance (Mcal./lb.)	Net energy for gain (Mcal./lb.)	Net energy for lactation (Mcal./lb.)
Corn grain	89.0	8.90	0.916	0.596	0.819
Corn silage	40.0	3.24	0.284	0.180	0.252
Corn stalks, grazed	87.2	5.14	0.480	0.218	0.522
Alfalfa hay	90.0	16.56	0.495	0.225	0.531
Pasture	21.6	4.23	0.130	0.069	0.138
Soybean meal	89.0	45.84	0.783	0.525	0.748
Urea	90.0	36.00	0.360	0.540	---

[a]Source: (National Academy of Sciences, 1976: National Academy of Sciences, 1978).

Purchasing and selling activities were indirectly referred to above. Prices represented by objective function coefficients for these activities are found in Table 7.

Table 7. Livestock sector prices paid and received

Item	Unit	Price paid ($/unit)	Price received ($/unit)
Soybean meal	ton	231.00	---
Urea	ton	160.00	---
Straw	ton	50.00	---
Labor	hour	4.50	---
Capital	dollar	0.15	
Fed steer	cwt.	---	58.66
Steer calf	cwt.	62.82	62.82
Heifer calf	cwt.	62.82	62.82
Cull cow	cwt.	---	39.60
Milk	cwt.	---	13.32
Cull dairy cow	cwt.	---	44.00
Dairy bull calf	head	---	110.44
Dairy heifer calf	head	---	43.11
Dairy springer	head	---	1,250.00
Market hog	cwt.	---	50.51
Cull sow	cwt.	---	42.78

Representative Farms

Five farms are constructed which represent different areas of the state of Iowa. The farms are thought to adequately represent the principal soil association from which they are derived and also cover extreme variations in erosive potentials. The five farms are derived from areas in east central Boone, northwest Van Buren, northeast Jasper, southwest Ida, and central Allamakee counties in Iowa and correspond to farms 3, 9, 17, 18, and 12, respectively, in the study by Pope, Bhide, and Heady, 1982 (Figure 1).

The Boone County farm, located in central Iowa, is derived from the Clarion-Nicollet-Webster principal soil association. Soils in this association are nearly level to gently sloping with a few strongly sloping areas. One of the problems in this area of the state is drainage of excess water in low-lying areas. Approximately one-third to one-half of the area in this association is artificially drained by tile and open ditches. The Clarion-Nicollet-Webster principal soil association is the largest in Iowa and occupies approximately 12,000 square miles or 20 percent of the state.

The Van Buren County farm, located in southeast Iowa, is derived from the Lindley-Keswick-Weller principal soil association. Types of soils in this association are quite variable. Soils range from very steep to nearly level. The steep soils are potentially very erosive while the flatter soils may require artificial drianage. The Lindley-Keswick-Weller principal soil association occupies about 1,700 square miles or 3 percent of Iowa.

The Jasper County farm, found in central Iowa, is derived from the Tama-Muscatine principal soil association. Soils in this area are nearly level to strongly sloping, predominantly loess soils. This principal soil association covers 4,000 square miles or 7 percent of the state.

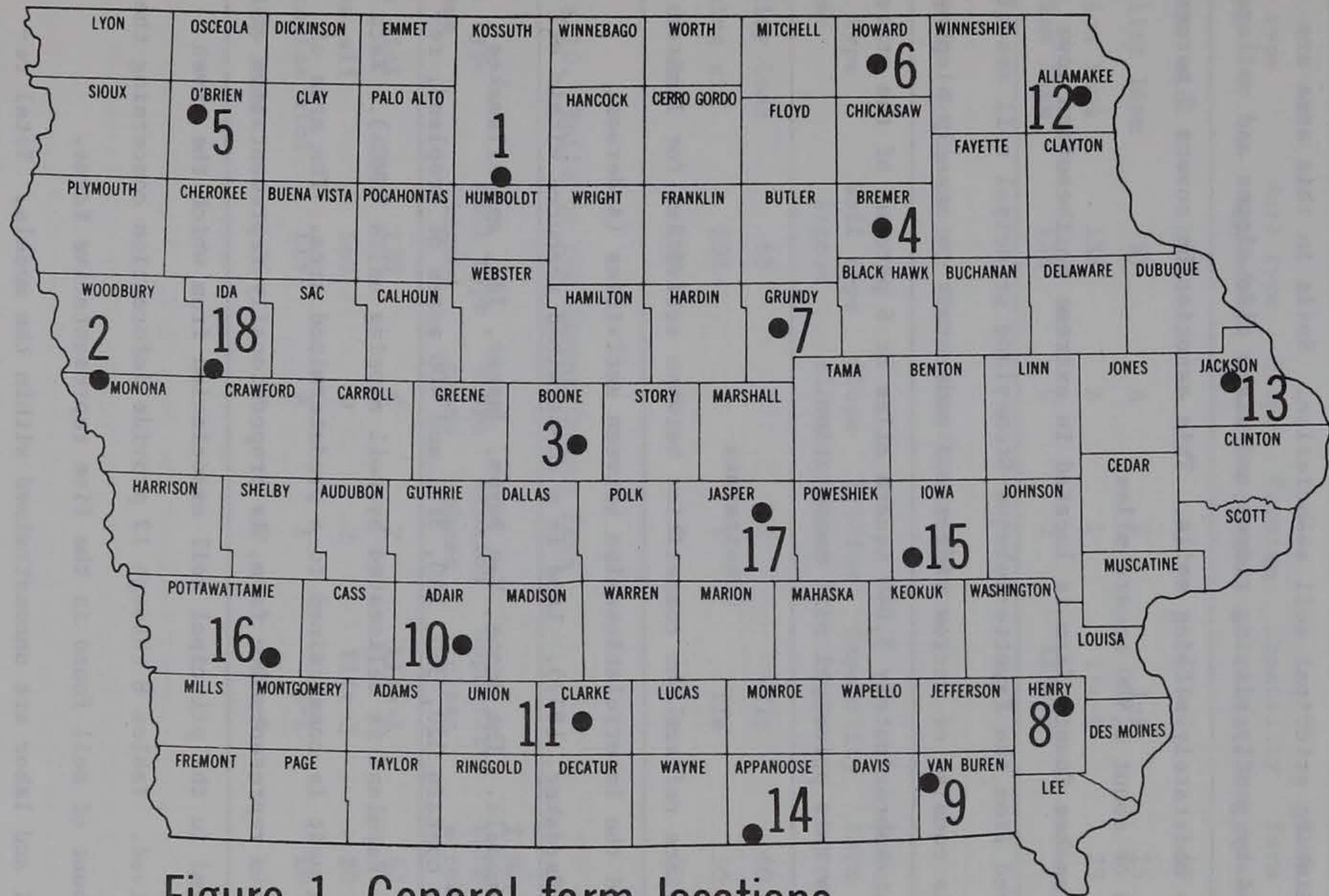

Figure 1. General farm locations

The Ida County farm, found in west central Iowa, is derived from the Monona-Ida-Hamburg principal soil association. Soils in this area are characterized by gently sloping ridges and steep side slopes and valleys with flat to moderately sloping soils. This association covers 5 percent of the state or about 2,900 square miles.

The Allamakee County farm is located in extreme northeastern Iowa and is derived from the Fayette-Dubuque-Stoneyland principal soil association. Soils consist of narrow ridges and moderately to steeply sloping side slopes. Approximately 3,640 square miles or 6 percent of the state is covered by this principal soil association.

Constraints

Constraints reflect the competition between activities for limited resources and the interrelationships between activities (Anderson, Dillon, and Hardaker, 1977). Land is a constrained resource within all of the farm models. The Boone, Van Buren, Jasper, Ida, and Allamakee county farms contain 320, 360, 340, 310, and 400 acres of cropland, respectively. Farmland is delineated by soil mapping units (SMUs). Each soil mapping unit is constrained to a predetermined area. The area of each SMU, on a representative farm, is proportionally representative of the area found in the principal soil association from which the given farm is derived. Tables 8 through 12 provide information concerning the type and amount of soil found in the five representative farms.

Capital and labor are unconstrained within the models. Total requirements are accounted for within the model, however, and reported

Table 8. Soils on the Boone County farm

Soil type name	Soil type legend	Slope class	Erosion phase	Capability class	% Net farm acres	Acres of SMU
Webster sicl	107	A	1	IIw-1	45	144
Nicollet loam	55	A	1	I-1	25	80
Clarion loam	138	B	1	IIe-1	23	74
Clarion loam	138	C	2	IIIe-1	7	22

Table 9. Soils on the Van Buren County farm

Soil type name	Soil type legend	Slope class	Erosion phase	Capability class	% Net farm acres	Acres of SMU
Lindley loam	65	E	2	VIe	40	144
Persing sil	131	B	1	IIe	30	108
Weller sil	132	C	2	IIIe	30	108

Table 10. Soils on the Jasper County farm

Soil type name	Soil type legend	Slope class	Erosion phase	Capability class	% Net farm acres	Acres of SMU
Tama sicl	120	C	2	IIIe-1	60	204
Downs sil	162	D	2	IIIe-3	20	68
Muscatine sicl	119	A	1	I-1	10	34
Shelby loam	24	E	2	IVe-1	10	34

Table 11. Soils on the Ida County farm

Soil type name	Soil type legend	Slope class	Erosion phase	Capability class	% Net farm acres	Acres of SMU
Ida sil	1	D	3	IIIe	15	47
Ida sil	1	E	3	IVe	30	93
Monona sil	10	C	2	IIe	18	56
Monona sil	10	D	2	IIIe	17	52
Napier sil	12	C	1	IIIe	20	62

Table 10. Soils on the Allamakee County farm

Soil type name	Soil type legend	Slope class	Erosion phase	Capability class	% Net farm acres	Acres of SMU
Fayette sil	163	C	1	IIIe-1	10	40
Fayette sil	163	D	2	IIIe-1	25	100
Fayette sil	163	E	2	IVe-1	7	28
Steep Rock	478	G	1	VIIs-1	28	112
Downs sil	162	C	1	IIIe-1	30	120

in the next chapter. There is also assumed to be highly competent managerial ability on the farms. This assumption is reflected in the fact that yield adjustments are not made across tillage systems.

Scenarios

A set of scenarios is analyzed for each farm. Scenarios are developed with respect to the livestock enterprises which the farmer is willing and able to have on his farm (livestock situations) and the restrictions placed on the farming practices (solution types). Six on-farm livestock situations are used which include cash crop (no livestock), feeder steer/cow-calf/hog, feeder steer/cow-calf, cow-calf, hog, and dairy situations. Restrictions on farming practices constitute the solution types and represent conditions where (1) the farmer is unwilling or unable to see soil and water conservation practices (conventional solutions), (2) the farmer is wililng and able to use any of the conservation practices (base solutions), and (3) the farmer is allowed to use only those farming practices which keep soil losses below tolerance levels (T-value solutions). Two types of T-value solutions are evaluated. Under one set of T-value restrictions, the farmer is able to sell meadow and pasture crops (T-value 1 solutions). This is also the condition under which conventional and base solutions are developed. This condition assumes that there is an off-farm demand for roughages. The other T-value solution type (T-value 2 solutions) assumes that the farmer is unable to sell meadow and pasture and that there is no off-farm demand for roughages. A scenario identification summary is provided in Table 13.

Not all scenarios are analyzed for each of the five farms. Livestock situations 1, 2, 3, 4, and 5 are included in the analysis for the Boone, Van Buren, Jasper, and Ida County farms while situations 1 and 6 are included for the Allamakee County farm. A total of 88 linear programming solutions are generated.

Table 13. Identification of scenarios used in farm models

Scenario name	Livestock situation: Name	Livestock situation: Alternative enterprises	Solution type: Name	Solution type: Type
1A	1	Cash crop (no livestock)	A	Conventional
1B		Cash crop (no livestock)	B	Base
1C		Cash crop (no livestock)	C	T-value 1
1D		Cash crop (no livestock)	D	T-value 2
2A	2	Feeder steer/cow-calf/hog	A	Coventional
2B		Feeder steer/cow-calf/hog	B	Base
2C		Feeder steer/cow-calf/hog	C	T-value 1
2D		Feeder steer/cow-calf/hog	D	T-value 2
3A	3	Feeder steer/cow-calf	A	Conventional
3B		Feeder steer/cow-calf	B	Base
3C		Feeder steer/cow-calf	C	T-value 1
3D		Feeder steer/cow-calf	D	T-value 2
4A	4	Cow-calf	A	Conventional
4B		Cow-calf	B	Base
4C		Cow-calf	C	T-value 1
4D		Cow-calf	D	T-value 2
5A	5	Hog	A	Conventional
5B		Hog	B	Base
5C		Hog	C	T-value 1
5D		HOg	D	T-value 2
6A	6	Dairy	A	Conventional
6B		Dairy	B	Base
6C		Dairy	C	T-value 1
6D		Dairy	D	T-value 2

CHAPTER III. RESULTS AND DISCUSSION

The results of each of the five farms are presented and discussed separately. No attempt is made to discuss individually all scenarios for each farm. Likewise, no attempt is made to report, compare, and discusss all variables generated from the farm models. Solution summaries for all 88 scenarios are provided in Krog (1982). Important variables which are discussed here relate to livestock production, crop management systems, soil loss, net returns, and capital and labor requirements. Summaries are provided for each farm.

The Boone County Farm

The Boone County farm contains 320 acres of cropland which consists of Clarion, Nicollet, and Webster soils. The farm is the most productive of the study farms in terms of crop production. As a result, the potential for producing livestock feed is relatively large. The Boone county farm is also relatively flat, and soil loss is much less severe than on other farms. A total of 20 scenarios are analyzed which are derived from five livestock situations and four solution types. The livestock situations used on the farm are cash crop, feeder steer/cow-calf/hog, feeder steer/cow-calf, cow-calf, and hog situations.

Livestock production

Feeder steer and hog enterprises enter the farm plan at capacity levels (600 head and 100 litters, respectively), for all four of the solution types. This is attributed to the fact that feeder steer and hog production are both profitable in the model and the farm has the capacity to produce abundant supplies of livestock feed. T-value restrictions on soil loss do not alter the sizes of these enterprises. Cow-calf production is unprofitable under all applicable livestock situations and solutions types. In order to observe impacts of the cow-calf enterprises on variables in the model, a lower bound of 75 units is placed on cow-calf production under the cow-calf situation. Table 14 summarizes livestock production for the 20 scenarios on the Boone County farm.

Rations fed to steers and cow-calf animals consist primarily of corn silage. Steers are fed some alfalfa hay along with small amounts of urea supplement. Cow-calf animals are also fed some alfalfa hay and, in addition, they are allowed to graze corn stalks in the fall. The composition of steer and cow-calf rations vary little as soil loss restrictions are imposed. Table 15 reports the composition of feeder steer and cow-calf diets. Percentage roughage figures for the diets are provided in Table 16. Percent roughage indicates to some extent the type of ration being fed across the various scenarios.

Crop management systems

Comparisons are made across solution types, as well as across livestock situations. Specific management systems are not referred to directly but are indirectly referenced in the discussions on rotations, tillage systems, and supporting practices.

Table 14. Livestock production on the Boone County farm under five livestock situations and four solution types

Livestock situation	Livestock enterprise	Solution Type A Conventional	B Base	C T-value 1	D T-value 2
1	Cash crop	-----	-----	-----	-----
2	Feeder steer (head)	600	600	600	600
	Cow-calf (units)	0	0	0	0
	Hog (litters)	100	100	100	100
3	Feeder steer (head)	600	600	600	600
	Cow-calf (units)	0	0	0	0
4	Cow-calf (units)	75[a]	75[a]	75[a]	75[a]
5	Hog (litters)	100	100	100	100

[a]Lower bound of 75 units

As expected, crop rotations vary substantially across the various livestock situations. Only slight differences are noted, however, across solution types. Table 17 reports acres of production of each of the six crops. Under the cash crop situation, the farm plan calls for corn grain and soybeans to be raised in rotation on all soils. Introducing feeder steer and cow-calf enterprises into the model results in plans which include rotations with large amounts of corn silage. Rotations with meadow are also grown to a limited extent in order to provide alfalfa hay for the livestock. Meadow rotations are found on the least productive, somewhat steep Clarion soil. The hogs require corn grain and thus livestock situations with the hog enterprise results in solutions with relatively

Table 15. Per unit composition of feeder steer and cow-calf diets on the Boone County farm

Scenario	Livestock enterprise	As fed basis						
		Corn grain (lbs.)	Corn silage (lbs.)	Alfalfa hay (lbs.)	Pasture (AUM)	Grazed corn stalks (lbs.)	Soybean (lbs.)	Urea (lbs.)
2A	Feeder steer	0	11,860	138	0	0	0	63
	Cow-calf	---	---	---	---	---	---	---
2B	Feeder steer	0	11,869	118	0	0	0	72
	Cow-calf	---	---	118	---	---	---	---
2C	Feeder steer	0	11,869	118	0	0	0	72
	Cow-calf	---	---	---	---	---	---	---
2D	Feeder steer	---	---	---	---	---	---	---
	Cow-calf	0	11,869	118	0	0	0	72
3A	Feeder steer	0	11,803	275	0	0	0	0
	Cow-calf	---	---	---	---	---	---	---
3B	Feeder steer	0	11,869	118	0	0	0	72
	Cow-calf	---	---	---	---	---	---	---
3C	Feeder steer		11,837	198	0	0	0	36
	Cow-calf	---	---	---	---	---	---	---
3D	Feeder steer	---	11,837	198	0	0	0	36
	Cow-calf	---	---	----	---	---	---	---
4A	Cow-calf	0	15,719	425	0	1,541	0	0
4B	Cow-calf	0	15,719	425	0	1,541	0	0
4C	Cow-calf	0	15,719	425	0	1,541	0	0
4D	Cow-calf	0	15,719	425	0	1,541	0	0

Table 16. Average percent roughage in livestock diets on the Boone county farm under five livestock situations and four solution types

Livestock situation	Livestock enterprise	A Conventional	B Base	C T-value 1	D T-value 2
1	Cash Crop	-----	-----	-----	-----
2	Feeder steer	52.68	52.42	52.42	52.42
	Cow-calf	-----	-----	-----	-----
	Hog	a	a	a	a
3	Feeder steer	54.44	52.42	53.43	53.43
	Cow-calf	-----	-----	-----	-----
4	Cow-calf	62.00	62.00	62.00	62.00
5	Hog	a	a	a	a

[a]Hogs are fed a predetermined ration consisting of corn grain and supplemental protein.

large amounts of corn grain acres. In general, raising feed for the livestock on the Boone County farm results in reductions in soybean production. The implications of this occurrence with respect to soil loss are discussed in the next section. The restrictions on management systems do not significantly alter rotation patterns on the Boone County farm.

Tillage practices are different for the various solution types. The base solution indicates that reduced tillage practices are the most profitable across all livestock situations. Specifically, the till-plant system enters the farm plan on all soils with the exception of where the COMMM rotation is grown. The slot-plant system is used for this rota-

Table 17. Acres of crop production on the Boone County farm under five livestock situations and four solution types

Scenario	Livestock situation	Solution type	Corn grain	Corn silage	Soybeans	Oats	Meadow	Pasture	Out of production
1A	Cash crop	Conventional	160.0	0.0	160.0	0.0	0.0	0.0	0.0
1B		Base	160.0	0.0	160.0	0.0	0.0	0.0	0.0
1C		T-value 1	160.0	0.0	160.0	0.0	0.0	0.0	0.0
1D		T-value 2	160.0	0.0	160.0	0.0	0.0	0.0	0.0
2A	Feeder steer/ cow-calf/hog	Conventional	71.9	213.2	16.0	3.0	9.3	6.5	0.0
2B		Base	70.8	214.5	17.7	2.7	7.9	6.5	0.0
2C		T-value 1	72.2	213.2	17.6	2.7	7.9	6.5	0.0
2D		T-value 2	72.2	213.2	17.6	2.7	7.9	6.5	0.0
3A	Feeder steer/ cow-calf	Conventional	0.0	206.7	89.2	6.0	18.1	0.0	0.0
3B		Base	0.0	208.0	102.2	2.5	7.3	0.0	0.0
3C		T-value 1	0.0	207.2	95.2	4.4	13.2	0.0	0.0
3D		T-value 2	0.0	207.2	95.2	4.4	13.2	0.0	0.0
4A	Cow-calf	Conventional	124.1	34.2	157.0	1.2	3.6	0.0	0.0
4B		Base	124.2	34.2	157.3	1.1	3.3	0.0	0.0
4C		T-value 1	124.1	34.2	157.0	1.2	3.6	0.0	0.0
4D		T-value 2	124.1	34.2	157.0	1.2	3.6	0.0	0.0
5A	Hog	Conventional	156.7	0.0	156.7	0.0	0.0	6.5	0.0
5B		Base	156.7	0.0	156.7	0.0	0.0	6.5	0.0
5C		T-value 1	156.7	0.0	156.7	0.0	6.5	0.0	0.0
5D		T-value 2	156.7	0.0	156.7	0.0	0.0	6.5	34.0

tion. T-value restrictions only affect tillage practices by bringing in slot-planting on the steep Clarion soil which raises a CB rotation.

Supporting practices are needed only to a limited extent on the Boone County farm. For the base solutions, contouring is practiced on the class C slope Clarion soil. Contouring and a limited amount of strip cropping is practiced on the Clarion soils for the T-value solutions.

Soil loss

Average annual soil loss on the Boone County farm ranges from a high of 3.38 tons per acre for scenario 1A (cash crop situation; conventional solution) to 0.52 tons per acre for scenarios 2C and 2D (feeder steer/cow-calf/hog; T-value 1 and T-value 2 solutions). Soil loss levels over all scenarios are reported in Table 18. Relative to the other livestock situations, the cash crop situations have the highest level of soil loss under the conventional solution type. Under the base solution, the cash crop situation has an average soil loss of 1.55 tons per acre--less than half that of the conventional solution. A closer examination shows that the adoption of optimal levels of soil conserving practices decreases soil loss much more under the cash crop situation than under livestock situations with the feeder steer enterprise (situations 2 and 3). This observation is understandable when considering the large amount of corn silage which is grown under situations 2 and 3. Reduced tillage practices do not go as far in controlling soil losses when residue levels on the soil surface are low. Soils, where corn silage is grown have relatively low levels of residue in comparison to soils where corn grain is

Table 18. Average annual soil loss on the Boone County farm under five livestock situations and four solution types

	Solution type							
	A Conventional		B Base		C T-value 1		D T-value 2	
Livestock situation	Soil loss (tons/ acre)	% of base	Soil loss (tons/ acre)	% of base	Soil loss (tons/ acre)	% of base	Soil loss (tons/ acre)	% of base
1	3.38	218	1.55	100	0.71	46	0.71	46
2	1.45	134	1.08	100	0.52	48	0.52	48
3	1.83	95	1.93	100	0.99	51	0.99	51
4	2.97	201	1.48	100	0.66	45	0.66	45
5	2.90	206	1.41	100	0.68	48	0.68	48

grown. Soil losses under the cow-calf and hog situations are similar to losses under the cash crop situation. Only a limited amount of corn silage needs to be grown for the cow-calf enterprise and hogs require only corn grain and a small amount of pasture. T-value restrictions cause average farm soil loss to fall below one ton per acre across all scenarios.

Net returns

Total farm net returns represent the net returns to land, family labor, management, and permanent livestock facilities. Table 19 provides net return figures for the Boone County farm.

Net returns, as expected, increase under all livestock situations as the model moves from the conventional solutions to the base solutions.

Table 19. Average annual net returns on the Boone County farm under five livestock situations and four solution types

	Solution type							
	A Conventional		B Base		C T-value 1		D T-value 2	
Livestock situation	Net returns (dollars)	% of base	Net returns (dollars)	% of base	Net returns (dollars)	% of base	Net returns (dollars)	% of base
1	64,382	94	68,754	100	68,657	100	68,657	100
2	118,116	96	123,650	100	123,636	100	123,636	100
3	116,619	96	120,985	100	120,888	100	120,888	100
4	62,576	94	66,739	100	66,657	100	66,657	100
5	77,572	95	81,856	100	81,779	100	81,779	100

The magnitude of the increase varies from situation to situation. The cash crop situation has the highest percentage increase in returns (6.8 percent) while the feeder steer/cow-calf/hog situation has the highest absolute increase ($5,534). These increases in returns are attributed to the savings in fuel, machinery, and capital costs that come from the adoption of conservation tillage. T-value restrictions on soil loss result in practically negibile reductions in net returns on the farm because conservation tillage can control most of the soil erosion with little need for supporting practices or less intensive crop rotations.

Capital and labor

Capital and labor are two resources which are left unconstrained within the model. Short-, medium-, and long-term capital are assumed to be readily available at market cost. An unlimited amount of hired labor is also assumed available if needed. Capital and labor requirements for the Boone County farm are accounted for in the model and reported in Table 20.

Table 20. Capital and labor requirements for the Boone County farm under five livestock situations and four solution types

Livestock situation	Solution type	Capital (dollars)	Labor (hours)
1	A	76,126	796
	B	65,223	620
	C	65,200	627
	D	65,200	627
2	A	341,890	4,404
	B	328,505	4,187
	C	328,505	4,187
	D	328,505	4,187
3	A	290,981	2,543
	B	283,338	2,340
	C	281,917	2,367
	D	281,917	2,367
4	A	80,336	1,171
	B	69,939	1,000
	C	69,932	1,009
	D	69,932	1,009
5	A	112,332	2,601
	B	101,651	2,427
	C	101,643	2,435
	D	101,643	2,435

Capital and labor are only briefly discussed here. In general, capital requirements decline as the model moves from the conventional to the base to the T-value solutions. This is due to reductions in fuel and machinery costs as the number of field operations decrease with reduced-tillage methods. Labor requirements are greatest for conventional solutions. Requirements for base and T-value solutions are nearly the same.

Summary

Profit-maximizing production of cash crops on the Boone County farm involves raising corn grain and soybeans in rotation using till-plant tillage practices and some contour planting on the moderately sloping soil. Livestock production can change crop production patterns but generally does not alter tillage systems and supporting practices. If the farmer is willing and able to produce steers in a profit-maximizing manner, a large amount of corn silage is grown. Feeding corn silage to steers is more profitable than feeding corn grain to hogs although hogs can be produced profitably. Hog production does not significantly alter crop production patterns in comparison with cash crop farming. Cow-calf production is unprofitable but if undertaken, will increase somewhat the production of corn silage and meadow. Like the cash crop situation, till-plant tillage practices are the most profitable for all livestock enterprises.

In relation to cash crop farming, profit-maximizing steer production creates slightly higher levels of soil loss. This increase in soil loss is attributed to the production of corn silage. Since soils on the farm are relatively flat, the increase in soil loss is not a major concern. Hog and cow-calf production do not significantly change soil loss relative to cash crop farming.

The Van Buren County Farm

The Van Buren County farm contains 360 acres of cropland which consists of Pershing, Weller, and Lindley soils. Over 30 percent of the farm contains slopes with steepnesses ranging from 15 to 19 percent. The farm has a high potential for severe soil erosion. The soil is not as productive as the Boone County farm and, as a result, the potential for producing livestock feed is more limited. The same 20 scenarios analyzed for the Boone County farm are analyzed here for the Van Buren County farm.

Livestock production

Feeder steer and hog production are both profitable on the Van Buren County farm. Limitations on the ability to produce feed inputs restrict production in these two enterprises, however. Table 21 shows the livestock production levels for the various scenarios. Under conventional and base solutions, feeder steer production is more profitable than hog production. It is more profitable to harvest corn silage and feed it to steers than to harvest corn grain and feed it to hogs. Production of feeder steers enters the farm plan at 510 head under situations 2 and 3. Hog production enters the farm plan at the 100-litter capacity level when

Table 21. Livestock production on the Van Buren County farm under five livestock situations and four solution types

Livestock situation	Livestock enterprise	Solution Type A Conventional	 B Base	 C T-value 1	 D T-value 2
1	Cash crop	-----	-----	-----	-----
2	Feeder steer (head)	510	510	93	190
	Cow-calf (units)	0	0	0	14
	Hog (litters)	0	0	100	100
3	Feeder steer (head)	510	510	219	277
	Cow-calf (units)	0	0	0	14
4	Cow-calf (units)	75[a]	75[a]	75[a]	45[b]
5	Hog (litters)	100	100	100	100

[a]Lower bound of 75 units.

[b]No lower bound.

feeder steer facilities are not available (situation 5). Cow-calf production is not profitable under conventional and base solutions, but a lower bound of 75 units is forced into the model under the cow-calf situation.

T-value restrictions on soil loss change the levels of livestock production. Feeder steer production is significantly reduced in relation to conventional and base solution production. Reductions are greater when hogs are included as an alternative enterprise (situation 2) than when hogs are not included (situation 3). Hog production under situation 2 enters the farm plan at 100 litters. Hog production under T-value restrictions, thus, gains in relative profitability in comparison with the feeder steer enterprise. T-value 1 solutions assume meadow and pasture can be sold off the farm while T-value 2 solutions assume they cannot. Feeder steer production is greater for T-value 2 solutions than for T-value 1 solutions. Herd size is larger in the event meadow cannot be sold off the farm because the meadow used to help reduce soil loss is profitably utilized in the feeder steer enterprise. The cow-calf enterprise becomes profitable under T-value 2 solutions. Production is not bounded for these solutions, and 45 units enter the farm plan under the cow-calf situation. Production under the hog situations is unaffected by T-value restrictions.

Rations fed to steers consist primarily of corn silage with some alfalfa hay. Cow-calf rations consist of corn silage, alfalfa, and grazed corn stalks. Table 22 provides the diet composition information for both feeder steers and cow-calf animals. The composition of livestock diets is the same for both conventional and base solution. The per head amount of corn silage which is fed declines and the amount of alfalfa fed increases for both feeder steers and cow-calf animals. The composition of livestock diets is the same for both conventional and base solutions. The per head amount of corn silage which is fed declines and the amount of alfalfa fed increases for both feeder steers and cow-calf animals as T-value restrictions are imposed. The amount of alfalfa fed is greatest under the T-value solutions. No corn silage is fed to cow-calf animals under the T-value 2 solutions. Percentage of roughage in the diet can help to indicate the types of rations fed to livestock. These figures are reported for the various scenarios in Table 23.

Table 22. Per unit composition of feeder steer and cow-calf diets on the Van Buren County farm

Scenario	Livestock enterprise	As fed basis						
		Corn grain (lbs.)	Corn silage (lbs.)	Alfalfa hay (lbs.)	Pasture (AUM)	Grazed corn stalks (lbs.)	Soybean meal (lbs.)	Urea (lbs.)
2A	Feeder steer	0	11,811	275	0	0	0	0
	Cow-calf	---	---	---	---	---	---	---
2B	Feeder steer	0	11,811	275	0	0	0	0
	Cow-calf	---	---	---	---	---	---	---
2C	Feeder steer	0	11,806	289	0	0	0	0
	Cow-calf	---	---	---	---	---	---	---
2D	Feeder steer	0	11,676	1,159	0	0	0	0
	Cow-calf	---	---	---	---	---	---	---
3A	Feeder steer	0	11,811	275	0	0	0	0
	Cow-calf	---	---	---	---	---	---	---
3B	Feeder steer	0	11,811	275	0	0	0	0
	Cow-calf	---	---	---	---	---	---	---
3C	Feeder steer	0	11,804	289	0	0	0	0
	Cow-calf	---	---	---	---	---	---	---
3D	Feeder steer	179	9,167	1,918	0	0	0	0
	Cow-calf	0	0	7,493	0	1,590	0	0
4A	Cow-calf	0	15,719	425	0	1,541	0	0
4B	Cow-calf	0	15,719	425	0	1,541	0	0
4C	Cow-calf	0	7,937	3,807	0	1,541	0	0
4D	Cow-calf	0	0	7,185	0	1,525	0	0

Table 23. Average percent roughage in livestock diets on the Van Buren County farm under five livestock situations and four solution types

Livestock situation	Livestock enterprise	Solution types A Conventional	B Base	C T-value 1	D T-value 2
1	Cash Crop	-----	-----	-----	-----
2	Feeder steer	54.44	54.44	54.56	61.59
	Cow-calf	-----	-----	-----	-----
	Hog	-----	-----	a	a
3	Feeder steer	54.44	54.44	54.56	65.77
	Cow-calf	-----	-----	-----	100.00
4	Cow-calf	62.00	62.00	80.80	100.00
5	Hog	a	a	a	a

[a]Hogs are fed a predetermined ration consisting of corn grain and supplemental protein.

Crop management systems

Rotations under the conventional and base solutions are similar within respective livestock situations. The cash crop situation results in CB rotations on the Pershing and Weller soils and pasture on the Lindley soil. The introduction of the feeder steer enterprise in situations 2 and 3 causes the farm plan to convert to continuous silage on the rolling Pershing and Weller soils. In addition, a meadow rotations and pasture are grown on the steep Lindley soil. This combination of rotations provides the maximum output of the steers' least-cost rations. Rotations under the cow-calf situation include CB and SB rotations along with the COMMM rotation and pasture on the Lindley soil. Rotations under the hog situation are the same as under the cash crop situation. The acres of production of each crop for all scenarios are found in Table 24.

T-value soil loss restrictions in general decrease the amounts of soybean and corn silage production. Soybeans under the cash crop situation are replaced by either less erosive meadow rotations (T-value 1) or continuous corn (T-value 2). Silage must be grown in rotation with meadow in situations 2, 3, and 4. The reduction in silage production, as discussed in the previous section, results in lower feeder steer production and a higher consumption of alfalfa hay by the remaining animals. Rotations under the hog situation are similar to rotations under the cash crop situation when T-value retrictions are imposed. T-value restrictions cause the Lindley soil to leave production. Due to USLE estimated soil losses which are slightly higher than the T-value level on this soil, not even permanent pasture is allowed to enter the solution. It should be noted, however, that most farmers would not leave this soil completely out of production and would continue to produce some type of pasture.

Types of tillage systems used across the solution types are similar to those used on the Boone County farm. Optimal tillage systems as indicated by base solutions are again those involving reduced tillage practices. The till-plant system is found to be the most profitable for most

Table 24. Acres of crop production on the Van Buren County farm under five livestock situations and four solution types

Scenario	Livestock situation	Solution type	Corn grain	Corn silage	Soybeans	Oats	Meadow	Pasture	Out of production
1A	Cash crop	Conventional	108.0	0.0	108.0	0.0	0.0	144.0	0.0
1B		Base	108.0	0.0	108.0	0.0	0.0	144.0	0.0
1C		T-value 1	75.6	0.0	54.0	21.6	64.8	0.0	144.0
1D		T-value 2	162.0	0.0	54.0	0.0	0.0	0.0	144.0
2A	Feeder steer/ cow-calf/hog	Conventional	11.1	216.0	0.0	11.1	33.4	88.3	0.0
2B		Base	11.1	216.0	0.0	11.1	33.4	88.3	0.0
2C		T-value 1	78.2	37.8	0.0	25.1	65.7	8.4	144.0
2D		T-value 2	92.7	66.2	0.0	23.0	25.7	8.4	144.0
3A	Feeder steer/ cow-calf	Conventional	11.1	216.0	0.0	11.1	33.4	88.3	0.0
3B		Base	11.1	86.4	0.0	11.1	33.4	88.3	0.0
3C		T-value 1	0.0	84.7	0.0	43.2	86.4	0.0	144.0
3D		T-value 2	8.5	42.8	0.0	41.5	81.3	0.0	144.0
4A	Cow-calf	Conventional	63.1	42.8	104.5	1.4	4.3	144.0	0.0
4B		Base	67.7	21.6	108.0	2.5	7.6	131.3	0.0
4C		T-value 1	54.0	0.0	54.0	21.6	64.8	0.0	144.0
4D		T-value 2	97.2	0.0	108.0	21.6	43.2	0.0	144.0
5A	Hog	Conventional	108.0	0.0	54.0	0.0	0.0	144.0	0.0
5B		Base	108.0	0.0	108.0	0.0	0.0	144.0	0.0
5C		T-value 1	76.8	0.0	54.0	20.0	56.9	8.4	144.0
5D		T-value 2	153.6	0.0	54.0	0.0	0.0	8.4	144.0

rotations. T-value restrictions require that additional acres on the farm be slot-planted. Slot-planted acres generally allow corn grain and soybeans to be produced on potentially erosive soils.

Supporting practices are important components in the the crop management systems on the Van Buren County farm. Base solutions use supporting practices under circumstances where the model is constrained to use contouring (till- and slot-plant tillage systems on class C slopes or steeper). Contouring strip cropping, and terracing are used under T-value restrictions. Terracing is used under three scenarios (1D, 2D, and 3D) on the Weller soil in order that continuous corn can be grown while still meeting tolerance levels of soil loss.

Soil loss

Average annual soil loss on the Van Buren County farm ranges from a high of 22.54 tons per acre for scenarios 2A and 3A feeder steer/cow-calf/hog and feeder steer/cow-calf situations; conventional solution type) to 0.82 tons per acre for scenario 5C (hog situation; T-value 1 solution type). Soil loss levels are reported for all scenarios in Table 25. Situations 2 and under 3 the conventional solution have only slightly higher soil loss levels than the other livestock situation. Under base solutions, however, situations 2 and 3 have significantly higher levels of soil loss. The Van Buren County farm indicates again that the adoption of optimal levels of soil conserving practices go farther in reducing soil loss under cash crop and hog situations than situations where silageconsuming livestock are being produced. T-value restrictions reduce soil loss to levels of less than two tons per acre per year across all scenarios.

Table 25. Average annual soil loss on the Van Buren County farm under five livestock situations and four solution types

	Solution type							
	A Conventional		B Base		C T-value 1		C T-value 2	
Livestock situation	Soil loss (tons/ acre)	% of base	Soil loss (tons/ acre)	% of base	Soil loss (tons/ acre)	% of base	Soil loss (tons/ acre)	% of base
1	22.16	157	14.12	100	1.94	14	1.30	9
2	22.54	117	19.33	100	0.99	5	1.51	8
3	22.54	117	19.33	100	1.25	6	1.27	7
4	22.45	136	16.56	100	1.01	6	1.10	7
5	22.16	157	14.12	100	0.82	6	1.29	9

Net returns

Net return figures for the 20 scenarios are provided in Table 26. Once again, net returns increase under all livestock situations as the farm plan converts from conventional tillage systems under the conventional solutions to reduced tillage systems in the base solutions. Increases are highest in percentage terms under the cash crop situation (8.6 percent), while absolute increases are highest under the feeder steer/cow-calf/hog and feeder steer/cow-calf situations ($4,040). T-value restrictions cause significant reductions in net returns. The most severe reductions occur under livestock situations which include the feeder steer enterprise. For example, under the feeder steer/cow-calf situation for the T-value 2 solution, net returns are $44,938 compared with $75,340 for the base solution. This represents a 40 percent reduction in net returns as a result of T-value restrictions. Restrictions affect net returns the least amount under the cow-calf situation.

Table 26. Average annual net returns on the Van Buren County farm under five livestock situations and four solution types

	Solution type							
	A Conventional		B Base		C T-value 1		D T-value 2	
Livestock situation	Net returns (dollars)	% of base	Net returns (dollars)	% of base	Net returns (dollars)	% of base	Net returns (dollars)	% of base
1	32,756	92	35,587	100	32,356	91	22,922	64
2	71,300	95	75,340	100	50,286	67	48,468	64
3	71,300	95	75,340	100	49,429	66	44,938	64
4	31,318	92	33,962	100	29,422	87	28,839	85
5	46,866	94	49,696	100	45,618	92	36,979	74

Capital and labor

Table 27 reports the capital and labor requirements for the Van Buren County farm. The same general observations can be made here as on the Boone County farm. That is, capital requirements decline as solutions go from conventional to base to T-value. In addition, labor requirements are always higher under conventional solutions than under base solutions.

Table 27. Capital and labor requirements for the Van Buren County farm under five livestock situations and four solution types

Livestock situation	Solution type	Capital (dollars)	Labor (hours)
1	A	60,293	676
	B	53,046	569
	C	41,973	511
	D	50,744	406
2	A	258,198	2,340
	B	247,514	2,202
	C	113,272	2,638
	D	153,562	2,842
3	A	258,198	2,340
	B	247,514	2,202
	C	119,488	1,227
	D	138,794	1,417
4	A	64,747	1,059
	B	59,155	978
	C	46,452	845
	D	45,074	655
5	A	97,449	2,488
	B	90,202	2,381
	C	77,435	2,305
	D	86,303	2,211

Summary

Profit-maxmizing production of cash crops on the Van Buren County farm involves raising corn grain and soybeans in rotation and growing permanent pasture. Corn and soybeans are grown using the till-plant tillage system and in addition, some planting is done on the contour. Crop production patterns change as livestock is produced. If the farmer produces feeder steers in a profit-maximizing fashion, a majority of the acres on the farm are planted with corn silage. As on the Boone County farm, feeding corn silage to steers increases profits more than feeding corn grain to hogs. In the event the farmer is unwilling or unable to produce steers, he should feed corn grain to hogs. The hog enterprise does not significantly alter crop production patterns in relation to cash crop farming. Cow-calf production requires that corn silage and meadow be grown. Till-plant tillage systems are the most profitable for all livestock enterprises, and livestock does not alter the use of contouring.

Relative to cash crop farming, profit-maximizing steer production creates moderately higher levels of soil loss. As expected, this increase in soil loss is caused by the production of corn silage. Cow-calf production also increases soil loss but only slightly. Hog production creates basically the same level of soil loss as cash crop farming.

Adoption of conservation practices which are required to meet T-value soil loss restrictions have differential impacts on livestock enterprises. Soil loss restrictions limit the amount of corn silage which can be grown and in effect, increase the cost of feeding steers. It is more profitable for the farmer to feed corn grain to hogs than to feed corn grain and meadow to steers and, thus hog production replaces steer production under soil loss restrictions. In the event that no market exists for forages, cow-calf production becomes profitable under T-value restrictions because cow-calf animals can profitably utilize meadow.

The Jasper County Farm

The Jasper County farm contains 340 acres of cropland which consist of Tama, Downs, Muscatine, and Shelby soils. The Tama, Downs, and Shelby soils are relatively steep-sloped and, therefore, susceptible to large amounts of soil erosion. The Muscatine soil is flat and relatively productive. The scenarios used on the previous farms are also used on the Jasper County farm.

Livestock production

Feeder steer and hog production enter the farm plan at capacity levels of 600 head and 100 litters, respectively, for conventional and base solutions. The cow-calf enterprise is unprofitable for these solutions, but again a lower bound of 75 units is put on cow-calf production under the cow-calf situation. Table 28 provides the livestock production figures for the Jasper County farm. As expected, T-value restrictions on soil loss causes feeder steer production to be reduced. Reductions are again larger when the hog enterprise is also included in the farm plan (situation 2). Feeding corn grain to hogs is more profitable than feeding corn grain and/or meadow to steers. Cow-calf production becomes a profitable proposition under T-value solutions assuming meadow cannot be sold off the farm (T-value 2 solutions). Cow-calf animals become valuable as utilizers of the alfalfa hay (meadow) which is used in rotations to reduce soil loss.

Table 28. Livestock production on the Jasper County farm under five livestock situations and four solution types

Livestock situation	Livestock enterprise	Solution type A Conventional	B Base	C T-value 1	D T-value 2
1	Cash crop	-----	-----	-----	-----
2	Feeder steer (head)	600	600	309	431
	Cow-calf (units)	0	0	0	18
	Hog (litters)	100	100	100	100
3	Feeder steer (head)	600	600	394	571
	Cow-calf (units)	0	0	0	15
4	Cow-calf (units)	75[a]	75[a]	75[a]	100[b]
5	Hog (litters)	100	100	100	100

[a]Lower bound of 75 units.

[b]No lower bound

Table 29 shows the composition of feeder steer and cow-calf diets on the Jasper County farm. Rations fed to feeder steer and cow-calf animals under conventional and base solutions are similar to the rations fed on the previous farms. Steer rations consist of large amounts of corn silage with some alfalfa hay. Urea is added as a protein supplement in the base solutions. Cow-calf rations consist of corn silage, alfalfa, and grazed corn stalks. T-value restrictions with the assumption that meadow and pasture can be sold off the farm do not significantly change livestock diets. Diets change significantly, however, when these forage crops cannot be sold. The farm plan then includes feeder steer diets which contain a large portion of corn grain and much less corn silage.

Table 29. Per unit composition of feeder steer and cow-calf diets on the Jasper County farm

		As fed basis						
Scenario	Livestock enterprise	Corn grain (lbs.)	Corn silage (lbs.)	Alfalfa hay (lbs.)	Pasture (AUM)	Grazed corn stalks (lbs.)	Soybean meal (lbs.)	Urea (lbs.)
2A	Feeder steer	0	11,805	275	0	0	0	0
	Cow-calf	---	---	---	---	---	---	---
2B	Feeder steer	0	11,869	118	0	0	0	72
	Cow-calf	---	---	---	---	---	---	---
2C	Feeder steer	0	11,775	288	0	0	0	0
	Cow-calf	---	---	---	---	---	---	---
2D	Feeder steer	2,233	3,951	315	0	0	0	0
	Cow-calf	0	0	7,209	0	1,530	0	0
3A	Feeder steer	0	11,805	275	0	0	0	0
	Cow-calf	---	---	---	---	---	---	---
3B	Feeder steer	0	11,869	118	0	0	0	0
	Cow-calf	0	11,775	289	0	0	0	0
3D	Feeder steer	2,787	3,205	489	0	0	0	0
	Cow-calf	0	0	7,366	0	1,564	0	0
4A	Cow-calf	0	15,719	425	0	0	0	0
4B	Cow-calf	0	15,719	425	0	0	0	0
4C	Cow-calf	0	15,719	425	0	0	0	0
4D	Cow-calf	0	0	7,259	0	1,417	0	0

Least-cost steer rations under the T-value 2 solutions thus contain more concentrate than under the other solution types. Table 30 clearly indicates this result for the feeder steer enterprise. Cow-calf animals, on the other hand, are fed diets which are composed entirely of roughages, alfalfa hay, and grazed corn stalks.

Table 30. Average percent roughage in livestock diets on the Jasper County farm under five livestock situations and four solution types

Livestock situation	Livestock enterprise	Solution Type A Conventional	 B Base	 C T-value 1	 D T-value 2
1	Cash crop	-----	-----	-----	-----
2	Feeder steer	54.44	52.42	54.56	30.11
	Cow-calf	-----	-----	-----	100.00
	Hog	a	a	a	a
3	Feeder steer	54.44	52.42	54.56	27.39
	Cow-calf	-----	-----	-----	100.00
4	Cow-calf	62.00	62.00	62.00	100.00
5	Hog	a	a	a	a

[a]Hogs are fed a predetermined diet consisting of corn grain and supplemental protein.

Results from the Van Buren County farm and results from the Jasper County farm seem to contradict each other in terms of the feeder steer diets fed under T-value 2 solutions. The Van Buren County farm feeds large amounts of alfalfa and slightly less corn silage relative to the other solutions while the Jasper County farm feeds a large amount of corn grain and much less corn silage. These results indicate that restrictions on soil loss do not automatically result in feeder cattle being fed larger amounts of roughage from the meadow or pasture. The livestock producer is concerned only with deriving rations which contribute the greatest value to the farming operation but which require crop management systems which still meet tolerance levels of soil loss. Rations which meet this objective will vary from farm to farm because the characteristics of soils vary from farm to farm.

Crop management systems

The rotation patterns for base and conventional solutions on the Jasper County farm are similar to patterns on the previous two farms. Table 31 provides the acres of crop production which are a direct result of rotations. The cash crop situation under conventional and base solutions results primarily in rotations of corn grain and soybeans. Incorporating feeder steer production in the farm plans (situations 2 and 3) requires that large amounts of silage be grown. Continuous corn silage and corn grain grown in rotation with soybeans are the primary sources of feed for the steers. Continuous corn is the primary source of feed for the hog enterprise. Rotations change only slightly within livestock situations as solution types go from conventional to base.

T-value restrictions significantly alter crop production patterns. Under the cash crop situation, T-value restrictions reduce the production of soybeans and either increase production of meadow (T-value 1) or increase the production of continuous corn (T-value 2). Corn silage pro-

Table 31. Acres of crop production on the Jasper County farm under five livestock situations and four solution types

Scenario	Livestock situation	Solution type	Corn grain	Corn silage	Soybeans	Oats	Meadow	Pasture	Out of production
1A	Cash crop	Conventional	159.8	0.0	153.0	6.8	20.4	0.0	0.0
1B		Base	170.0	0.0	170.0	0.0	0.0	0.0	0.0
1C		T-value 1	98.6	0.0	51.0	47.6	108.8	0.0	34.0
1D		T-value 2	289.0	0.0	17.0	0.0	0.0	0.0	34.0
2A	Feeder steer/ cow-calf/hog	Conventional	63.7	216.3	25.1	6.2	18.5	10.3	0.0
2B		Base	65.3	216.3	38.8	2.3	7.0	10.3	0.0
2C		T-value 1	67.6	100.9	0.0	39.6	91.5	6.5	34.0
2D		T-value 2	204.0	46.3	0.0	12.3	36.9	6.5	34.0
3A	Feeder steer/ cow-calf	Conventional	0.0	212.9	102.5	6.2	18.5	0.0	0.0
3B		Base	0.0	214.6	116.1	2.3	7.0	0.0	0.0
3C		T-value 1	0.0	129.2	0.0	54.4	122.4	0.0	34.0
3D		T-value 2	198.0	50.0	0.0	14.8	43.2	0.0	34.0
4A	Cow-calf	Conventional	126.4	40.9	165.5	1.8	5.5	0.0	0.0
4B		Base	129.8	37.8	165.5	1.8	5.5	0.0	0.0
4C		T-value 1	66.0	13.8	50.0	47.8	110.3	0.0	34.0
4D		T-value 2	153.8	0.0	40.6	37.2	74.4	0.0	34.0
5A	Hog	Conventional	157.7	0.0	153.0	4.7	14.2	10.3	0.0
5B		Base	164.8	0.0	164.8	0.0	0.0	10.3	0.0
5C		T-value 1	97.3	0.0	51.0	46.3	104.9	6.5	34.0
5D		T-value 2	245.6	0.0	17.0	12.3	24.6	6.5	34.0

duction is reduced under situations 2 and 3 because silage is required to be grown in rotation with meadow on most soils. Continuous silage can only be grown on the Muscatine soil. In general, T-value restrictions on soil loss reduce soybean production and silage production and increase production of the less erosive meadow. In the event that meadow cannot be sold off the farm, large increases in corn grain production occur.

Tillage practices vary over the range of solution types. The base solutions indicate that reduced tillage practices are the most profitable across all livestock situations on the Jasper County farm. Till- and slot-plant tillage systems are included in these optimal farm plans. T-value restrictions cause less till-planting and more slot-planting to occur. In particular, much of the corn and soybean acres on the Tama and Downs soils are slot-planted when tolerance levels of soil loss are desired.

Contouring is the most prevalent supporting practice on the Jasper County farm. In the base solutions, model restrictions require that till- and slot-planting be done on the contour for all soils except Muscatine. Contouring, strip cropping, and terracing are needed when T-value restrictions are imposed. Strip cropping is done on many of the corn silage acres in rotation with meadow. Terracing enters the farm plan only under the cash crop situation with soil loss restrictions (T-value 2 solution). Terracing is done in order that continuous corn can be grown on the Downs soil.

Soil loss

The Jasper County farm is relatively erosive. Average annual soil loss ranges from 57.44 tons per acre for scenario 4A (cow-calf situation; conventional solution type) to 2.18 tons per acre for scenario 2D (feeder steer/cow-calf/hog situation; T-value 2 solution type). Table 32 reports average farm soil loss levels for all scenarios. Converting from conventional tillage practices in the conventional solution to reduced tillage practices in the base solutions reduces soil loss across all livestock situations. The largest reductions occur under the cow-calf situation while the smallest reductions occur under the livestock situations which include the feeder steer enterprise (situations 2 and 3). The highest level of soil loss for base solutions is under the feeder steer/cow-calf situation where 600 head of feeder steers are produced. Again, this result is because reduced tillage methods do not contribute as much to reducing soil loss on acres planted to corn silage as on acres planted to other crops. T-value restrictions reduce soil loss 90 percent or more relative to base solutions.

Net returns

Net return figures for the Jasper County farm are provided in Table 33. The adoption of reduced tillage practices in the base solution increased income across all livestock situations. Again, the highest percentage increase comes under the cash crop situation (6.6 percent) while the highest absolute increase comes under the feeder steer/cow-calf/hog situation ($5,651).

Table 32. Average annual soil loss on the Jasper County farm under five livestock situations and four solution types

Livestock situation	A Conventional: Soil loss (tons/acre)	A Conventional: % of base	B Base: Soil loss (tons/acre)	B Base: % of base	C T-value 1: Soil loss (tons/acre)	C T-value 1: % of base	D T-value 2: Soil loss (tons/acre)	D T-value 2: % of base
1	45.90	134	34.29	100	3.31	10	2.22	6
2	45.96	111	41.28	100	2.63	6	2.18	5
3	53.17	114	46.67	100	2.83	6	2.19	5
4	57.44	160	35.86	100	3.26	9	3.07	9
5	45.66	143	32.00	100	3.32	10	2.30	7

Table 33. Average annual net returns on the Jasper County farm under five livestock situations and four solution types

Livestock situation	A Conventional: Net returns (dollars)	A Conventional: % of base	B Base: Net returns (dollars)	B Base: % of base	C T-vaue 1: Net returns (dollars)	C T-vaue 1: % of base	D T-value 2: Net returns (dollars)	D T-value 2: % of base
1	66,954	94	71,366	100	61,448	86	44,553	62
2	123,570	96	129,221	100	98,695	76	93,710	73
3	121,087	97	125,397	100	95,697	76	88,955	71
4	65,517	94	69,762	100	59,507	85	52,590	75
5	80,441	95	84,729	100	74,827	88	58,753	69

T-value restrictions cause substantial reductions in net returns. The largest reductions occur when meadow and pasture crops cannot be sold off the farm. Under T-value 2 solution types, net return reductions as a percentage of the base returns are largest under the cash crop situation (38 percent). Terracing costs are a major contributor to this result. The largest absolute reductions in net returns occur under the feeder steer/cow-calf situation. A large part of this reduction is caused by the decline in the number of feeder steers produced relative to the base solution. Net returns under the cow-calf situation are affected the least with the T-value restrictions.

Capital and labor

Table 34 shows the requirments for capital and labor on the Jasper County farm to be similar to the previous two farms. Generally, capital requirements are largest for conventional solutions. One exception is the cash crop situation. In this case, capital requirements are highest for the T-value 2 solution since terracing is needed. Capital requirements for base solutions, however, are lower than requirements for conventional solutions under all situations. Labor requirements are also highest for conventional solutions across all situations.

Summary

Maximizing the profits of cash crops on the Jasper County farm involves raising corn and soybeans in rotation using the till-plant tillage system and contour planting. Livestock's demand for least-cost feed rations change cropping patterns. A large amount of corn silage is grown

Table 34. Capital and labor requirements for the Jasper County farm under five livestock situations and four solution types

Livestock situation	Solution type	Capital (dollars)	Labor (hours)
1	A	79,964	863
	B	69,116	694
	C	63,960	794
	D	80,680	626
2	A	341,479	4,461
	B	330,775	4,271
	C	211,788	3,481
	D	256,770	3,624
3	A	294,561	2,592
	B	286,718	2,433
	C	201,928	2,138
	D	268,119	2,138
4	A	84,943	1,227
	B	74,053	1,083
	C	68,584	1,171
	D	72,369	1,122
5	A	115,795	2,657
	B	105,316	2,498
	C	100,734	2,606
	D	108,832	2,481

when steers are produced. Hog production does not significantly alter crop production patterns in relation to cash crop farming. Corn silage and meadow production increase somewhat with cow-calf production. Like cash crop farming, till-plant tillage systems and contour planting are used with all livestock enterprises.

In comparison with cash crop farming, profit-maximizing steer production creates moderately higher levels of soil loss. Corn silage production causes this increase in soil loss. Cow-calf production causes a slight increase in soil loss, and hog production decreases soil loss somewhat because of the small pasture requirement.

T-value restrictions limit the amount of corn silage which can be fed on the Jasper County farm. Steers are fed large amounts of corn grain, but grain is more profitably fed to hogs and thus feeder steer production falls along with steer profits. Hogs are not affected by T-value restrictions, but cow-calf production becomes profitable when utilizing large amounts of meadow. Strip cropping is used with the various meadow rotations.

The Ida County Farm

The Ida County farm contains 310 acres of cropland consisting of Ida, Monona, and Napier soils. Soils on the farm are all relatively steep and potentially very erosive. The Ida County farm is the most erosive of the five farms included in this study. The farm is only moderately productive in terms of crop yields, and therefore, has a limited ability to produce feed for livestock. Once again, the scenarios analyzed on previous farms are also analyzed on this farm.

Livestock production

Feeder steer production enters the farm plan at capacity levels of 600 head for conventional and base solutions. Hog production under the hog situation enters at the 100-litter capacity level. The two enterprises do not enter the farm land together under situation 2 because the farm's feed-producing capacity is exhausted after the feed needs of the feeder steers are met. Although both steers and hogs are profitable, raising feeder steers contributes more to the value of the objective function under existing conditions than does raising hogs. Cow-calf production is unprofitable for conventional and base solutions but as with previous farms, 75 units of the cow-calf enterprise are forced into the farm plan under the cow-calf situation. Table 35 reports the livestock production results.

Table 35. Livestock production on the Ida County farm under five livestock situations and four solution types

Livestock situation	Livestock enterprise	Solution Type A Conventional	 B Base	 C T-value 1	 D T-value 2
1	Cash Crop	-----	-----	-----	-----
2	Feeder steer	600	600	91	134
	Cow-calf	0	0	0	14
	Hog	0	0	100	100
3	Feeder steer	600	600	205	275
	Cow-calf	0	0	0	11
4	Cow-calf	75[a]	75[a]	75[a]	63[b]
5	Hog	100	100	100	100

[a]Lower bound of 75 units.

[b]No lower bound

T-value restrictions reduce feeder steer production and cause the hog enterprise to enter the farm plan under the feeder steer/cow-calf/hog situation. Soil loss restrictions limit the amount of the least-cost, high-silage ration which can be fed to steers. As a result, size of the feeder steer enterprise is reduced. Hogs, on the other hand, consume corn grain which can be raised on the farm at quantities sufficient enough to meet the feed needs of the hog enterprise while still meeting tolerance levels of soil loss. Cow-calf production is a profitable proposition under T-value restrictions when meadow cannot be sold off the farm. The cow-calf animals are able to give the meadow crop a value in production. In general, T-value restrictions decrease the feeder steer enterprises' competitive advantage over the hog and cow-calf enterprises.

The composition of diets fed to feeder steers and cow-calf animals is shown in Table 36. Diets for conventional and base solutions are very similar. Steer rations contain primarily corn silage with small amounts of alfalfa, soybean meal, and urea. Cow-calf animals are fed corn silage, alfalfa hay, and corn stalks.

T-value restrictions change least-cost rations. The most significant changes occur when meadow and pasture are not allowed to be sold (T-value 2 solutions). Steers are fed less corn silage and more alfalfa hay. In addition, steers are fed corn grain. The feeder steer enterprise competes with the hog enterprise for corn grain under situation 2. Corn grain's feed value is larger when fed to hogs than when fed to steers. Therefore, the grain needs of hogs are satisfied before any grain is committed to the steers. More corn grain and less corn silage are fed to the steers under situation 3 (no hog enterprise). Cow-calf diets under T-value 2 solutions consist entirely of alfalfa hay and grazed corn stalks. Table 37 shows the percent roughage figures for the various scenarios. Relationships concerning diets resemble relationships found on the Jasper County farm.

<u>Crop management systems</u>

Crop management systems on the Ida County farm are similar to those on the Jasper County farm. Rotation patterns do not change significantly

Table 36. Per unit composition of feeder steer and cow-calf diets on the Ida County farm

		As fed basis						
Scenario	Livestock enterprise	Corn grain (lbs.)	Corn silage (lbs.)	Alfalfa hay (lbs.)	Pasture (AUM)	Grazed corn stalks (lbs.)	Soybean meal (lbs.)	Urea (lbs.)
2A	Feeder steer	0	11,883	62	0	0	21	72
	Cow-calf	---	---	---	---	---	---	---
2B	Feeder steer	0	11,898	0	0	0	44	72
	Cow-calf	---	---	---	---	---	---	---
2C	Feeder steer	0	11,718	287	0	0	0	0
	Cow-calf	---	---	---	---	---	---	---
2D	Feeder steer	2,954	2,714	506	0	0	0	0
	Cow-calf	0	0	7,155	0	1,519	0	0
3A	Feeder steer	0	11,883	62	0	0	21	72
	Cow-calf	---	---	---	---	---	---	---
3B	Feeder steer	0	11,898	0	0	0	44	72
	Cow-calf	---	---	---	---	---	---	---
3C	Feeder steer	1,319	7,795	343	0	0	0	0
	Cow-calf	0	0	---	---	---	---	---
3D	Feeder steer	3,211	1,893	531	0	0	0	0
	Cow-calf	---	---	7,522	0	1,604	0	0
4A	Cow-calf	0	15,711	425	0	1,541	0	0
4B	Cow-calf	0	15,711	425	0	1,541	0	0
4C	Cow-calf	0	0	2,345	0	1,207	0	0
4D	Cow-calf	0	11,517	7,313	0	1,552	0	0

Table 37. Average percent roughage in livestock diets on the Ida County farm under five livestock situations and four solution types

Livestock situation	Livestock enterprise	Solution Type A Conventional	B Base	C T-value 1	D T-value 2
1	Cash Crop	-----	-----	-----	-----
2	Feeder steer	51.72	50.95	54.56	25.52
	Cow-calf	-----	-----	-----	100.00
	Hog	-----	-----	a	a
3	Feeder steer	51.72	50.95	42.64	22.29
	Cow-calf	-----	-----	-----	100.00
4	Cow-calf	62.00	62.00	71.48	100.00
5	Hog	a	a	a	a

[a]Hogs are fed a predetermined ration consisting of corn grain and supplemental protein.

as the farm converts from conventional tillage methods in the conventional solutions to reduced tillage methods in the base solutions. Rotations for these solutions consist primarily of corn grain and soybeans under the cash crop and hog situations and corn silage under situations which include the feeder steer enterprise. Rotation patterns are altered significantly when T-value restrictions are imposed. Corn silage and soybean production are reduced sharply and meadow production is increased. In the event meadow cannot be sold, corn grain production increases. Table 38 shows production acres for each crop.

Optimal tillage systems observed in the base solutions are generally till-plant systems. As soil loss restrictions are imposed, slot-planting is utilized to a large extent on the corn grain acres. Also, under T-value restrictions strip cropping is needed. No terracing is used on the Ida County farm.

Table 38. Acres of crop production on the Ida County farm under five livestock situations and four solution types

Scenario	Livestock situation	Solution type	Corn grain	Corn silage	Soybeans	Oats	Meadow	Pasture	Out of production
1A	Cash crop	Conventional	155.0	0.0	155.0	0.0	0.0	0.0	0.0
1B		Base	155.0	0.0	155.0	0.0	0.0	0.0	0.0
1C		T-value 1	59.2	0.0	19.6	39.4	98.8	0.0	93.0
1D		T-value 2	170.0	0.0	0.0	0.0	0.0	0.0	140.0
2A	Feeder steer/	Conventional	0.0	301.8	0.0	2.1	6.2	0.0	0.0
2B	cow-calf/hog	Base	0.0	303.4	6.6	0.0	0.0	0.0	0.0
2C		T-value 1	91.6	38.6	0.0	22.9	53.1	10.8	93.0
2D		T-value 2	152.8	14.1	0.0	10.6	28.6	10.8	93.0
3A	Feeder steer/	Conventional	0.0	301.8	0.0	2.1	6.2	0.0	0.0
3B	cow-calf	Base	0.0	303.4	6.6	0.0	0.0	0.0	0.0
3C		T-value 1	52.0	56.6	0.0	33.3	75.5	0.0	93.0
3D		T-value 2	153.2	10.5	0.0	14.6	38.7	0.0	93.0
4A	Cow-calf	Conventional	95.0	56.3	148.9	2.4	7.3	0.0	0.0
4B		Base	95.0	56.3	148.9	2.4	7.3	0.0	0.0
4C		T-value 1	28.0	33.5	13.9	40.5	101.1	0.0	93.0
4D		T-value 2	89.4	0.0	19.6	39.4	68.6	0.0	93.0
5A	Hog	Conventional	124.5	0.0	108.5	16.0	47.9	13.0	0.0
5B		Base	148.4	0.0	148.4	0.0	0.0	13.3	0.0
5C		T-value 1	91.7	0.0	19.6	32.3	64.8	8.8	93.0
5D		T-value 2	170.0	0.0	0.0	0.0	0.0	10.8	129.2

Soil loss

The Ida County farm, as expected, can be very erosive. Average annual farm soil loss ranges from 97.88 tons per acre for scenario 1A (cash crop situation; conventional solution) to 1.69 tons per acre (cash crop situation; T-value 2 solution). Table 39 shows soil loss levels for all scenarios. Converting from conventional tillage practices to optimal reduced tillage practices results in lower soil loss levels under all livestock situations with the exception of the hog situation. The conversion results in the largest reductions under the cash crop situation (36 percent). Reductions are much less under situations which included the feeder steer enterprise (situations 2 and 3). In addition, these two situations have significantly higher soil loss levels than other livestock situations for the base solution. T-value restrictions reduce soil loss 95 percent or more relative to base solutions.

Table 39. Average annual soil loss on the Ida County farm under five livestock situations and four solution types

	Solution type							
	A Conventional		B Base		C T-value 1		D T-value 2	
Livestock situation	Soil loss (tons/ acre)	% of base	Soil loss (tons/ acre)	% of base	Soil loss (tons/ acre)	% of base	Soil loss (tons/ acre)	% of base
1	97.88	164	59.54	100	2.42	4	1.69	3
2	90.09	107	84.33	100	2.38	3	2.19	3
3	90.09	107	84.33	100	2.48	3	2.19	3
4	97.28	145	67.28	100	2.43	4	2.84	4
5	47.36	86	55.20	100	2.72	5	1.81	3

Table 40. Average annual net returns on the Ida County farm under five livestock situations and four solution types

Livestock situation	A Conventional: Net returns (dollars)	A Conventional: % of base	B Base: Net returns (dollars)	B Base: % of base	C T-value 1: Net returns (dollars)	C T-value 1: % of base	D T-value 2: Net returns (dollars)	D T-value 2: % of base
1	31,989	90	35,650	100	25,053	70	16,766	47
2	78,699	94	84,136	100	44,247	53	42,264	50
3	78,699	94	84,136	100	40,111	48	47,609	45
4	31,690	91	35,254	100	22,382	63	20,502	58
5	45,639	93	49,110	100	37,636	77	30,895	63

Net returns

Net return figures for the Ida County farm are reported in Table 40. The adoption of reduced tillage practices in the base solution increased net returns the most under the two situations which included feeder steers (situations 2 and 3). In percentage terms, the largest increase came under the cash crop situation (10 percent). T-value restrictions reduced net returns the most under the feeder steer/cow-calf situation. For the T-value 2 solution, the reduction amounted to $46,527, a 55 percent decrease relative to the base solution. All livestock situations, however, realize substantial net return penalties when tolerance soil loss levels are obtained. In terms of absolute net return changes, situations on the Ida County farm which include the feeder steer enterprise have the most to gain from adoption of optimal crop management practices and the most to lose from imposition of soil loss restrictions.

Capital and labor

Table 41 shows the requirements for capital and labor. Once again, capital requirements are found to be largest for conventional solutions. Labor requirements are largest for conventional solutions under all situations with the exception of situation 2. The addition of the hog enterprise into the farm plan for T-value solutions increases labor requirements for this situation.

Table 41. Capital and labor requirements for the Ida County farm under five livestock situations and four solution types

Livestock situation	Solution type	Capital (dollars)	Labor (hours)
1	A	66,920	740
	B	57,478	607
	C	41,348	583
	D	38,720	338
2	A	301,436	2,642
	B	288,873	2,471
	C	112,281	2,597
	D	127,887	2,657
3	A	301,436	2,642
	B	288,873	2,471
	C	113,886	1,127
	D	139,351	1,179
4	A	71,777	1,138
	B	63,270	1,020
	C	46,794	958
	D	45,289	776
5	A	100,423	2,577
	B	93,466	2,407
	C	77,596	2,342
	D	76,982	2,165

Summary

Profit-maximizing production of cash crops on the Ida County farm involves raising corn grain and soybeans in rotation. The corn and soybeans are raised primarily with the till-plant tillage system with planting done on the contour. As livestock are produced, patterns in crop production are altered while tillage systems and supporting practices are basically not changed. Feeder steer production causes corn silage to be grown on practically all acres of the farm. Hog production does not significantly change crop production patterns in relation to cash crop farming, but cow-calf production somewhat increases production of corn silage and meadow. Common tillage systems and supporting practices used by livestock enterprises include till-plant and contouring, respectively.

Relative to soil loss under cash crop farming, profit-maximizing steer production creates substantially higher levels of soil loss. The large-scale production of corn silage is again blamed for the increase in soil loss. Cow-calf production creates a moderately higher level of soil loss than what cash crop farming creates, and hogs decrease soil loss somewhat because of the pasture requirement.

Adopting conservation practices which keep soil losses to below T-value levels significantly affect crop production practices and thus livestock diets. Corn silage production is reduced substantially and so, steers are fed a large amount of corn grain. Steer production and steer profits decline drastically. Hogs are not affected a great deal by soil loss restrictions. Cow-calf production, however, becomes profitable when no forage market exists. Soil loss restrictions bring strip cropping in to the farm plan when steers are produced but terracing is not profitable on the Ida County farm.

The Allamakee County Farm

The Allamakee County farm contains 400 acres of farmland consisting of Fayette, Steep Rock, and Downs soils. Soils are all relatively steep and subject to severe erosion. The Steep Rock is unproductive and able to produce only permanent pasture. The other soils are moderately productive. Two livestock situations, cash crop and dairy, are used for analysis. The same solution types used on other farms are used on this farm. Eight scenarios are, therefore, generated.

Livestock production

The dairy enterprise on the Allamakee farm is profitable, and a capacity herd of 60 milking cows enters the farm plan under all four solutions types (Table 42). Dairy rations consist primarily of corn silage and alfalfa hay under conventional, base, and T-value 1 solutions. No corn silage is fed to the dairy animals under the T-value 2 solution. Table 43 shows what happens to percent roughage in the diet as T-value restrictions are imposed.

Table 42. Average percent roughage in livestock diets on the Allamakee County farm under two livestock situations and four solution types

Livestock situation	Livestock enterprise	Solution type A Conventional	 B Base	 C T-value 1	 D T-value 2
		Percentages			
1	Cash Crop	-----	-----	-----	-----
6	Dairy (head)	60	60	60	60

Table 43. Average percent roughage in livestock diets on the Allamakee County farm under two livestock situations and four solution types

Livestock situation	Livestock enterprise	Solution type A Conventional	 B Base	 C T-value 1	 D T-value 2
		Percentages			
1	Cash Crop	-----	-----	-----	-----
6	Dairy (head)	83.32	83.32	80.65	100.00

Crop management systems

Crop production figures are provided in Table 44. Cash crop rotations under conventional and base solutions are the same. Pasture is grown on the Steep Rock soil while corn grain and soybeans are grown in

Table 44. Acres of crop production on the Allamakee County farm under two livestock situations and four solution types

Scenario	Livestock situation	Solution type	Corn grain	Corn silage	Soybeans	Oats	Meadow	Pasture	Out of production
1A	Cash crop	Conventional	144.0	0.0	144.0	0.0	0.0	112.0	0.0
1B		Base	144.0	0.0	144.0	0.0	0.0	112.0	0.0
1C		T-value 1	57.6	0.0	0.0	57.6	172.8	0.0	112.0
1D		T-value 2	260.0	0.0	0.0	0.0	0.0	0.0	140.0
6A	Dairy	Conventional	95.4	26.2	112.4	9.2	44.7	112.0	0.0
6B		Base	94.6	27.1	106.8	14.9	44.7	112.0	0.0
6C		T-value 1	32.3	25.3	0.0	57.6	172.8	0.0	112.0
6D		T-value 2	155.3	0.0	0.0	50.8	83.0	0.0	112.0

rotation on the other soils. T-value restrictions eliminate production completely on the Steep Rock soil and eliminate soybean production on the other soils. Meadow-intense rotations are grown under the cash crop situation when alfalfa hay can be sold off the farm, and continuous corn is grown when meadow cannot be sold.

The dairy enterprise requires meadow (alfalfa hay) and corn silage and so COMMM and SB rotations enter the farm plan in the conventional and base solutions under the dairy situation. T-value restrictions cause more meadow to be grown when it can be sold and cause more corn to be grown when meadow cannot be sold.

The base solutions indicate that the till-plant tillage system is generally the most profitable system on the Allamakee County farm. As expected, T-value restrictions result in the need for slot-plant systems on most soils. These restrictions result in a need for strip cropping and terracing. Terracing is done on the class E slope Fayette soil.

Soil loss

Soil loss is much higher under the cash crop situation than under the dairy situation for conventional and base solutions. This is attributed to the fact that the dairy animals require alfalfa in their least-cost diets. Soil loss levels are compared in Table 45. Adoption of optimal conservation tillage practices is seen to decrease soil loss more under the cash crop situation than the dairy situation.

Table 45. Average annual soil loss on the Allamakee County farm under two livestock situations and four solution types

	Solution type							
	A Conventional		B Base		C T-value 1		D T-value 2	
Livestock situation	Soil loss (tons/ acre)	% of base	Soil loss (tons/ acre)	% of base	Soil loss (tons/ acre)	% of base	Soil loss (tons/ acre)	% of base
1 Cash crop	54.96	167	32.97	100	1.50	5	1.89	6
6 Dairy	35.95	158	23.00	100	1.43	6	2.24	10

Net returns

Net returns are shown in Table 46. As conservation tillage practices are adopted in the base solution, net returns increase 7 percent under the cash crop situation relative to the conventional system as compared with only two percent under the dairy situation. Under T-value restrictions (T-value 2 solution) cash crop net returns are reduced 48 percent from the base solution, as compared with only a 3 percent reduction when dairy is included in the farm plan. Under T-value restrictions, the dairy farmer will suffer a much less severe income penalty than the cash crop farmer. This is attributed to the fact that the dairy animals can profitably utilize the meadow crop.

Table 46. Average annual net returns on the Allamakee County farm under two livestock situations and four solution types

Livestock situation	A Conventional: Net returns (dollars)	A Conventional: % of base	B Base: Net returns (dollars)	B Base: % of base	C T-value 1: Net returns (dollars)	C T-value 1: % of base	D T-value 2: Net returns (dollars)	D T-value 2: % of base
1 Cash crop	51,986	93	55,765	100	45,791	82	29,067	52
6 Dairy	111,139	98	113,917	100	103,795	91	99,043	87

Capital and labor

Table 47 shows the requirements for capital and labor on the Allamakee County farm. The dairy enterprise increases capital requirements moderately and increases labor requirements substantially. Requirements for capital and labor are generally highest with conventional tillage practices.

Summary

The profit-maximizing means of producing cash crops on the Allamakee County farm is not significantly different than on previous farms. Corn grain and soybeans are grown in rotation on all soils with the exception of the Steep Rock soil where permanent pasture is grown. Corn and soybeans are grown using the till-plant tillage system with planting done on the contour. To achieve a least-cost ration, the dairy enterprise changes crop production patterns but does not significantly affect tillage and supporting practices. Dairy increases the production of corn silage and meadow. More meadow acres than corn silage acres enter the farm plan and soil loss is lower than levels for cash crop farming. Dairy thus increases the profitability of adopting conservation practices on the Allamakee County farm.

Table 47. Capital and labor requirements for the Allamakee County farm under two livestock situations and four solution types

Livestock situation	Solution type	Capital (dollars)	Labor (hours)
1	A	75,282	826
	B	65,616	702
	C	61,384	869
	D	68,932	528
6	A	101,271	4,020
	B	93,775	3,935
	C	88,943	4,016
	D	91,408	3,822

CHAPTER IV. POLICY IMPLICATIONS AND MODEL LIMITATIONS

Policy Implications

The major objective of soil and water conservation policy is to obtain farmer behavior which results in reduced soil erosion (Hildreth, 1982). Various types of policy options can be used to accomplish this objective. Four general categories of policy alternatives are (1) technical assistance and education designed to inform farmers of available soil-conserving technologies and associated technical and cost information, (2) incentives in the form of cost-sharing and other subsidies on the use of conservation practices, (3) disincentives in the form of taxes on soil loss, and (4) direct regulation on the use of management practices. The results of this study indicate that livestock considerations need to be made when formulating useful conservation policies.

Technical assistance and education can help farmers achieve profit-maximizing farm plans and thereby help to reduce soil loss. Results of the study indicate that farmers who both do and do not raise livestock need to be informed of the benefits of and assisted in the adoption of till-plant tillage practices. Till-plant tillage practices in comparison with more intensive tillage pratices reduce soil loss and increase net returns.

Results indicate that incentive payments designed to encourage the adoption of reduced tillage practices would be better spent on cash crop farms than on farms which raise feeder steers and produce large amounts of corn silage. Reduced tillage practices go farther in reducing soil loss on corn-soybean rotations than on intense corn silage rotations. In addition, reduced tillage practices increase net returns more for corn grain and silage production than for soybean, oat, and meadow production. This indicates that steer producers who raise a large amount of corn silage and who, through the adoption of reduced tillage practices stand to profit relatively more than cash crop farmers, would not need as large of an incentive in order to initiate the use of these practices.

Disincentives designed to control soil erosion through taxes on excessive levels of soil loss will be more costly to profit-maximizing steer producers than to cash crop or hog producers. The tax penalty differentials between steer and non-steer producers will be an increasing function of the erodibility of the soils on the farms. Taxes on soil loss will decrease steer production with the largest reductions occurring on the most erosive farms. In northeast Iowa, taxes on soil loss will be more costly to cash crop farmers than dairy farmers.

In order for direct regulation on the use of management practices to be effective, it will need to restrict somewhat the intense production of corn silage and soybeans on moderately to severely erosive soils. Regulation of management practices will become more expensive and steer production will decline. Dairy producers will be penalized less than cash crop producers as these mandatory regulations are implemented.

Soil and water conservation policies have income redistribution implications which policy makers need to know. This study indicates that disincentive and regulatory programs will not only redistribute income away from erosive areas of Iowa but also, relatively more income will be redistributed away from profit-maximizing steer producers. Disincentives and crop management regulations will redistribute income away from cash crop farmers relatively more than dairy farmers.

Disincentive and regulatory programs will affect production patterns of livestock within Iowa. The concentration of specific livestock enterprises within a given area is a function of variables relating to comparative advantage (Nicol and Heady, 1971). As soil loss taxes and mandatory regulations are enforced, feeder steer production loses its comparative advantage to hogs in areas which are relatively erosive. Thus, feeder steer production will move away from erosive areas and into nonerosive areas where feed inputs are less costly. Cow-calf and dairy production will tend to increase in the erosive areas as these soil loss controls are implemented.

In general, the results of the study indicate that soil loss may increase as a result of policy which directly or indirectly promotes the production of feeder steers. Promoting steer production encourages the consumption of forages, but steer rations obtain forages most profitably from corn silage. Thus, as steers are produced, forages are not used to control soil erosion but used only to produce livestock products. Policies which promote dairy production in Northeast Iowa, on the other hand, will result in lower levels of soil loss. Profit-maximizing dairy production consumes corn silage, but it also consumes a large amount of meadow. Meadow provides continuous soil cover, and it is usually grown on the most erosive soils.

Model Limitations

Models are only as good as the assumptions and data on which they are based. Furthermore, an understanding of the underlying assumptions and data is required to usefully interpret the results. The linear programming models used in this study are normative tools. That is, they reflect what farmers should do and not necessarily what farmers will do. Farmers usually fall short of normative behavior because of multiple objectives, risk and uncertainty and a general lack of information, and limited capital availability.

This study assumes that farmers have a single objective, profit maximization. Although this may be the primary objective in farming, secondary objectives and preferences play a role in farmers' decisions. Leisure time and other family considerations are sometimes influential in decision making. In addition, farmers may have personal preferences on the types of and ways to produce crops and livestock. This study uses the single objective of profit maximization so modeling can be simplified and results can be generalized.

The models in this study assume perfect knowledge and ignore risk and uncertainty in prices. This study is conducted using one set of prices and one set of production coefficients. Price and production parameterizations are needed to observe the sensitivity of solutions. Variability of crop yields because of the effects of different reduced-tillage practices is an issue of concern which could be evaluated within the framework of this study. This issue is analyzed for the cash crop situation in a study by Pope, Bhide, and Heady (1982a). Differential livestock growth rates could also be examined with respect to the composition of livestock feed rations. This study assumes the amount of roughage in the diet had no impact on growth rate.

Farmers are assumed to have unlimited access to capital in this study. Farmers faced with a limited stock of capital, however, may not be able to acquire the specialized machinery needed for reduced-tillage practices, and the production of livestock may be limited because of the relatively large requirements for operating capital. Effects of limited capital on the economics of conservation practices are examined for cash crop farming in a study by Banks, Bhide, Pope, and Heady, 1982.

CHAPTER V. SUMMARY AND CONCLUSIONS

The types of livestock produced, the level of production of each livestock enterprise, and the least-cost ways to feed the animals in each enterprise have a direct bearing on the crop production activities and, therefore, on soil erosion. The general objective of this study is to estimate the roles which feeder steer finishing, cow-calf, hog farrow-to-finish, and dairy enterprises play in determining the profitablity of soil and water conservation practices and in determining the degree of soil loss in Iowa. In order to meet this objective single-period linear programming models are developed for 18 synthesized Iowa farms.

Results of the study indicate that livestock enterprises do not greatly affect the use of tillage practices. For the farmer who is interested only in maximizing profits and not interested in controlling soil erosion, the till- and slot-plant tillage practices are the most cost efficient practices for growing crops which are to be sold off the farm, as well as crops which are to be used in livestock rations. In the event that the farmer is concerned with restricting soil loss to T-value levels, tillage practices do not change significantly but instead, the farmer alters supporting practices and crop rotations.

Livestock enterprises do not significantly affect the use of supporting practices when the farmer is unconcerned about soil loss. Contour planting is the only supporting practice used, and it is done with row crops on soils with slopes steeper than five percent. Livestock enterprises which require that some meadow be grown, decrease the amount of contouring needed only by decreasing the amount of row crops grown on the steeper soils. Other supporting practices are used as soil loss restrictions are imposed.

When the farmer is striving to meet T-value levels of soil loss, the supporting practices used when livestock feeds are being produced are somewhat different than practices used when only cash crops are being grown. Strip cropping is used more with livestock feed crops than with cash crops because there is generally more acres of meadow rotations when forage-consuming livestock are being produced. In addition, strip cropped meadow rotations will sometimes eliminate the need for terracing which is needed occasionally on cash crop farms.

Livestock enterprises have a significant influence on the types of crop rotations grown. Unconcerned about soil loss, the farmer grows the crops which are needed to formulate least-cost rations for the most profitable livestock enterprises which he is willing and able to produce on the farm. Least-cost rations are different for the various livestock enterprises; consequently, the crops grown on the farm depend on the livestock being produced.

Crop rotations are instrumental in determining the level of soil loss because soil loss is partly a function of the amount of residue left on the soil surface. Relative to the CB rotation on cash crop farms, meadow and pasture provide year-around cover for the soil and thus help reduce soil erosion. Conversely, corn silage and grazed corn stalks result in less cover and contribute to higher levels of soil loss. The effects of livestock on soil loss and the profitability of conserving the soil, therefore, are closely related to the least-cost means of feeding the livestock on the farm.

Least-cost feeder steer rations contain primarily corn silage. As a result, feeder steer production tends to increase soil loss, and the profitability of conserving the soil declines. The extent of the increase in soil loss is related to the types of soils on the farm. If concerned with restricting soil loss to T-value levels, steers are fed more corn grain and/or alfalfa hay. The consequence of using less soil-depleting crops for steer feed is an increase in the cost of production of steers, a fall in the production of steers, and a reduction in profits. In fact, controlling erosion beyond that which is profitable from the farmer's point of view is more costly to the feeder steer producer than to the cash crop farmer or any other livestock producer.

The least-cost ration for cow-calf animals contains corn silage, alfalfa hay, and grazed corn stalks. This ration minimizes the loss in profit incurred from the cow-calf enterprise when the farmer is unconcerned about soil loss. Under these conditions, the cow-calf enterprise tends to increase soil loss on relatively erosive farms. Cow-calf production contributes to the profit of the farm when the farmer strives to meet T-value levels of soil loss. The animals consume primarily alfalfa hay.

Hogs consume corn grain grown on the farm and thus do not significantly affect soil loss and the profitability of adopting conservation practices. Hogs decrease soil loss if corn grain needed for hog feed replaces production of soybeans or corn silage. This occurs when the hog enterprise is large in comparison to acres of land available for hog feed production and the CB rotation cannot supply enough corn grain to meet the feed requirements. In addition, hogs will decrease soil loss and increase the profitability of conserving the soil when feeding corn grain to hogs becomes more profitable than feeding corn silage to steers.

The least-cost feed ration for dairy animals in Northeast Iowa consists primarily of corn silage and alfalfa hay. The meadow raised for dairy has a larger impact on decreasing soil loss than corn silage has on increasing soil loss and thus the dairy enterprise decreases total farm soil loss and increases the profitability of adopting soil conservation practices. When the dairy farmer restricts soil loss to T-value levels, the feeding of corn silage is halted but the cost of production rises only a small amount. The dairy farmers' net returns are reduced much less than the net returns of the cash crop farmer when soil loss restrictions are imposed.

In conclusion, on-farm hog enterprises have little impact on the economics of soil and water conservation practices. On-farm cattle enterprises do not greatly alter the relative profitability of using reduced tillage or supporting practices but do affect the relative profitability of using various crop rotations. Feeder steers can utilize relatively nonerosive crops such as alfalfa hay and pasture but because there is an opportunity cost of using land to raise feed for on-farm livestock, the farmer can increase profits by growing and feeding corn silage and/or corn grain which supply a larger per acre output of feed than alfalfa hay and pasture. Cow-calf and dairy enterprises, which utilize meadow more efficiently than the steer enterprise, should be located on farms with relatively erosive and unproductive soils. Steers should be produced on farms with less erosive soils where corn silage can be grown without resulting in excessive levels of soil loss.

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