INCOME EFFECTS OF REDUCING AGRICULTURAL POLLUTION*

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INTRODUCTION

The value and quantity of agricultural commodity production in various regions of the United States determines farmers' income in each region. Many farmers, businessmen, policy makers and administrators are concerned with the problem of change in farm income resulting from water quality restraints placed on cropland agriculture. This study evaluates the income change from a series of hypothetical national water quality policies by examining the changes in national and regional gross farm income. Long-run changes in total national income of controlling water pollution from farmland by soil loss restraints are relatively small, as aggregate gross income increases by four to six percent depending on the level of control studied.[1]

The changes in regional gross farm income are more extreme since various regions of the country, including the southern states, are affected differently by potential water quality control. This study utilizes a national modeling system to examine these variables and reports an analysis of potential changes in gross farm income caused by environmental restraints placed on agriculture. Environmental goals analyzed are national soil conservation ones, with implications for national and regional farm incomes.

THE SETTING

The U.S. Congress and various state legislatures enact water quality regulating legislation that affects farm production technologies and resource use and potentially changes farm income levels. For example, some states have enacted land use laws to control soil erosion, increase soil conservation and improve water quality simultaneously. One such law, the Iowa State Conservancy Law [3], provides legal action against farmers whose soil erodes at rates exceeding a predetermined annual allowable level. Cropland use and technologies provide the basic mechanism for controlling soil erosion and reducing water pollution from farmlands. Redistribution of crop production among production technologies and production regions could reduce sediment pollution. For example, production of cotton or corn on highly erosive land of the Southeast might be moved to western irrigated areas where water erosion is a small problem. Hay and livestock production could replace row crops in the Southeast, the shift thereby reducing soil loss and nonpoint water pollution. But farm incomes in the two regions would also be altered, changing both general welfare of farm producers and agri-business sectors linked to agriculture.

GROSS FARM INCOME

The primary variable of interest in the study is "gross farm income." The variable is analyzed for the nation and for various subregions to indicate the relative change in aggregate farm output under varying policies of water quality control through the restrictions of agricultural production. Gross farm

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[1] We assume throughout this paper that a reduction in average annuals oil loss results in an increase in water quality. No explicit run-off levels are computed.

income was chosen because it reflects the aggregate impact of controls after all shifts in crop production within and among regions have taken place. Gross farm income is defined as the total value of crops and livestock produced in linear programming model of United States agriculture.[2] The crops included in this analysis accounted for 88.7 percent of the harvested acres and about 65.7 percent of the total dollar value of production of crops harvested in 1970. Commodities omitted from the model are included in land and water resource use by fixing the location of production according to historic patterns and reducing the area's resource base accordingly. Thus, income from these commodities is produced in each region, but since regions do not change under the policies analyzed, is not included in this study. The term "gross farm income" hereafter is briefed to "income." We examine redistribution of farm income among agricultural regions as soil loss restraints of three and five tons per acre are imposed on the nation's agriculture as potential conservation goals.

THE MODEL

The model used in this study is one of a set constructed at the Center for Agricultural and Rural Development (CARD) under an NSF-RANN grant to examine impacts of environmental constraints on agriculture [5, 6]. The tool used is a large-scale programming model covering all major regions, commodity markets, resources and transportation networks that underlie United States agriculture as projected to the year 2000. A narrative description of the model is given below. The mathematical description is available from other sources [2, 5, 6].

Regions

The basis of the interregionally competitive agriculture model is a set of regional delineations that specify areas of production, demand and resource availability.

The Production Areas (PAs) shown in Figure 1 are subdivisions of river sub-basins designated by county boundaries. The 223 regions give a detailed breakdown of the United States into agricultural production areas. Although these regions do not give a complete description of the United States' diversity,

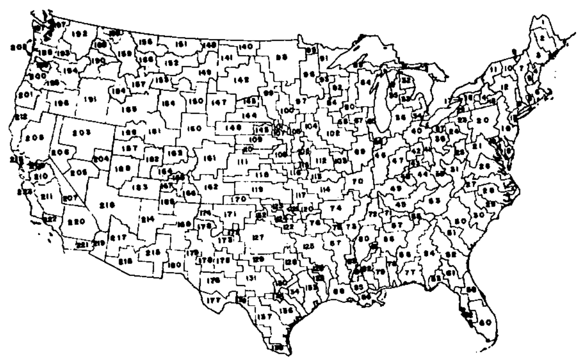

FIGURE 1. THE 223 FARM PRODUCTION AREAS OF THE LINEAR PROGRAMMING MODEL

they provide, along with other variables, a basis for regional level implications. Individual analysis of regional and subregional goals can be carried out using other planning tools.[3]

The Market Regions (MRs) of Figure 2 are aggregations of the PAs and provide a basis for trade in agricultural commodities utilizing major trade centers. Commodities produced in each PA are a part of the MR's pool of commodities, usable in three ways: to satisfy intraregional consumer demands projected to the future; to satisfy intraregional intermediate commodity demands such as livestock feeds; or to export—either to another market region

FIGURE 2. THE 30 FARM COMMODITY MARKETING REGIONS OF THE LINEAR PROGRAMMING MODEL

[2]Crops included are barley, corn, corn silage, cotton, legume hays, nonlegume hays, oats, sorghum, sorghum silage, soybeans, sugar beets, and wheat. Livestock commodities produced are pork, fed beef, nonfed beef, milk and beef feeders.

[3]The authors recognize that these delineations do not represent every variation in crop production potential. Variations in soil types, climates, and other similar significant factors exist within the designated regions which cannot be modeled accurately under the size and scope of the model designed here. To this extent, taking this analysis and applying its results at the producing area (PA) level is highly questionable. However, aggregate totals give a clear indication of potential impacts of national level policy.

or internationally. A commodity transportation network functions between MRs for all commodities except the hays and silage—which are not shipped among regions, and cotton and sugar beets—which are consumed from a single national market.

In addition to PAs and MRs, the Water Supply Regions (WSRs) are aggregations of PAs for the 17 western states and act as supply and transfer regions for water resources; to be utilized for both agricultural and nonagricultural purposes.

Land Base

The land resource base is defined for each PA based on the 1967 Conservation Needs Inventory (CNI) of the U.S. Department of Agriculture [7]. Land in each PA is divided into nine land quality classes based on production capability and erosive characteristics (Table 1). Irrigated and dry cropland are differentiated for regions of the West that correspond to WSRs.

Crop Production

The technologies of crop production and land use are the crucial elements of the study. They produce the basis for meeting both commodity demands and the environmentally controlled substance, soil loss. Production activities use land, water and nitrogen fertilizer (plus other fixed cost inputs) at costs determined in part by land class, technology and region of the country. Each activity produces agricultural commodities and soil loss for various production technologies. These technologies represent various methodologies for producing crops which result in different levels of soil loss from cropland. They include crop rotations, land tillage practices and soil conservation practices.

TABLE 1. LAND CLASS DEFINITIONS

Number Given to Land Class in This Study	Land Capability Class of the U.S. Soil Conservation Service
1	I
2	IIe
3	IIs, IIw, IIc
4	IIIe
5	IIIs, IIIw, IIIc
6	IVe
7	IVs, IVw, IVc
8	Vw, Ve, Vs, Vc
9	all of VI, VII, and VIII

SOURCE: [7].

Soil Loss. The soil loss for each production activity is computed from the Universal Soil Loss equation [8] which computes a gross annual soil loss rate in tons per acre for various crop production technologies. The equation is based on soil erodability, rainfall intensity, land slope, land slope length, crop production system and conservation practice.

Elements used to compute a contribution of the production system are crop rotation, crop type, residue management, rainfall intensity and tillage practice. Alternative crop rotations are chosen from a large number of possibilities determined by soil conservation experts as those technically feasible in each PA [5]. Conventional tillage with residue removed, conventional tillage with residue left and minimum tillage practices are applied to the applicable rotations.

Four alternative conservation practices are available for alternate applications; straight row, contouring, strip cropping and terracing, each with a higher level of control of soil loss. These conservation practices are available for each tillage practice on each crop rotation system on applicable land classes.

Yields. The yield for each crop depends on time (i.e., projected to the year 2000) and inputs of nitrogen, phosphorous and potassium as fertilizer, for each PA [6]. Yields are adjusted for variations due to changing production technologies such as conservation and tillage practices and crop rotations. Nitrogen is available from artificial sources and crop and livestock production.

Livestock production. Livestock production activities are an intermediate demand for crop commodities and satisfy final (consumer and export) demands for livestock commodities. Several feed mix rations are available for each class of livestock production with different requirements for feed commodities [6]. Optimal livestock feeding systems are determined internal to the linear programming model according to the cost of feed inputs.

Costs. Crop production costs represent on-farm costs, excluding land, water and nitrogen fertilizer, of producing one acre under the activity's crop and land management system [1]. Water and nitrogen fertilizer must be purchased for use in the appropriate cropping systems. The value of land resources is computed by the model. Livestock production costs are nonfeed costs associated with the production of one unit of livestock. Water is purchased for livestock consumption in western regions. Costs are also estimated for interregional shipment of farm commodities.

Demand. Final commodity demands are determined by using population projects for each MR and using national per capita demand figures to compute domestic consumption demand for each of the commodities in the year 2000. For those regions having export facilities, 1969-71 average export demand is added to domestic consumer demand for each commodity. Intermediate demands for livestock feeding are extracted from the total commodity supply before final demands are met. A national population projection of 280 million people in year 2000 is divided among the MR according to proportions of 1970 population.

Methodology

The model described in the previous section is a linear programming model that simulates economic, production and water quality aspects of agriculture. The model minimizes total cost of producing and transporting agricultural commodities demanded by domestic and foreign consumers, subject to resource and water quality constraints. It computes an interregional competitive equilibrium and requires each unit of resource to receive its market rate of return. The detailed mathematical description of the model can be found in other published works [2, 5, 6].

ALTERNATIVE FUTURES

The model has been used to analyze several alternative futures of national environmental goals, food production and export capacity. We compare only three alternatives or scenarios, although others exist, because of space limitations. These scenarios impose limits on soil loss from croplands, a primary source of nonpoint water pollution. We examine alternatives where soil loss per acre per year is not limited, is limited to five tons per acre, and is limited to three tons per acre on each of the 1,891 land resource groups of the model.

As a summary variable, regional income is an aggregate measure of each region's ability to adapt to imposed environmental controls. This normative analysis assesses the change in regional agricultural income from included crops and livestock for each of three alternative futures: the Base Future, where no soil loss restraints are assumed, the five tons per acre annual soil loss limit Future (hereafter, the 5-ton Future), and the three ton per acre annual soil loss limit Future (hereafter, the 3-ton Future).

Two potential sources of variation exist in regional income computed for the various alternatives. First is the variation due to increased valuation of crop and livestock products. Increases in farm supply prices, resulting from the increased cost of technology required to control erosion, are reflected in income as marginal production costs of commodities increase. The second source of variations in income is the change in quantity of commodities produced. This change occurs as technical costs of production increases in some regions to meet the constrained soil loss level, while other regions can produce the commodities at lower cost. This is a case of regional economics advantage and technical efficiency in meeting conservation and water quality goals.

ANALYSIS OF RESULTS

Changes in gross farm income[4] reflect the direct long-term consequences of public policy. In terms of environmental policy, those changes in income also reflect aggregate costs to society for the proposed conservation policy. National incomes in Table 2 can be summarized in several ways to reflect various changes in the configuration of agriculture as public policies change. The increase in national gross farm income reflects an increase in total national cost of the included agricultural commodities as environmental improvement is obtained through limiting soil loss levels. Total costs to consumers and total increases in income for all produced commodities under constrained soil loss levels are low compared with soil loss reductions attained. The four percent increase in gross farm income between Base and 5-ton Futures results in a reduction from 2,677 million tons

TABLE 2. NATIONAL GROSS FARM INCOME BY COMMODITY, YEAR 2000, BY ALTERNATIVE FUTURE

	Base Future	% of Total Base Income	5-Ton Future	% of Total 5-Ton Income	5-Ton % Change From Base	3-Ton Future	% of Total 3-Ton Income	3-Ton % Change From Base
				(Billion Dollars)				
Corn	5.65	10	6.19	10	10	6.41	10	-13
Sorghum	.54	1	.60	1	11	.47	1	-11
Barley	.58	1	.56	1	-5	.66	1	13
Oats	.16	0	.22	0	33	.31	0	87
Wheat	2.27	4	2.33	4	3	2.04	3	-10
Oil Meals	2.77	5	3.04	5	10	3.12	5	13
Legume Hays	3.02	5	3.21	5	6	3.58	6	18
Nonlegume Hays	2.89	5	3.20	5	11	3.28	5	12
Silage	1.02	2	.67	1	-34	.48	1	-52
Pasture	1.43	2	1.43	2	0	1.61	3	12
Cotton	.82	1	.93	2	14	1.05	2	28
Sugar	.26	0	.26	0	1	.27	0	5
Pork	4.64	8	4.87	8	5	4.82	8	4
Milk	3.68	6	3.69	6	0	3.78	6	3
Feeders	9.87	17	10.11	17	2	10.42	17	6
Fed Beef	15.85	27	16.41	27	4	16.71	27	5
Nonfed Beef	2.90	5	3.00	5	3	3.09	5	7
Total Income	58.35		60.72		4	62.06		6

[4] Gross farm income is the value of all commodities produced in the model, using the model's regional supply price to determine each crop's value. This measure of income, therefore, includes returns to land, labor, water, and other resources and is not adjusted for farm cost.

to 726 million tons in gross annual soil loss from cropland agriculture of approximately 73 percent. For the 3-ton Future, gross annual soil loss is reduced to 483 million tons, a reduction of 82 percent. The corresponding increase in gross farm income to 62.1 billion dollars represents a change of only six percent from the Base Future.

Total national income from the individual commodities is also shown in Table 2, with the proportion of the total income which came from each commodity and the percent change from the Base Future to the 5-ton and 3-ton Futures. The proportion of national income derived from each commodity does not change drastically from the Base to the 5-ton Future. The income derived from less erosive small grain, hay and corn-sorghum crops increases, while that derived from silage is significantly reduced. National income increases only four percent.

For the 3-ton Future, total national farm income increases by six percent. Changes in the proportions of total income derived from individual commodities do not alter significantly for the 3-ton Future. However, changes in farm income derived from some specific commodities are significant, as row crops of corn and sorghum used both for grain and silage are reduced because of high erosion. Hay and related small grain crops increase in their contribution to total income. Fixed demands for nonfeed commodities of cotton and sugar beets increase the crops' value, since higher cost technologies and more cropland acres must be utilized to produce these commodities. Little substitution among the crops is available to offset increased production costs.

Interregional Analysis

Regionally, the distribution of income effects is lacking in equity. Some farm production areas gain and others sacrifice in income, as soil loss restraints are imposed. Several areas of the country not endangered by high soil loss rates can gain as farming becomes more intense. Regions with heavy rainfall and more erosive lands are faced with a different outcome, since these regions have high average soil loss levels. A constant soil loss limit such as three or five tons requires (1) cessation of some types of farming technology in some regions, forcing a reallocation of production of the commodity to other regions, or (2) adoption of a more expensive technology within the erosive regions.

Regions for summary in this study are the Market Regions (MRs) of Figure 2. These are the model's smallest regions between which transportation of commodities occurs. Variation in prices among the MRs can be attributed to locational economic advantage provided by differences in climate and soil types [4]. To illustrate variations in farm income stemming from imposed environmental rules, Figures 3 and 4 illustrate changes in income between the Base Future and the 5-ton and 3-ton Futures.

Because of inelastic demands and increased supply prices, national income increases by about four percent from the Base Future to the 5-ton Future. Differences for individual regions, however, are much more pronounced (Figure 3). Income increases by more than 10 percent in New England, the central and southern Atlantic coast areas, the Memphis region and the Upper Midwest. Decreases in income occur in the arid Southwest and the central Great Plains areas, where rainfall is light and much of the land is level, as changes in availability of hay and small grains in other areas of the country modify the livestock production systems.

In the 5-ton Future, most changes in agricultural production required to reduce soil loss levels are obtained by modified technologies. One way this is done is by the introduction of more hay and small grains into areas of the Midwest and South that historically have high erosion. These changes allow local income levels to remain near or above Base Future levels and, in some instances, pull production advantages away from other regions of the country, as in Great Plains and southwestern regions. The significant increase in income in the Southeast results from increased livestock and small grain and decreased row crop production.

In the 3-ton Future (Figure 4), the income effects of environmental changes are much greater, and interregional shifts in income are even more distinct. For example, the Lower Mississippi River Basin, an area noted for its highly erosive soils, has a

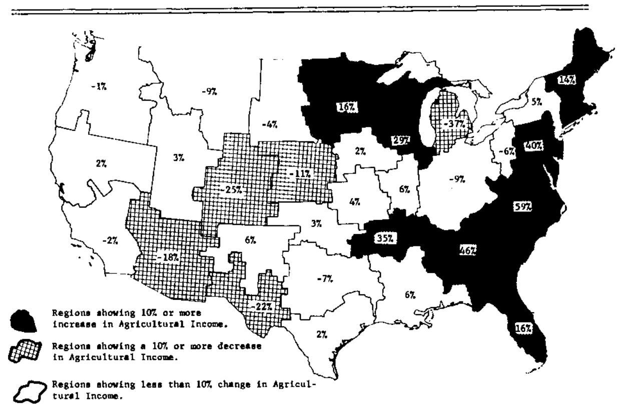

FIGURE 3. PERCENT CHANGES IN REGIONAL GROSS AGRICULTURAL INCOME BETWEEN BASE FUTURE AND 5-TON SOIL LOSS LIMIT FUTURE, YEAR 2000

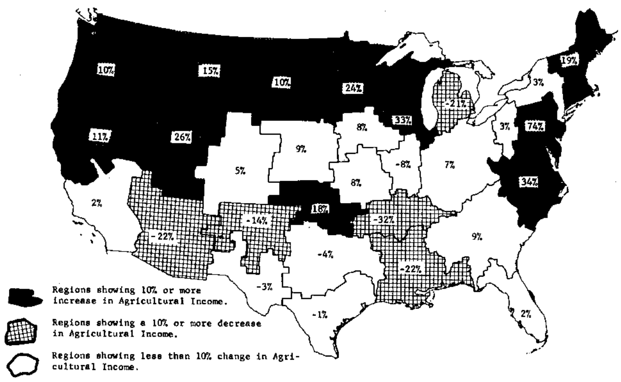

FIGURE 4. PERCENT CHANGES IN REGIONAL GROSS AGRICULTURAL INCOME BETWEEN BASE FUTURE AND 3-TON SOIL LOSS FUTURE, YEAR 2000

sharp income decline where soil loss is limited to three tons per acre per year. Fewer crop alternatives are available to substitute for present high-return crops if soil loss levels are limited to three tons per acre. Pasture and rotation hays are amply available, but intensive row crops are moved to other regions under the locational advantage and regional interdependence of the model. Livestock production based on high levels of grain inputs is at a disadvantage because feed grains and soy protein must be produced elsewhere and shipped to the region. Cotton can be produced on a much smaller acreage at the 3-ton soil loss level as compared with the Base and 5-ton Futures. In contrast to the 5-ton Future, the 3-ton Future has shifts in location of production that parallel regional shifts in income. To meet the 3-ton constraint on soil loss, some land must be taken entirely out of production or put in grass or trees. Therefore, shifts in income and production intensity highly correspond.

The more restrictive 3-ton Future severely limits types of production available to farmers. Although in arid areas of the West technologies are not severely limited, significant reductions in income occur from increased availability of low-cost livestock inputs in the more erosive areas of the country. Overall, however, increased cost of technologies required to control erosion increases production costs of almost all areas of the country. With cropland use at near capacity in less erosive areas, there is less potential for increased income, and shifts in type of production draw down regional income levels.

Single Region Analysis

Analysis of income variations of a single region gives additional insight into impacts and changes possible under environmental strains. Market Region 21, pinpointed by Lincoln, Nebraska, is used as an illustration.[5] This transport and consumption center does not show large shifts in commodities produced or in technologies under either the 5-ton or 3-ton Futures. However, a reduction of 11 percent in income under the 5-ton Future and an increase of nine percent under the 3-ton Future illustrate the importance of the level of environmental restraint to a region.

Table 3 gives details of changes in commodity production and income for this region. Proportions of total income derived from each of the commodities have major differences. Production of silage (removing residue) is highly erosive. Therefore, silage technologies are not used as much under the 3-ton and 5-ton Futures. Income from silage production as a proportion of total income decreases to only four percent of total regional income in the 3-ton Future, as production is reduced 57 percent from the Base Future. This follows the national trend in silage production as shown in Table 3. Since silage does not have a final consumer demand, it is replaced by grains in livestock rations resulting in increased corn production (residue remaining to protect the land). The largest component of the 11 percent decline in Market Region 21's income for the 3-ton Future is a shift away from feeder cattle, which are produced in other regions at lower cost.

TABLE 3. REGIONAL GROSS FARM INCOME BY COMMODITY, LINCOLN, NEBRASKA, MARKET REGION 21, YEAR 2000, BY ALTERNATIVE FUTURE

	Base Future	% of Total Base Income	5-Ton Future	% of Total 5-Ton Income	5-Ton % Change From Base	3-Ton Future	% of Total 3-Ton Income	3-Ton % Change From Base
			(000 Dollars)					
Corn	118,816	7	192,287	12	62	102,211	5	14
Sorghum	6,405	0	5,289	0	-17	55,596	3	768
Barley	1,454	0	1,100	0	-24	2,245	0	54
Oats	7,493	0	8,694	1	16	11,699	1	56
Wheat	39,351	2	20,235	1	-49	71,558	4	82
Oil Meals	53,805	3	45,235	3	-16	99,891	5	86
Legume Hays	173,299	10	160,854	10	-7	265,407	14	53
Nonlegume Hays	119,887	7	142,163	9	19	131,535	7	10
Silage	179,915	10	75,592	5	-58	76,853	4	-57
Feeders	599,606	33	461,637	29	-23	557,330	28	-7
Fed Beef	325,299	18	354,719	22	9	426,214	22	31
Nonfed Beef	158,618	9	121,528	8	-23	144,963	7	-9
Total Income[1]	1,795,580		1,594,241		-11	1,964,703		9

[1] Greater than sum of columns due to commodities not listed.

[5] Market Region 21 was chosen arbitrarily and shows average changes in income and production.

For the 3-ton Future, incomes from grains other than corn increase dramatically. This increase accompanies a substantial increase in fed beef and a decrease (from the 5-ton Future) in income from feeders. The 768 percent increase in sorghum income under the 3-ton Future results from a shift to less erosive sorghum from corn and silage.[6] As noted in Figures 3 and 4, the erosion limitation has had a pronounced effect on the agricultural production of the Southeast, particularly the South Central and Mississippi Delta States. Crops and technologies available in these regions are highly restrained. Thus, rowcrop production of feed grains and soybeans must shift to other regions. The midwest and Great Plains areas benefit from this shift. Market Region 21 has a high economic advantage in feed grain and wheat production and thus produces more of these commodities to meet national demands under water quality restraints. Pasture and hay production increase in Market Region 21 for the 3-ton Future after a precipitous decrease in these commodities for the 5-ton Future.[7] This increase corresponds to greater production of feeders under the 3-ton Future.

The shift in income sources within a region have a significant effect on its income. For example, feed costs to the livestock producer are accounted as a cost of producing the livestock output regardless of whether a farmer produces his own feed. The same is true of nonfeed inputs such as feeder calves for feedlots. Thus, regional income is, in a sense, double counted for some commodities. That is, feed grains used to feed livestock produce income in the region, but so do livestock fed the grain which is included in the supply price of producing the livestock.

CONCLUSIONS

In an agricultural economy not limited to commodity production in specific regions, extreme variations in location, value and quantity of production may occur in the long run. These variations result from an allocation of production in a least-cost and efficient manner. American agriculture has great capacity and flexibility in meeting domestic and export demands even under imposition of rigid restraints on nonpoint water pollution; this study leads to some important conclusions relating to interregional equity under such an environmental restraint. It should be remembered that the goals of the analysis are national in nature, and regional development is not a specific goal of this analysis. Thus, on a national basis, per capita costs of reducing soil loss are not great when represented by either per capita total cost or the change in prices for the commodities. Total farm income increases four percent from the Base Future to the 5-ton Future and six percent from the Base Future to the 3-ton Future. However, distribution of farm income among the Market Regions can be substantially changed. Forced by reallocation of production among regions and technologies to meet commodity demands and soil loss limits, regional incomes may be reduced when soil loss control technologies do not exist or are too expensive to allow local production under an imposed restraint. Rather than a national soil loss constraint, regional or local constraints reflecting local conditions may be preferable. Soil loss restrictions of five tons and three tons per acre could be met with cost of commodities increasing to the consumers and with fairly large shifts in farm income.

REFERENCES

[1] Eyvindson, R. H. "A Model of Interregional Competition in Agriculture Incorporating Consuming Regions, Producing Areas, Farm Size Groups, and Land Classes," Volumes I through V, Unpublished Ph.D. Dissertation, Iowa State University of Science and Technology, Ames, 1965.

[2] Heady, Earl O. and Kenneth J. Nicol. "Models and Projected Results of Soil Loss Restraints for Environmental Improvement Through U.S. Agriculture," *Agriculture and Environment*, Volume 1, pp. 355-371, 1974, Amsterdam.

[3] Iowa State University of Science and Technology, Cooperative Extension Service. *Iowa's New Conservancy Districts and Soil Loss Limit Regulations*, PM-536, June 1972.

[4] Isard, Walter H. *Methods in Regional Analysis*, MIT Press, Boston, Massachusetts, 1960.

[6] To some extent, large changes in production must be attributed to linearity assumptions of the model and the assumption of a long run market equilibrium in the agricultural market. These assumptions do not allow for individual risk aversion or changes in market demand with changes in the price structure of agricultural products. Thus, results of this model represent trends toward aggregate regional changes and do not represent individual farmer actions.

[7] Hay and silage are not interregionally transported and are utilized to meet demands within the Market Region only.

[5] Nicol, Kenneth J. "A Modeling Approach to the Economics and Regional Impacts of Sediment Loss Control," Unpublished Ph.D. Dissertation, Iowa State University of Science and Technology, July 1975.

[6] Nicol, Kenneth J. and Earl O. Heady. *Models of Soil Loss, Land and Water Use, Spatial Agricultural Structure, and the Environment*, CARD Report 49T, Center for Agricultural and Rural Development, Iowa State University of Science and Technology, July 1975.

[7] U.S. Department of Agriculture. *National Inventory of Soil and Water Conservation Needs*, 1967, USDA Statistical Bulletin No. 461, Washington, D.C.

[8] Wischmeier, Walter H. and Dwight D. Smith. *Predicting Rainfall-Erosion Losses from Cropland East of the Rocky Mountains*, USDA, Agricultural Handbook No. 282, May 1965.