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Effect of Export, Environmental and Soil Conservancy Measures on Productivity, Land Use and Income of Iowa

Earl O. Heady
Iowa State University

Effect of Export, Environmental and Soil Conservancy Measures on Productivity, Land Use and Income of Iowa[1]*

EARL O. HEADY[2]

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A national model was constructed to evalute the Iowa conservancy law as it might affect environmental quality, land productivity, export potentials and income of the Iowa and national farm sectors. The mathematical model analyzed 12 land classes in each of 12 Iowa agroclimatic regions and in 105 natural agroclimatic regions. Alternatives analyzed included limiting annual soil loss per acre to 2.5 and 5 tons, reduction of chemical nitrogen and shift of pesticides to organophosphates and carbamates in Iowa while parallel adjustments are not made in the rest of the nation's agriculture. Exports at various levels are evaluated. While full implementation of Iowa's conservancy law apart from the nation would maintain land productivity in the state, farm income would decline in Iowa but increase elsewhere, with increased exports, Iowa would gain in farm income but by a smaller proportion than the rest of the nation.

INDEX DESCRIPTORS: resource productivity, environment, erosion, exports.

Several goals revolving around food production and exports, resource conservation and environmental quality have come to the forefront in recent years. A burst in world demand has caused large exports to be favored by farmers since their incomes have increased accordingly. Persons and groups of humanitarian concern also have favored greater production and exports to help lessen the world's hunger and malnutrition. These goals are, however, somewhat in conflict with other publicly expressed goals such as soil conservation and environmental improvement or maintenance. The practice of "fence row to fence row" production is conducive to increased soil erosion while intensified use of chemicals to raise per acre yields generates residuals to be fed into streams.

Iowa serves an important role in this complex of goals because it produces a large portion of the food output and has productive land resources for doing so. However, Iowa also has a Conservancy District Law creating six conservancy districts. Potentially to help protect the land and prevent environmental degradation, the Iowa Act establishes the intent to encourage, promote and mandate conservation and proper control of Iowa soil and water resources. It established maximum limits on soil loss at one to five tons per acre.

To determine the impact on agricultural production, soil loss prevention, farm income and resource prices, we completed a large-scale study which supposes that Iowa completely implements its Soil Conservancy Act while other states do not. The study was made in a national model and context so that the market impact on both Iowa and the rest of the nation could be evaluated. We examined the effects when soil loss per acre per year was set at two different levels, 5 tons and 2.5 tons per acre. We also examined cases in which nitrogen fertilizer and pesticides were restricted in use in Iowa but not elsewhere in the nation.

Mostly, we were concerned with how the pattern of land use, productivity and income of Iowa would be affected under these conditions. In recent years, Iowa produced about 20 percent of the nation's corn and similarly large proportions of the nation's soybeans, pork and fed beef. Obviously, then, tight environmental controls in Iowa could have heavy impacts on national supplies and prices and the distribution of farm income and asset values among states and locations.

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[2]Department of Economics, Iowa State University, Ames, IA 50011. This paper is based on one given at a symposium, "The food chain in Iowa," held at the 1977 Academy meeting at Drake University.

METHOD USED

The study was made by means of a large-scale mathematical programming model applied to all major resource and commodity producing regions of the United States. The model was specified to conform with, and validated repeatedly against, the real world. Extensive explanations of these real world specifications and validations are available elsewhere [1, 2, 7].

Iowa was divided into 12 conservancy-producing areas shown in Figure 1. The 12 conservancy-producing areas are a modification of the

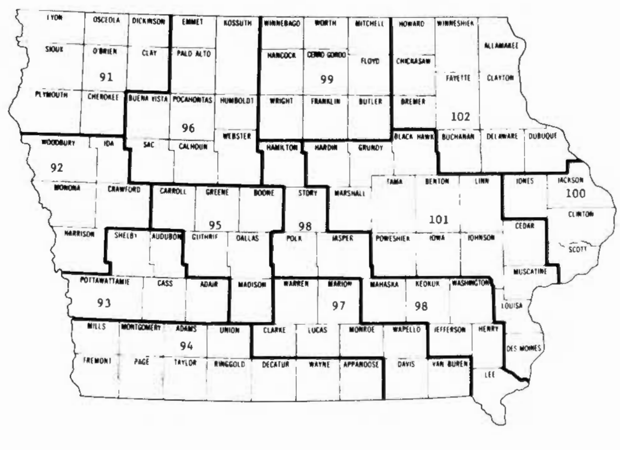

Figure 1. The 12 conservancy-producing areas in Iowa.

original 6 conservancy districts since data are more nearly available in county aggregations. Each soil group or association in each of conservancy-producing areas was maintained as a separate entity as the analysis was applied. The model selected the cropping systems and conservation practices which cause the soil loss or chemical restriction to be met, with profits otherwise maximized in each of these soil areas within a conservancy-producing area.

The rest of the U.S. was divided into the production areas shown in Figure 2 and an average of 9 soil resource groups were differentiated in each. This detail was needed to determine which regions of other states would pick up the production sacrificed in particular soil areas as environmental restraints are applied at different levels of individual conservancy districts in Iowa. The model caused every region and every land resource group in each region to be interdependent for the analysis. The U.S. was separated into 29 market regions (Figure 3) and also considered 35 separate water supply regions in the Western states. The details on the mathematical model are supplied elsewhere [4].

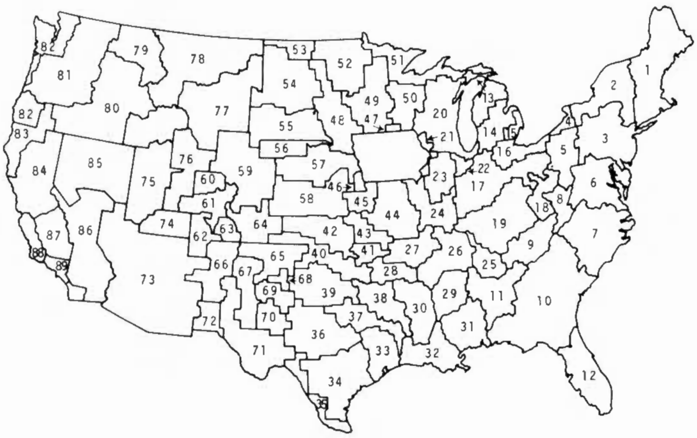

Figure 2. The 102 producing areas for the rest of the U.S.

Figure 3. The 29 consuming regions.

Crop rotations used in each producing area were determined by combining the rotations recommended by the Soil Conservation Service in each of the Land Resource Areas [4]. Soil loss was calculated from the Universal Soil Loss Equation of Wischmeier and Smith [10] and the data obtained from the regional specialists of the Soil Conservation Service [6, 7]. Four conservation practices, namely, straight row cultivation, contouring, strip cropping and terracing are considered. Each conservation practice was associated with three types of tillage practices: conventional tillage, residue management and reduced tillage. Each of these combinations was defined on all the land classes wherever the data were available. Each rotation combined with specific conservation practice and tillage practice defined a unique crop management system. A detailed description of the methodology used and the assumptions made is given elsewhere [5].

Alternatives analyzed by the model

The model was used to analyze 7 alternatives in possibilities of soil loss and environmental limits applied in Iowa. All results refer to 1985, and per capita incomes, estimated by the Bureau of Economic Analysis [9]. The 7 alternatives analyzed by the model are summarized in Table 1. Under alternative A, the benchmark case for comparison, no restrictions on soil loss or chemical applications were applied to any soil area in Iowa and exports were at normal levels. Normal levels of exports used were 626 billion bushels of corn, 659 billion bushels of wheat, 276 million bushels of soybeans and 3.3 million bales of cotton in 1985. High 1985 export levels were 2,610 billion bushels of corn, 1,200 billion bushels of wheat, 350 million bushels of soybeans and 13 million bales of cotton.

Table 1. *The seven alternatives for 1985 comparing Iowa and the rest of the nation by means of the National Programming Model.*

Alternative	Soil loss per acre allowed in Iowa	Nitrogen limit in Iowa, lbs./acre	Pesticides limit in Iowa	Export level
A	no restriction	none	none	normal
B^1	5 tons	none	none	normal
B^2	2.5 tons	none	none	normal
D	5 tons	100	none	normal
E	5 tons	100	minimum	normal
C	5 tons	100	none	high
F	5 tons	100	minimum	high

The acreage available by each land class in Iowa and the rest of the nation was determined from the National Inventory of the Soil Conservation Service [8] was grouped into the 9 land classes shown in Table 2.

Table 2. *Land classes and subclasses aggregated into nine land groups*[a]

Land groups	Inventory class-subclass
1	I
2	IIE
3	IIS, IIC, IIW
4	IIIE
5	IIIS, IIIC, IIIW
6	IVE
7	IVS, IVC, IVW
8	all of V
9	all of VI, VII and VIII

[a]Inventory classes and subclasses are as defined by the Soil Conservation Service for the National Inventory (5).

Alternative B1 supposed that Iowa imposes a soil loss upper limit of 5 tons per acre per year in each soil area under normal exports. Model B2 reduced the allowable soil loss under normal exports to 2.5 tons. In Alternatives D and E, soil loss was set at 5 tons and at normal export levels. However, in model D, chemical nitrogen per acre was limited to 100 pounds. Under E, in addition to this 100 pound limit, pesticides were limited to organophosphates and carbamates. Model C and F were the same as D and E respectively, except that exports were at the high level for C and F. The computed programming or supply price levels which result in solution of the several alternatives are summarized in Table 5. As experienced recently, prices were much greater under high than under normal export levels.

LAND USE AND CROP CHANGES IN IOWA

With the absence of soil loss restrictions, Alternative A, about 1.75 billion tons of soil would be carried from the cultivated lands in the country. The total soil loss in Iowa would be 362 million tons. About 85 percent of Iowa's cropped area would be grown with straight rows, and soil erosion would be excessive.

Land use patterns

Under Alternative A, production of crops would be shifted to areas where the greatest comparative advantage exists for any given crop, satisfying the demand and upper and lower production bounds. As soil loss restrictions were imposed under Alternative B1, farmers would have to move to farming practices which result in less erosion. Some areas in Iowa would be taken out of production and compensated by greater production in other U.S. regions. As the farming practices were changed under B1 and the 5 ton soil loss limit, yield rates in Iowa would increase, as would production costs. With the imposition of the 5 ton limit, Alternative B1, the production of row crops would decrease by 250 thousand acres and close grown crops would increase by 27 thousand acres. Owing to changed farming practices, corn yields would increase slightly (from 114.3 bushels per acre to 116.1 bushels per acre) and soybeans (from 38.3 bushels per acre to 39.6 bushels per acre, Table 3).

Table 3. *Acreage, yield and production of major crops in Iowa under the seven alternatives (bmillion acres and bushels).*

	Alternative						
Item	A	B1	B2	D	E	C	F
Corn:							
Acreage	10.2	10.0	10.9	11.3	10.0	20.1	17.6
Yield[a]	114.3	116.1	118.9	116.0	113.0	114.6	110.7
Production	1,172	1,162	1,306	1,314	1,154	2,309	1,954
Soybeans:							
Acreage	7.0	6.9	7.1	6.4	6.9	4.2	6.8
Yield[a]	38.3	39.6	40.6	39.7	39.6	39.8	40.2
Production	127	129	136	120	129	80	129

[a]Bushel per acre.

Under B1, all forms of conservation practices would be used (Table 4). Iowa farmers would move to conventional tillage contouring, then to conventional tillage-strip cropping and terracing and finally to reduced tillage-contouring. Under Alternative A, 87 percent of the land in Classes I and II would be under conventional tillage practices. This would decrease to about 56 percent under Alternative B1. The distribution of more erosive lands (Classes IIIE and IVE) would be more significant. The proportion of land in these land classes farmed under straight row practices would decrease from 82 percent under Alternative A to less than 46 percent under B1. About 19 percent of the acreage in these land classes would be farmed under conventional tillage-strip crop and terracing practices under Alternative B1 as compared to none under Alternative A. With shifts in production patterns and farming practices, soil loss in Iowa would decline from 362 million tons per year under the unrestricted soil loss Alternative A to less than 108 million tons under B1. The most important decrease would occur on Classes IIIE and IVE.

Table 4. *Acres under conservation practices in Iowa under seven alternatives (000).*

	Alternative						
	A	B1	B2	D	E	C	F
Conventional tillage:							
Straight row	23,232	10,554	4,487	8,647	11,848	6,917	8,553
Contour	215	2,288	4,156	4,499	2,288	353	2,048
Strip crop and terrace	1	4,085	7,098	4,301	4,068	7,687	4,264
Reduced tillage:							
Straight row	3,064	6,111	4,236	1,993	4,834	7,680	4,192
Contour only	0	3,294	3,254	3,171	3,294	3,343	4,988
Strip crop and terrace	697	697	3,609	4,053	667	1,939	3,979

Under Alternative B2, the maximum per acre soil loss was reduced to 2.5 tons from 5 tons, as in Alternative B1. As a result, marked changes occurred in production patterns and farming practices, resulting in reduced quantities of annual soil erosion.

Under conditions of B2, gross soil loss in Iowa would be about 362 million tons per year, a decrease of 60 million tons from the five ton alternative. The reduction of soil lost in Iowa would be more than offset by increases in the rest of the country as crop production is intensified there.

Reduction in allowable soil loss per acre from 5 tons to 2.5 tons shifted farming practices to more soil conserving practices such as contouring, strip cropping and terracing (Table 4). Under the 5 ton alternative, about 17 million acres were under straight row farming, accounting for about 62 percent of the total land under crops. This was reduced to 8.7 million acres under Alternative B2, accounting for only 32 percent of the total cropped area and soil loss declined from 50 million tons per year to 32 million tons from straight row farming alone. The most significant change in farming practices would be in strip crop and terracing with an increase of 6 million acres (an increase of about 124 percent compared to the 5 ton alternative).

Land under Classes I and II contributed about 62 percent of gross soil loss from the agricultural lands of Iowa, compared to 69 percent under Model B1 and 33 percent under Model A. But, the gross soil loss from these land classes would decrease from 75 million tons (Model B1) to under 39 million tons (Model B2) per year. A more significant change in farming practices would be on more erosive land classes, IIIE and IVE, where the total area under reduced tillage practices would increase from 2 million acres under Model B1 to 3 million acres under Model B2.

LAND USE AND ENVIRONMENTAL RESTRICTIONS IN IOWA

Chemical fertilizers and livestock wastes providing nitrogen for crops were restricted in Alternative D. The crop sector was forced to use the livestock wastes as a source of nitrogen. Farmers were free to use rotations with soybeans and legume hay to augment the nitrogen supply to the crops. Farmers also were free to purchase nitrogen fertilizers to supplement the nitrogen supply after using the livestock wastes as a source of this nutrient. In Alternatives D and E, the quantity of chemical nitrogen was restricted to a maximum of 100 lbs. per acre.

With restricted nitrogen fertilizer use and a 5 ton soil loss in Alternatives D and E, total cropped acreage in Iowa would decrease by 542 thousand acres. Most corn would be grown in rotation with legumes and yield decreases would be significant. Part of the yield decrease resulting from fertilizer use limitations in D would be compensated by better farming practices in B_2. About 80 percent of corn under Model D is grown under contouring, strip cropping and terracing.

EFFECTS UNDER HIGH EXPORT LEVELS

In previous sections, the export levels used were those of 1969-72. The U.S. had surplus producing capacity under these export levels and would do so again in 1985. Hence, we now turn to comparisons where 1985 exports are set at higher levels — following recent experiences. The first high export alternative, C, had a 5 ton maximum annual allowable soil loss for each soil in Iowa. The second alternative, F, also had restrictions in the use of nitrogen and pesticides.

There would be significant shifts in Iowa farming practices under Alternative C with very high export levels and environmental restraints in Iowa alone. These shifts would be mainly towards strip cropping and terracing. The combined reason would be the reduced soil loss per acre and higher yield rates under these practices. With high export levels, the agricultural sector would produce more with the given supply of land to meet the higher demand requirements, even with higher costs. Total area under straight row practices decreased to 14.6 million acres compared to 26 million acres under Alternative A. The restriction of a 5 ton maximum soil loss could have been satisfied with more area under straight row farming, as evidenced under Alternative B1. But, the need to produce more would shift land to strip cropping and terracing. The relatively less productive Land Classes IIIE and IVE would shift towards strip cropping. About 10 percent of the area in these land classes would be under strip cropping and terracing under Alternative A and 38 percent under Alternative B1; whereas this proportion increases to about 89 percent under Model C.

The total soil loss from Iowa would be 108.25 million tons under Alternative C, more than that under Alternative B1. But Alternative C has a higher land base and the average soil loss per acre is only 3.87 tons per acre, compared to 3.98 tons per acre under Alternative B1 and 13.30 tons per acre under A.

Alternative F was similar to E, except for the demand and export levels. The export and the domestic consumption levels for F were the same as those of Model C. The use of nitrogen was restricted to a maximum of 100 lbs. and the use of chemical pesticides was limited to organophosphates and carbomates. The yields and the interaction coefficients of the crop management systems with the nitrogen balance equation were adjusted accordingly.

The total area under straight row farming in Iowa decreased by 1.9 million acres under Alternative F from 14.6 million acres under Alternative C (Table 4) while the area under contouring increased to 7 million acres under F.

Large amounts of nitrogen fertilizer would be required to achieve the high demand and export levels of C and F alternatives. The use of nitrogen under Alternative C would be more than twice the use under Alternative A where the nation has surplus capacity. In C, the use of nitrogen was not restricted. As a result, the use of nitrogen for all crops increased to 1,449 thousand tons, compared to only 711.5 thousand tons under A. Moreover, due to increases in grain prices brought about by expanded exports and reduced livestock production, the demand for livestock products decreased under Alternative C. Thus, less nitrogen was obtained from livestock wastes. The quantity of nitrogen from chemical fertilizers increased substantially, to 1,312 thousand tons under Alternative C, an increase of about 26 percent over Alternative A. Nitrogen applied per acre would be about twice as much under C as compared to A.

Under Model F, with nitrogen restricted to 100 lbs. per acre, the total quantity used would decrease to 1,083 thousand tons in Iowa, a reduction of 25 percent compared to Alternative C. However, this quantity would be substantially higher than under Alternative A with its lower exports.

Increased export demands put pressure on the land resource in Iowa and in the rest of the country as reflected in the land rental values (shadow prices). The shadow or rental price of land in Iowa would increase to $175.81 per acre under C and to $177.95 under F, compared to only $38.61 under A, very large increases in C and F over A. The increase in rental or shadow prices of land under Alternative F could be attributed to the increased use of land required to compensate for the reduction in yield rates brought about by limited use of nitrogen fertilizer and pesticides.

INCOME EXPENDITURE AND RELATED EFFECTS

The seven alternatives in production, soil conservation, environmental practices and exports had considerable impacts on national farm prices and income. Nationally, export level was the crucial variable. Under Alternatives A, B1, B2, D and E, demand for U.S. food was less because exports are at 1969-72 levels when the U.S. had to subsidize a large amount of its exports even though foreign sales were much lower than in the 1972-74 period. Hence, if U.S. agriculture were to operate under 1969-72 export levels in 1985, with some improvement in technology, the nation would again produce large amounts of grain relative to demand and surpluses again would prevail. Hence, prices for corn, wheat and soybeans would be at only modest levels for Alternatives A, B1, B2, D and E (Table 5). Under the high export levels of Alternatives C and F, grain and other farm commodity prices would be much higher. Under the higher export levels for C and F, U.S. livestock production would be curtailed. The high levels of grain exports (especially feed grains) could be attained only if all cropland were fully utilized, some less beef and pork were produced in the U.S. and a large substitution of corn silage for corn grain were made in cattle fattening. (The prices in Table 5 are in 1970 dollar values. Inflated to 1975 dollar values, they would be considerably higher).

Table 5. *Equilibrium National Programming or supply prices for major commodities under the several models (dollars per unit).*

	Alternative						
Commodity	A	B1	B2	D	E	C	F
Corn (bu.)	1.11	1.10	1.08	1.12	1.12	2.51	2.73
Wheat (bu.)	1.17	1.16	1.14	1.16	1.16	3.02	3.13
Soybeans (bu.)	3.70	3.66	3.54	3.77	3.67	9.53	8.60

Farming profitability

The imposition of soil loss limits would make farming in Iowa less profitable relative to the rest of the country (see Table 6). Net farm income in Iowa decreased with the imposition of soil loss restrictions, from $2,019 million under A with no soil loss restrictions to $1,890 million with the imposition of a 2.5 ton restriction. At the same time, income increased in the rest of the country. As Iowa produces less in a market with an inelastic demand, the rest of the country would gain from the higher prices if production were retained at previous levels or increased slightly. A redistribution of income would take place with soil conserved and the environment improved through implementation in Iowa alone.

Income, expenditure and farm level prices

With the imposition of limits on the use of nitrogen and pesticides (Alternative E), as well as limits on soil loss, farming in Iowa would be even less profitable relative to the rest of the country (Table 6). The cost of production of crops in Iowa increased from $1,756 million under a 5

Table 6. *Total costs of production and net income of Iowa and the rest of the country under alternatives ($ million).*

	Alternative						
Item	A	B1	B2	D	E	C	F
Iowa							
Crop costs	1,677	1,756	1,812	1,813	1,741	2,324	2,070
Livestock costs	4,459	4,727	4,050	4,378	4,727	3,162	3,274
Net income	2,019	1,964	1,890	1,913	1,882	5,311	5,266
Rest of U.S.							
Crop costs	18,005	17,906	17,892	17,944	17,921	26,026	26,308
Livestock costs	32,582	32,234	32,809	32,803	32,261	43,526	45,202
Net income	17,791	17,854	17,887	18,461	17,947	43,552	48,139

ton soil loss limit to $1,813 million with a combined limit of 5 ton soil loss and a 100 lb. limit on the use of nitrogen. This increase resulted from an increase in other inputs such as labor and machinery substituted for nitrogen.

High exports

The expenditure on crops in Iowa would increase to $2,324 million with high exports and a 5 ton soil loss. Iowa net farm income would increase to $5,311 million or by $3,212 million as compared to Alternative A and its low export levels and lack of conservation restrictions. At the same time, farm income in the rest of the country would increase to $43,522 million. In shifting from Alternative A to B1 with a 5 ton soil loss, the increase in Iowa would be 163 percent compared to only 145 percent in the rest of the country. In other words, Iowa has a comparative advantage under increased grain export levels, even with a 5 ton soil loss restriction. But, this advantage would be partly lost with the addition of other environmental restrictions. With the additional restrictions on the use of nitrogen fertilizer and pesticides, the farm income in Iowa would decline to $5,266 million under Alternative F, as compared to $5,311 million under C. Under high exports, the rest of the country would increase income from $43,552 million to $48,139 million as tight environmental controls are imposed on Iowa and not elsewhere in the nation. Compared to the normal export level and some level of environmental controls, the increase in the farm income in Iowa would be only 161 percent whereas the corresponding increase in the rest of the country would be 171 percent. Iowa would gain in net farm income under the higher exports, but by not as much as the rest of the country.

DECISION ON ENVIRONMENTAL IMPROVEMENT

Our analysis emphasized the economic outcome of land and environmental measures fully implemented by a single state. As illustrated in Table 6, farmers of the individual state, especially those on erosive soils, would pay the costs of the environmental improvement. Benefits would accrue to the nation's consumer generally in improved environmental quality and to farmers elsewhere in the form of higher income. An income redistribution would take place with farmers of Iowa (in this case) sacrificing and consumers and other farmers enjoying the benefits. Sacrifice falling on the state's farmers could be handled in different ways: (1) Society could decide that while farm income is reduced, the sector should bear the economic cost because it owns the land. (2) The state could pay an annual subsidy to the farmer equal to the amount of income he sacrificed as he shifts land use and farming systems to conform with land-environmental regulations. The income sacrificed frequently will much exceed the cost of applying soil conservancy practices for farmers who have to make large shifts in their operational system. (3) The environmental program can be applied on a national basis. Under this system, the income to be "restored" to the farmers of the particular state will be less (than if only this state applied the program) but welfare gains over all groups still may be guaranteed only if farmers who sacrifice in shifting to new systems are compensated. These are issues yet to be decided as various combinations of state and federal regulations on land use and environmental practice might be legislated and implemented.

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