1984

8/6/84

Economic Analysis of Long-Term Acreage Reduction Strategies

Shwu-Eng H. Webb, Clayton W. Ogg, and Wen-Yuan Huang *

Soil Conservation

To be presented to AAEA Summer Meetings, Cornell University, Ithaca, New York, August 5-8, 1984.

* Agricultural Economists with Natural Resource Policy Branch, Natural Resource Economics Division, U.S. Dept. of Agriculture.

"Economic Analysis of Long Term Acreage Reduction Strategies" Shwu-Eng H. Webb, Clayton W. Ogg, and Wen-Yuan Huang (Economic Research Service, USDA)

ABSTRACT

A national LP model is used to examine long-term acreage reduction strategies: a least cost strategy, targeting on erosive land, and continuing current acreage reduction patterns. It is shown that Government costs are not dramatically different among strategies. The "targeting" strategy is the most effective; 40 percent of the critically erosive lands will be placed on long-term reserve.

ACKNOWLEDGMENTS

Dick Clark, Neill Schaller, John Hostetler, and Alan Webb of ERS provided helpful comments and suggestions in their reviews of the draft. We also thank Venita Dimmick for Statistical work and typing.

ECONOMIC ANALYSIS OF LONG-TERM ACREAGE REDUCTION STRATEGIES

INTRODUCTION

Soil erosion reduces the depth of topsoil and humus content, impairs the soil's capacity to retain water, and reduces water infiltration. These factors affect soil productivity. In addition, runoff from fields carries along fertilizer and pesticide residues, dissolved minerals, and animal wastes with associated bacteria. Soil erosion and agri-chemical run off from cropland are considered a main source of the nation's nonpoint water pollution.

Commonly discussed ways to reduce cropland soil erosion include: (1) Conservation tillage methods; these leave crop residue on field surfaces to help protect the soil from wind, sheet and rill erosion and conserve soil moisture; (2) Crop rotations; these reduce erosion relative to continuous single crop cultivation: (3) Contouring and strip cropping which slow the velocity of the water movement; and (4) Shifting crop acres into pasture or forest maintains a permanent soil cover. The fourth method appears to be especially desirable, and feasible, during periods of excess crop production.

Federal farm programs, in various ways, have supported and stabilized farm prices and incomes since 1933. Heavy government involvement in agriculture was not necessary during the export boom of the mid-1970's, when market prices rose well above price supports. However, "with the onset of global recession and the strengthening of the dollar 2 years ago, farm exports fell and farm prices dropped well below loan rates.

There were bumper crops in 1981 and 1982, and stocks in the Farmer Owned Reserve and in CCC inventories burgeoned." (2, p. 136.) 1/

Erosion is costly but becomes even more costly when it is a consequence of programs which encourage surplus production. Long-term acreage reduction could conserve soils and reduce excess production, thus shrinking program outlays on deficiency payments and storage costs. If properly implemented it could also reduce related water pollution problems.

This paper examines three scenarios for placing 20 million acres of cropland into reserve: (1) using the acreage reduction pattern which is least costly to the government; (2) targeting to critically erosive and fragile lands; and (3) following the 1978 program acres set-aside pattern. A national linear programming (LP) model was used to evaluate the consequences of the three strategies by using a bid or offer system for withdrawing 20 million acres of cropland. We analyze Government outlays on renting lands, soil erosion, and crop production. The results of our study indicate that to provide any given amount of production control, the targeting strategy is by far the most effective strategy in reducing soil erosion.

DATA

Two sources of data are used for this study: (1) The 1977 National Resource Inventory (NRI) which provides land use and soil erosion data for 6 land groups in 105 producing areas (PAs), and (2) data developed at Iowa State University for a USDA study under the Resource Conservation Act (RCA).

The 1977 NRI used the Universal Soil Loss Equation (USLE) to estimate annual sheet and rill erosion for the entire nation. USLE is expressed

---

1/ Underscored numerals enclosed in parentheses refer to entries in the References Section.

as: A = R•K•L•S•C•P. The average annual erosion rate in tons per acre (A) in a given area is the product of its rainfall erosion index (R), soil erosion index (K), slope length (L), slope steepness (S), cropping practice (C), and conservation practices (P). The R•K•L•S factors represent the physical features of cropland which are less amenable to manipulation in conservation assistance programs. (6)

For the purpose of examining alternative acreage reduction programs, we identify the cropland with a high R•K•L•S (over 50) for which even the most effective conservation practices will generally not reduce the soil erosion rate to a tolerable level (usually defined as 5 tons per acre per year) as long as it is used for cropping. Such critically erosive cropland if periodically removed from intensive crop production might gradually restore the productivity of these soils.

The Soil Conservation Service (SCS) land capability class and subclass system is also widely used to identify land types with limitations for agricultural use. The Class number, which ranges from I (few limitations) to VIII (land which should be restricted to recreation, wildlife habitat, water supply or other esthetic purposes), identifies the kinds or levels of land use restraints. Within each of these soil classes (except I and V), subclasses identify the dominant limitations to agricultural use. These include erosion hazards (e), wetness (w), stony or root-zone limitations (s) and climatic limitations (c). SCS's land capability class (LCC) defines the most fragile lands as those classified LCC VI and above--that is, VI, VII, and VIII. For many soil conservation studies, this method has a drawback as subclass e identifies only those soils for which the erosion hazard is the dominant limitation. Soils falling in other subclasses, however, may also have substantial erosion problems. Moreover, the acreage of critically erosive land in classes IIe and IIIe is larger than the total in classes IVe and above. This study combines the RKLS and LCC to define erosive and fragile lands. Six land groups pertinent to the analysis of soil erosion related issues include: (1) land groups 1 and 3 with high yields and low erosion potential; (2) land groups 4 and 5 with high yields but high erosion potential; (3) land group 2 with low yields and a low erosion potential; and (4) a small land group 6 designated by SCS as unsuitable for crop production. The grouping of cropland in the model is presented as follows:

Model Land Groups	Land Capability Class and Subclass
1	I, IIwa, IIIwa
2	Rest of II, III, IV
3	IIe, IIIe and IVe with RKLS < 50
4	IIe, and IIIe with RKLS > 50
5	IVe with RKLS > 50
6	VI, VII, and VIII

Cost, yield, and other technical production coefficients were developed for each of the 6 land groups and in each of 105 producing areas. The documentation for this set of data is presented in (3) and (4).

THE MODEL

U.S. agriculture is characterized by wide regional variations in climate, topography, soil types, and local governmental programs. Regional characteristics influence the type and the mix of crops to be grown, method of production and resource uses. To be useful a model must recognize these regional differences.

Our analysis uses a modification of the linear programming model developed at Iowa State University for the Resource Conservation Act analyses. The model includes 105 producing areas (PA's) and incorporates the six land groups noted above. Ten crops are included in the model: corn grain, sorghum grain, wheat, oats, barley, soybean, cotton, hay, nonlegume hay, and corn silage. As the main objective of the study is to analyze the consequences of acreage reduction strategies, conservation-related management practices are limited to reduced tillage and conventional tillage.

The Mathematical Expression of the Model

Objective Function

The objective function maximizes the total net returns of crop production to land and management

$$\max \ OBJ = \sum_{i=1}^{10} \sum_{j=1}^{105} \left[\sum_{k=1}^{6} \sum_{r=1}^{R} (XD_{irjk} + XI_{irjk}) \right] P_{ij} -$$

$$\sum_{i=1}^{10} \sum_{j=1}^{105} \sum_{k=1}^{6} \sum_{r=1}^{R} CD_{irjk} \cdot XD_{irjk} - \sum_{i=1}^{10} \sum_{j=1}^{105} \sum_{k=1}^{6} \sum_{r=1}^{R} CI_{irjk} \cdot XI_{irjk}$$

where:

P_{ij} = Price 2/ of the ith crop in the jth PA

CD_{irjk} = unit production cost for crop i using rotation r in the jth PA on the kth land group of dryland.

XD_{irjk} = amount of crop i produced by using rotation r in the jth PA and land group k of dryland

CI_{irjk} = unit production cost for crop i using rotation r in the jth PA and kth land group of irrigated land

XI_{irjk} = amount of crop i produced by using rotation r in the jth PA on the kth land group of irrigated land.

$i = 1 \ldots 10$ for ten crops

$j = 1 \ldots 105$ for the producing areas

$r = 1 \ldots R$ for possible number of R rotations for a particular crop in a particular land group.

2/ Crop prices were set at the 1985 target prices guaranteed to program participants, except for soybean prices. Soybean price is set to equal to the product of 1982 soybean/corn price ratio times 1985 corn target price.

Resource Restraints

The objective function is subject to the availability of land, water, and other resources, and minimum regional production requirements.

A. Restraints on different land groups

a) Dry cropland restraint for PA 1 through 105

$$\sum_{i=1}^{10} \sum_{k=1}^{6} \sum_{r=1}^{R} XD_{irjk} \cdot d_{irjk} \leq LD_j \quad \text{for each of 105 PAs}$$

where d_{irjk} indicates the amount of dryland required to produce a unit of XD_{irjk} in the jth PA, and LD_j is the amount of dryland available in the jth PA.

b). Irrigated Cropland

A similar constraint holds for irrigated land in PA 48 to PA 105

$$\sum_{i=1}^{10} \sum_{k=1}^{6} \sum_{r=1}^{R} XI_{irjk} \cdot g_{irjk} \leq LI_j$$

Crop Acreage or Production Flexibility Restraint for Each PA

This restraint is imposed on the model to avoid unrealistic production shifts caused by removing crop acreage from production. Farmers' multiple cropping practices are simulated to allow for risk reduction and the imperfect mobility of resources.

$$\sum_{k=1}^{6} \sum_{r=1}^{R} X_{irjk} \cdot W_{irjk} \leq MINA_{ij}$$

X_{irjk} = acres planted for crop i with rotation r on land group k in PA_j

W_{irjk} = the rotation weight for crop i with rotation r on land group in PA_j

$MINA_i$ = minimum acreage of crop i required in the jth PA

The production of each crop in each PA is bounded by its 1982 production for that PA.

$$\sum_{k=1}^{6} \sum_{r=1}^{R} XD_{irjk} + \sum_{k=1}^{6} \sum_{r=1}^{R} XI_{irjk} \leq Q_{ij}^{1982}$$

Q_{ij}^{1982} = the amount of crop i produced in 1982 in PA_j

The model includes accounting rows to provide for the calculation of soil loss, water and fertilizer use, and total crop production. The base run solution represents the most efficient pattern of crop production in the 1982 base year. This optimum production pattern maximizes the total net returns to land and mangement given the availability of resources, technology and management.

ACREAGE REDUCTION STRATEGIES

It is not feasible, for two reasons, to set aside acres so as to fully meet both price support and conservation objectives. Erosion-prone crops are not always in excess production, and those in excess production are not always erosion-prone. Wheat supply relative to demand is much greater than feedgrain supply versus demand; based on recent experience achieving target price levels for both would require idling about 3 acres of wheat for each feed grain acre. Yet, as shown in Table 1, more than 17 million acres of land in corn and soybeans are eroding at a rate greater than 15 tons per acre, but only 6 million average feedgrain acres are needed to be set aside to meet price support objectives. Less than 7 million wheat acres are eroding at more than 15 tons. But over three times that acreage might have to be set aside to support the wheat price at current levels (1). Cotton on the other hand, has a problem similar to corn. Soil conservation objectives would be achieved by taking about 6 million cotton acres out of production. But, it is unrealistic to take out half of total cotton acreage.

This study assumes that 20 million acres placed in a long-term reserve--less than half of the total set aside required to protect critically

Table 1: Critically Erosive Land by Crop

Crop	Total Acreage	Critically Erosive land 1/	Critical land as Percentage of land in crop
	--------million acres-------		---percent---
Soybean	59.3	6.8	11.5
Corn	93.5	11.1	11.9
Cotton	16.6	6.0	36.1
Wheat	71.6	6.6	9.2
Other	66.7	11.5	17.2
Total 3/	307.7	42.0	13.7

1/ The study uses the national average C·P factor = .3 to get erosion rate: 15 tons per acre is the same as R·K·L·S = 50.

2/ Total cultivated cropland in 1977 NRI includes land planted to row crops, close-grown crops, summer fallow.

Source: (5).

erosive land. The 20 million acres consist of 11 million acres of wheat, 4 million of corn, 2 million of soybeans and 3 million of cotton. 3/ To meet price suport objectives for wheat, additional non-erosive acres would possibly have to be withdrawn through annual diversion programs.

The LP model used in the study compares the impacts of alternative reserve strategies on soil erosion, the Government costs of retiring cropland (excluding cover establishment cost), and production shifts.

The 4 million acres of corn, 2 million acres of soybeans and 11 million acres of wheat are converted to a production equivalent by using 1977-81 weighted average yields. This amounts to a reduction of 402 million bushels of corn, 59.6 million bushels of soybeans and 360.8 million bushels of wheat.

We examine three strategies for achieving the required reduction in output. The first strategy is called <u>the least cost approach:</u> producers are free to choose the land to be withdrawn from production. To minimize the decrease in total net returns, they take the least profitable lands out of prduction first. The second strategy is called <u>targeting to erosive and fragile lands</u>: acres taken out of the production must first come from land with critical sheet and rill erosion and fragile land. The erosive and fragile lands are land groups 4, 5, and 6 in the model, which include LCC IIe, IIIe and IVe eroding at greater than 15 tons per acre annually and LCC VI and above. The third strategy is the <u>1978 program pattern:</u> land is taken out of

---

3/ This study does not include cotton in the impact analysis for the following reason. Dryland cotton yields in the southern plains are so low that 3 to 4 million acres would never enter production in the model without disaster subsidies. This result seems to imply that the current policy of phasing out disaster payments may either eliminate much of the 30 tons per acre erosion in Texas or make it inexpensive to idle that land.

production in a manner that approximates the actual pattern of acres diverted and set aside under the 1978 commodity program.

There are two ways of implementing these three strategies. One is the "bid" system and the other is "offer" system. Under the bid system, producers in a county would submit bids to the local ASCS office representing the minimum payment they would be willing to accept to take a given parcel of land out of production. Assuming bids are competitive, net returns are an appropriate proxy for bids producers are likely to submit. In the offer system the government gives producers of the particular crop in a particular PA the same payment per acre for withdrawing land from this crop's production. In general, Government costs are less under the bid system than the offer system, but how much less depends on how lands are taken out of production in each PA. This study assumes use of the bid system.

DISCUSSION OF RESULTS

Under the least cost approach, Government costs per bushel (excluding cover establishment costs) would be $1.01 for corn, $2.12 for soybeans and $1.86 for wheat (Table 2). (These cost estimates are for comparison with the other two acrage reduction strategies. Actual costs would depend on prices and program options in any year.) As shown that in Table 3, the least cost approach places very little erosive land in reserve. Instead, wet, stony and saline land in land group 2 is idled or land is withdrawn in regions with less productive but non-erosive land. The least cost approach would idle only about 30 percent or 5.9 million acres of the total 20.6 million acres of erosive land in these three crops (land groups 4, 5, and 6 in Table 3).

If land is withdrawn as it was under the 1978 program, the cost per bushel to the Government would be $1.50 for corn, $2.97 for soybeans, and $2.33

for wheat (Table 2). Under this set-aside pattern, just about 15 percent of the land taken out consists of erosive and fragile lands. This strategy would achieve little in terms of soil conservation objectives.

Table 2: Cost per Bushel of Production Adjustment Under Alternative Reserve Strategies by using bid system 3/

Crop	Least Cost	1978 Pattern	Targeting erosive land
		$/bushel	
Corn	1.01	1.50	1.54
Soybean	2.12	2.97	2.69
Wheat	1.86	2.33	1.80

3/ Cost figures reflect 1985 target prices used in the model, but not 1982 actual prices. In most crop surplus years, prices and therefore, acreage reduction costs will be lower.

If the acres taken out of production are targetted to erosive and fragile lands, the cost per bushel to the Government would be $1.54 for corn, $2.69 for soybeans, and $1.80 for wheat (Table 2). Using this approach most of the idled acres come from land with critical sheet and rill erosion (groups 4 and 5 eroding at greater than 15 tons per acre), fragile (group 6) and less productive lands (group 2). For the same amount of production control, this strategy takes out far more erosive acres than any other strategy (13.4 million acres or about 65 percent of the total critically erosive acreage for these three crops). Thus, it is the most effective strategy considered in this study for reducing soil erosion.

Table 3: Acres Set Aside by Land Group Under Alternative Reserve Strategies

Land Group \ Alternative	Base Run	Difference From Base Run: Least Cost	Difference From Base Run: 1978 Patterns	Difference From Base Run: Targeting Erosive and Fragile Lands
		---------- 1,000 acres ----------		
Corn:				
1	46,230	407	281	0
2	7,788	3,060	2,109	0
3	18,630	1,726	1,813	0
4	5,968	1,759	527	3,834
5	1,390	124	406	1,390
6	53	53	39	53
Total	80,059	7,129	4,796	5,277
Soybeans:				
1	26,094	0	59	0
2	5,797	1,649	1,267	0
3	21,741	309	327	0
4	5,928	423	218	1,521
5	1,615	539	463	953
6	39	39	0	39
Total	61,214	2,959	2,334	2,513
Wheat:				
1	8,489	341	412	340
2	18,912	4,675	8,024	3,358
3	44,744	7,534	4,144	4,786
4	4,068	1,764	320	4,068
5	929	594	255	929
6	601	599	427	601
Total	77,743	15,507	13,582	14,082
Land Group:				
1	80,813	748	752	340
2	32,497	9,384	11,400	3,358
3	85,115	9,569	6,284	4,786
4	15,964	3,946	1,065	9,423
5	3,934	1,257	1,124	3,272
6	693	691	466	693
Total	219,016	25,595	21,091	21,872

The regional shares of idled acreage will differ for each of the three strategies, because the ratio of erosive land to non-erosive land differs across regions. The Lake States region, for example, has a relatively low proportion of erosive land, while the Appalachian and Southeastern regions have a relatively high proportion of erosion-prone lands. It is not surprising then to note that the Lake States' share of total land idled under the targeted bid strategy is 50 percent less than the Lake States share under the 1978 pattern. Likewise the Appalachian and Southeastern regional shares of idled acreage, as expected, are higher under the targeted bid program than under the 1978 pattern.

CONCLUSION

The competitive bid system costs less than the offer system for placing land in the long-term reserve. Under the competitive bid system, Government costs for renting lands are about 35 percent higher following 1978 program pattern than the least cost strategy and 20 percent higher under targeting strategy. Soil savings are largest under the "targeting" approach. It retires about half of the critical sheet and rill erosion land that is devoted to major crops or about 40 percent of the total damaging erosion in the United States.

References

(1) Congressional Budget Office, 1984. An Anaysis fo the President's Budetary Proposals for Fiscal Year 1985. February

(2) Council of Economic Advisors, Economic Report of President, February, 1984.

(3) English, Burt, Klaus Alt and Earl Heady, A Documentation of the Resources Conservation Act's Assessment Model of Regional Agricultural Production, Land and Water Use, and Soil Loss, the Center for Agricultural and Rural Development, Iowa State University, CARD Report 107T.

(4) Huang, Wen-Yuang, Reuben Weisz, and Klaus Alt, An Overview of Data Processing Activities in CARD-NRED LP Model, Working paper, Center for Agricultural and Rural Development, Iowa State University.

(5) U.S. Department of Agriculture. National Resources Inventory, Computer tapes, 1978.

(6) Wischmeier, W.H., and D.D. Smith, Predicting Rainfall Erosion Losses-A Guide to Conservation Planning, AH-537. U.S. Department of Agriculture, Science and Education Administration, December 1978.