An Evaluation of Post Conservation Reserve Program Alternatives In The Texas High Plains

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Abstract

Four policy alternatives for CRP lands upon expiration of the current contracts in Hale County, Texas are evaluated using chance-constrained programming. It was found that if CRP contracts are extended at the current average rental rate, 40 percent of the current enrollment would be expected to return to crop production, while 66 percent would return to crop production if the program were eliminated. The results also indicate that the marginal value of CRP payments to producers is lower than the marginal value of deficiency payments.

Key Words: Conservation Reserve Program, soil erosion, chance-constrained programming

Future policy toward lands currently enrolled in the Conservation Reserve Program (CRP) will be addressed in the 1995 farm policy legislation. The question as to what will happen to these lands upon contract expiration has generated policy debate within the federal government and among interested producer, environmental, and commodity groups. Many of these groups advocate the protection of at least a portion of the conservation and environmental benefits bought at a total cost of almost $20 billion (Nowak et al.).

An appropriate policy question relates to the future of the CRP lands as expiration of the first contracts enrolled in the program nears. Relevant policy considerations regarding post-CRP lands include impacts on land owner welfare, government costs, and conservation/environmental impacts. This paper evaluates the post-CRP land use decision by contract holders given selected program alternatives toward CRP lands upon expiration of the current contracts in Hale County, Texas.

A survey of CRP contract holders was conducted by the Soil and Water Conservation Society to determine the future use of CRP acres (Osborn et al.). The survey results indicated that 63 percent of the CRP acres nationally and 56 percent of CRP acres in the Southern Plains would be returned to crop production after contracts expire. The survey also asked if contracts would be extended for a period of 10 years with no haying or grazing in exchange for alternative payment amounts. The results for the Southern Plains Region indicated that at 80 and 100 percent of current rental rates, 26 and 72 percent, respectively, of CRP acres would be extended by contract holders.

Conceptual Framework and Methods

Agricultural producers and land owners will be faced with a decision regarding the use of CRP lands at contract expiration. It is reasonable to expect that this decision will be made relative to

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expected economic returns for alternative uses of these lands. This assumption relative to firm behavior is based on the hypothesis of profit maximization. A profit maximizing firm will choose both inputs and outputs with the sole goal of achieving maximum economic profits (Nicholson). The assumption that CRP contract holders will seek to maximize profits on CRP lands following contract expiration was used in this study as a basis for the land use decision.

The mathematical optimization model for profit maximization may be formulated and expressed in matrix form as follows:

$$\text{Max NR} = C'X \quad (1)$$

$$\text{subject to:} \quad AX \leq B \quad (2)$$

$$X \geq 0, \quad (3)$$

where NR is the value of the objective function of expected net returns, X is a vector of alternative activities, C' is a transposed vector of net returns, A is a matrix of technical coefficients, and B is a vector of resources or other constraints.

Chance-constrained programming (CC) models were used to estimate response of land owners and producers to various post-CRP policy alternatives; impacts of production decisions on environmental damage through soil erosion, and effects on government expenditures. The formulation of the CC models allowed for solutions to be obtained using a 90 percent probability for expected yields of the crop activities.

Model Specification

The objective function of the models maximized net returns above variable costs for lands currently enrolled in the CRP. Alternative uses of these lands included the return to crop production, grazing livestock, and maintaining as CRP lands. Limited resources and other restrictions specified in the model included existing crop bases prior to entry into the CRP; level of erosion allowed for these lands; and aggregate amount of government payments available for commodity price support programs and the CRP.

Alternative crop enterprises included cotton, corn, grain sorghum, and wheat under both irrigated and dryland conditions. Livestock enterprises included grazing cow-calf and stocker cattle. Consideration also was given to the production potential of the various crop and grazing enterprises with regard to land capability class. The general model specification was:

$$MAX\ NR = \sum_{i=1}^{8} \sum_{k=1}^{6} R_{ik} W_{ik} + \sum_{j=1}^{2} \sum_{k=1}^{6} R_{jk} W_{jk} - \sum_{i=1}^{8} \sum_{k=1}^{6} C_{ik} X_{ik} - \sum_{j=1}^{2} \sum_{k=1}^{6} C_{jk} X_{jk} + \sum_{k=1}^{6} G_k\, CRPAC_k \quad (4)$$

Subject to:

$$\sum_{i=1}^{8} \sum_{k=1}^{6} A_{ik} X_{ik} + \sum_{j=1}^{2} \sum_{k=1}^{6} A_{jk} X_{jk} + \sum_{k=1}^{6} A_k\, CRPAC_k \leq ENROLL \quad (5)$$

$$\sum_{i=1}^{8} \sum_{k=1}^{6} A_{ik} X_{ik} \leq BASE_i \quad (6)$$

$$\sum_{i=1}^{8} \sum_{k=1}^{6} A_{ik} X_{ik} + \sum_{j=1}^{2} \sum_{k=1}^{6} A_{jk} X_{jk} + \sum_{k=1}^{6} A_k\, CRPAC_k \leq LCC_k \quad (7)$$

$$\sum_{i=1}^{8} \sum_{k=1}^{6} A_{ik} X_{ik} + \sum_{j=1}^{2} \sum_{k=1}^{6} A_{jk} X_{jk} + \sum_{k=1}^{6} A_k\, CRPAC_k \leq EROSION \quad (8)$$

$$\sum_{i=1}^{8} \sum_{k=1}^{6} A_{ik} X_{ik} + \sum_{k=1}^{6} A_k\, CRPAC_k = TGP \quad (9)$$

$$-\sum_{i=1}^{8} \sum_{k=1}^{6} A_{ik} W_{ik} - \sum_{j=1}^{2} \sum_{k=1}^{6} A_{jk} W_{jk} + \sum_{i=1}^{8} \sum_{k=1}^{6} A_{ik} X_{ik} + \sum_{j=1}^{2} \sum_{k=1}^{6} A_{jk} X_{jk} \leq 0 \quad (10)$$

$$X's, \quad W's, \quad CRPAC \quad \geq 0, \quad (11)$$

where NR is expected net returns, i represents the ith crop production activity, j represents jth livestock grazing activity, k represents the kth land capability class (LCC), X_{ik} represent eight crop and two livestock production activities in acres, W_{ik} represent selling activities for crops and livestock in units of production, $CRPAC_k$ represent the CRP activities in acres, C_{jk} represent the cost coefficients, R_{ik} represent prices per unit of X, G_k represent net returns per acre of CRP, A_{ik} represent technical coefficients for the model constraints, $ENROLL$ represents acres of CRP currently enrolled in the study area, $BASE$ represents base acres available for each crop i, LCC_k represents acres of each LCC, $EROSION$ is a restriction on the level of total soil erosion, and TGP is a total government expenditure constraint.

Equation (4) specifies total expected net returns (NR) as: gross returns for acres returned to crop production and acres grazed, less production cost for crop production and grazing, plus net returns for acres in CRP. Equation (5) limits the total acres for all activities to the total CRP acres currently enrolled. Equation (6) limits acres that may be returned to production of each crop i under program provisions to the acres of base for crop i. Equation (7) represents constraints for each of the k land capability classes. Activities for crop and livestock production were differentiated by LCC whenever a difference in the productivity of these activities for different LCC's may exist. Equation (8) allows limits on the level of total erosion on the acres included in the model. Equation (9) is used to limit government expenditures for deficiency payments and CRP payments.

Selling activities, W_{ij} for the ith crop activity and jth livestock activity, help facilitate the changing of crop and livestock prices for different model solutions. Equation (10) represents constraints that transfer production to selling activities. Equation (11) represents non-negativity constraints on the model activities.

Overall, 130 production activities were considered accounting for irrigated and dryland crop production and land capability classes. In addition, each production activity was divided into owner/operator and landlord management status (Johnson). A total of 64 constraints were included for crop base, LCC, irrigation, and management status, with two constraints included for maximum levels of erosion and government payments.

Chance-Constrained Programming

The model expressed by equations (4) through (11) was formulated as a linear programming model (LP). The assumption of certainty (single-valued expectations) for resource supplies, technical coefficients, and prices of resources and activities makes the LP model results deterministic (Agrawal and Heady). In reality, the values of these parameters are stochastic in nature. Chance-constrained programming methods were used to incorporate probabilistic constraints into mathematical optimization models.

Values of the technical coefficients of the A matrix in equation (10) represent expected production levels for the crop and livestock activities. These production levels have probability density functions associated with them and may be summarized as $a_{ikh} \sim N(\mu_{ikh}, \sigma^2_{ikh})$. It is assumed that the a_{ikh}'s are independently distributed with production levels not related across activities.

The constraints represented by equation (10) are selling constraints where the output of a production activity is transferred to a selling activity. The a coefficients associated with the X_{ik} and X_{jk} activities in equation (10) represent expected output levels for the respective activities. An example of a selling activity for a specific crop i may be written as:

$$a_{ik}X_{ik} - a_i W_i = 0, \tag{12}$$

where a_{ik} is the expected mean yield of crop i for LCC_k, X_{ik} is the acres of crop i for LCC_k, a_i is -1, and W_i is the amount of crop i being sold. The constraint is equal to 0, therefore, transferring production of crop ik from activity X_{ik} to the selling activity W_i.

The general specification of the constraints that allows for the consideration of the stochastic properties of the technical coefficients was:

$$\Sigma_j X_{ij}\mu_{ij} + D^*(\Sigma_j \sigma^2_{ij} X^2_j)^{\frac{1}{2}} \leq b_i, \tag{13}$$

where D^* is the standardized normal value associated with a D percent probability of the constraint being satisfied, and b_i is the available amount of the constraint. This formulation of the constraint implies that each constraint must be satisfied at a specific level of probability (Anderson, Dillon and Hardaker). Thus, the chance-constrained model allows for a probability level (D) to be assigned to crop output levels.

The non-linear nature of the chance-constrained formulation can create difficulties in obtaining a globally optimal solution. Segarra et al. show that the formulation in equation (14) can be linearized to obtain:

$$\Sigma_j X_{ij} \mu_{ij} + D^* \Sigma_j \sigma_{ij} X_j \leq b_i. \qquad (14)$$

The linearized constraint is biased when compared to the true non-linear formulation, but this bias is in a known direction with the actual probability being greater than the specified value (Segarra et al.). In other words, a specified value for D of 80 percent gives a result at a probability slightly greater than 80 percent. Although the chance constrained programming used in this study does not directly incorporate risk into the decision process, the assigning of a probability for expected production nevertheless gives some indication of the response of producers to uncertain conditions.

Study Area and Data

Hale County is located in the central part of the Texas High Plains Region, see figure 1, and is representative of a tier of transitional counties between the cotton producing region to the south and the feed grain and wheat producing region to the north. Hale County was selected as the study area because it contains both irrigated and dryland crop production with diversified cropping patterns and enterprises. Lands enrolled in the CRP were primarily in cotton, corn, grain sorghum, and wheat production. The average rental rate for CRP acres was $39.65 per acre. A summary of the total CRP acres, crop base reductions, and non-allotted acres by land capability class is presented in table 1.

Alternative post-CRP policies evaluated included: (1) extension of the CRP at rental rates of $40, $30, and $20 per acre; and (2) a zero rental rate, representing no extension of the CRP. Each scenario was evaluated at various levels of constrained soil erosion. This expanded the policy alternatives to recognize that some conservation and environmental considerations might be incorporated into the policy alternatives. Expected levels of wind and water erosion for each cropping activity was estimated under the assumption that the return of CRP lands to crop production would be under a conservation plan.

The models were estimated using mean crop and livestock prices for the period 1978 through 1989 -- $2.66/bu for corn, $2.35/bu for grain sorghum, $3.11/bu for wheat, $0.53/lb for cotton, and $0.88/lb for calves. Provisions for the commodity price support program were included in the model with Acreage Reduction Program requirements specified at 10 percent for all crops and deficiency payment rates adjusted to account for the 15 percent flex acres.

Data for all CRP contracts in Hale County were obtained from the Hale County Agricultural Stabilization and Conservation Service office (USDA). The CRP contract data included contract size, crop bases, base yields, land capability class, and estimated erosion rates. The farming status of contract owners was considered to be a factor in land use decisions, with contract holders that are owner-operators realizing a different net return than contract holders that are landlords. The proportion of contracts under owner/operator or landlord management status in Hale County is 37 and 63 percent, respectively (Ervin and Johnson). Enrolled CRP acres were grouped into six LCC designations, 2, 3, 3E, 4, 6, and 7. Those acres included in the LCC 6 and 7 designations were assumed to not be suitable for returning to crop production. Production activities in the model were stratified by land capability class, crop base, and management status.

Results

The model solution at a CRP rental rate of $40 per acre, model S-A in table 2, indicates that 59,255 acres (60 percent) of existing enrollment would remain in the CRP and 39,906 acres would return to crop production. Acres returning to crop production are indicated to be entirely in corn and

Figure 1. The Texas High Plains Region and Hale County

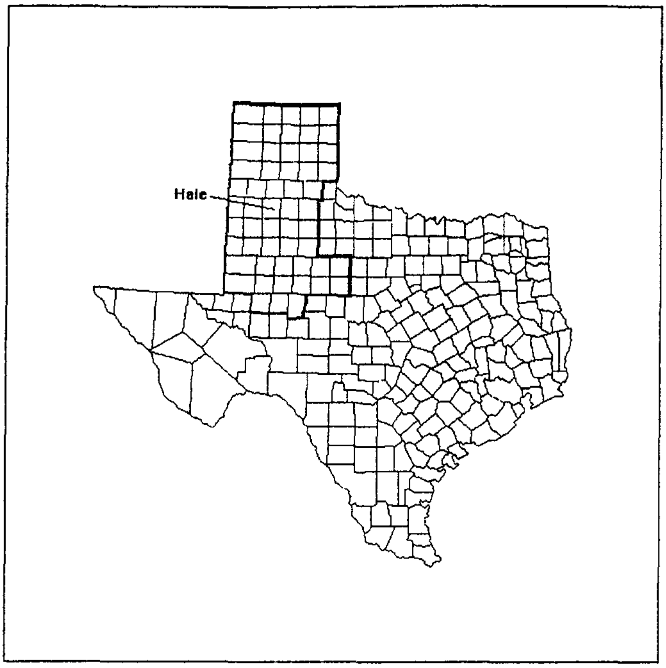

Table 1. Summary of CRP Acres In Hale County by LCC, Through Twelve Signup Periods

LCC	Contracts	CRP Acres	Base Acres Total	Base Acres Irrg.	Base Acres Dry	Non-Base Acres
2	250	37,704	35,245	25,282	9,963	2,459
3	299	49,788	45,404	19,223	26,181	4,384
3E	83	9,290	8,421	5,785	2,636	869
4	30	2,010	1,833	797	1,036	178
6	30	117	107	86	21	10
7	1	252	220	220	0	31
TOTAL	693	99,161	91,230	51,393	39,837	7,931

cotton, with none in grain sorghum or wheat. A breakdown of the acres returning to crop production revealed that all LCC 2 lands in corn and cotton base; all LCC 3 and 3E lands in cotton base; and LCC 3 and 3E lands in corn base under landlord management status would return to crop production. The estimated producer surplus at the $40 per acre CRP rental rate was $4,591,731 or $46 per acre, while the producer surplus at $20 and $30 per acre CRP rental rates were estimated at $41 and $37 per acre, respectively.

The solution for the model at a CRP rental rate of $0, model S-D, indicates that 33,910 acres (34 percent) would remain in grass for grazing if no CRP option were available. The acres returning to crop production would increase to 65,251 (66 percent) compared to 39,906 (40 percent) at the $40 rental rate. The estimated producer surplus in this case was $3,539,642 or $36 per acre. Producer surplus with no CRP extension was 5.5 percent greater than the $3,356,215 producer surplus under the current CRP.

Soil erosion rates associated with the alternative policies were compared to the estimated annual soil erosion of 99,161 tons on these acres with current CRP enrollment. Overall, soil erosion increased under all alternative policies and were greatest under the $0 rental rate scenario, where

Table 2. Chance-Constrained Results at CRP Annual Rental Rates of $40, $30, $20 and $0 Per Acre

Model	CRP Rental ($/AC)	Producer Surplus (Mil $)	Corn Acres	Sorghum Acres	Cotton Acres	Wheat Acres	CRP Acres	Grazing Acres
S-A	40	4 591731	9,227	0	30,677	0	59,255	0
S-B	30	4 039860	11,064	1,428	30,760	4,495	51,411	0
S-C	20	3 640527	11,289	3,991	43,080	6,480	20,160	14,158
S-D	0	3.539642	11,289	3,991	43,489	6,480	0	33,910
Current	40	3.356215	0	0	0	0	99,161	0

Model	Erosion[a] Wind (Tons)	Water (Tons)	Total (Tons)	Government Expenditures Deficiency ($)	CRP ($)	Total ($)
S-A	164,840	170,260	335,100	1,357,700	2,370,200	3,727,900
S-B	174,960	174,760	349,730	1,492,100	1,542,300	3,034,400
S-C	361,150	201,340	562,490	1,770,390	403,210	2,173,600
S-D	371,090	203,610	574,700	1,782,000	0	1,782,000
Current	0	99,161	99,161	0	3,934,324	3,934,324

[a] The soil erosion rates used in the model were obtained from the Soil Conservation Service and are associated with specific cropping activities assuming conservation compliance requirements are met The soil erosion rates used are less than theerosion rates reported in the CRP contract data. Soil erosion rates for the current CRP is estimated at one ton per acre and is assumed to be from water erosion.

approximately 66 percent of acres are returned to crop production. Also, the proportion of soil erosion from wind increases as the level of cotton acres returning to production increases.

A reduction in CRP rental rates lowers CRP expenditures as fewer acres are enrolled at lower rental rates. Government expenditures for these acres were greatest under the current CRP at $3.934 million. The lowest level of government expenditures occurs with no extension of the CRP.

The reduction or abatement of soil erosion on the acres enrolled in CRP in Hale County is estimated at 700,000 tons annually -- erosion on these acres is estimated to be 800,000 tons annually under crop production minus 100,000 tons annually under CRP. Various combinations of crop production, CRP, and grazing would allow different levels of soil erosion on these acres.

The models were solved with total soil erosion constrained at various levels and marginal value products for soil erosion derived from those solutions. The marginal value product of soil erosion can be restated as a marginal cost of soil erosion abatement, as it represents an opportunity cost to producers for limiting soil erosion. Figure 2 shows the estimated marginal cost functions for soil erosion abatement in Hale County. The marginal cost functions are shown for the CRP rental rate at $40 per acre and no CRP option. These marginal costs of erosion abatement represent the opportunity costs to CRP contract holders for choosing combinations of production activities that would meet specified levels of soil erosion. Note that the level of soil erosion decreases along the horizonal axis of figure 2 as the level of soil erosion abatement increases.

The off-site environmental benefits of reducing wind erosion have been estimated for Eastern New Mexico by Huszar and Piper at $1.45 per ton. The damage from water erosion in the Southern Plains Region of the U.S. was estimated by Ribaudo to be $1.60 per ton. Given these estimates of environmental benefits, a value of $1.50 per ton of soil erosion was assumed and is shown in figure 2. The level of soil erosion where the marginal cost of soil erosion abatement equals the environmental benefits represents the optimal level of soil erosion abatement. The levels of optimal soil erosion under the two models depicted in figure 2, 437,000 to 458,000 tons annually, are below the 495,805 tons annually that is the maximum amount of soil loss per acre per year that will permit a high level of productivity to be sustained economically and indefinitely (Stamey and Smith).

Figure 2. Marginal Cost Functions for Soil Erosion Abatement at CRP Rental Rates of $40 and No CRP Option with Environmental Benefits of $1.50 per Ton of Soil Erosion CC Models

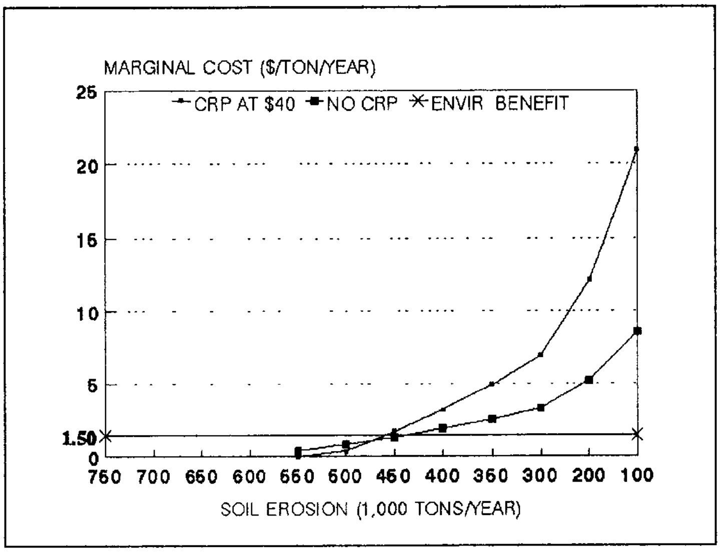

Table 3. Results at $40 Per Acre CRP Rental Rate With Constrained Levels of Government Payments From $3,727,900 to $2,000,000

Producers Surplus ($)	Government Payments ($)	Soil Erosion (Tons)	CRP (Acres)	CRP Payments ($)	Deficiency Payments ($)
4,591,732	3,727,900	335,100	59,255	2,370,200	1,357,532
4,542,448	3,500,000	336,610	51,691	2,067,600	1,432,400
4,430,940	3,250,000	337,110	45,340	1,813,600	1,436,400
4,319,220	3,000,000	337,110	39,090	1,563,600	1,436,400
4,206,811	2,750,000	363,060	32,840	1,313,600	1,436,400
4,060,630	2,500,000	392,300	26,590	1,063,600	1,436,400
3,904,380	2,250,000	392,300	20,340	813,610	1,436,390
3,748,130	2,000,000	392,300	14,090	563,610	1,436,390

The models were solved with government expenditures constrained from $3,727,900 to $2,000,000 for the acres currently enrolled in the CRP. Table 3 shows results for the model solution with the CRP rental rate at $40. As the level of government expenditures was reduced, the level of CRP payments decreased while the level of deficiency payments increased. These results indicate that the marginal value of government expenditures to producers is greater from deficiency payments than from CRP payments.

Summary and Conclusions

The objective of this analysis was to evaluate the post-CRP land use decision by contract holders for specific policy alternatives using a profit maximization decision rule. Chance-constrained programming models were used to estimate the response of land owners and producers to various post-CRP policy alternatives, the impacts of production decisions on environmental damage through soil erosion, and the effect on government expenditures. Alternative uses of these lands included the return to crop production, grazing livestock, and maintaining as CRP lands. Alternative post-CRP policies evaluated included: (1) extension of the CRP at rental rates of $40, $30, and $20 per acre; and (2) a zero rental rate, representing no extension of the CRP.

The estimates of CRP acres derived from the models indicate that if the CRP were to be extended at the $40 rental rate, 59,255 acres, which represents 60 percent of current CRP enrollment, would remain in CRP. This should be viewed as the lower bound of extended CRP acres because of the possible difficulty that CRP contract holders in a landlord management status may have in finding tenant farmers who would return these acres to production, and the influence of other non-profit maximization factors which were considered when the decision to enroll acreage was made. Also, it was found that if no CRP option is available, 66 percent of the total acres currently enrolled in CRP in Hale County would be expected to return to crop production. The results obtained in this analysis fit well with the indications for the return of CRP lands to crop production reported in the Soil and Water Conservation Society 1993 survey which estimated that 56 percent of the acreage would return to crop production (Osborn et al.).

These results indicate that an extension of contracts at the current rental rate would reduce the acres returning to crop production by 26 percent or 25,345 acres (66 percent returning with no extension and 40 percent returning with extension at the current rental rate) compared to the acres returning to crop production with no extension of the program. The annual rental payments associated with an extension at the $40 per acre rental rate was estimated at $2,370,200 which represents a cost of $95 per acre to maintain an additional 25,345 acres in CRP. The difference in erosion between the two policies amounts to 239,600 tons annually, at a cost of $9.50 per ton.

The characteristics of CRP lands in Hale County may account for the amount of acres estimated to return to crop production with an extension at the $40 per acre rental rate. First, CRP lands returning to corn production amount to 9,227 acres, representing 89 percent of the corn base reduction. These acres were enrolled with the corn base bonus payment which represents an effective rental rate above the average annual rental rate for the county. Second, CRP acres in LCCs 2, 3 and 3E are considered productive lands. Only under a policy alternative with constrained erosion do these acres remain in the established cover at the $40 per acre rental rate. The implication of these results is that under a profit maximization objective without a soil erosion reduction constraint, certain acres enrolled in the CRP in Hale County should be returned to crop production.

The results of the models indicate that as the total expenditures for deficiency and CRP payments are constrained, CRP acres decline and fall out of the solutions. Thus, from the producer's stand point, any reductions in government expenditures under agricultural programs should come from CRP expenditures before deficiency payments.

The optimal level of total soil erosion derived by the models with the environmental benefit of reduced soil erosion at $1.50 per ton is estimated at approximately 450,000 tons annually. This level of soil erosion on these acres may be obtained with a rental rate of $20 to $30 per acre. To obtain the optimal level of soil erosion, future policies may reduce the rental payment levels or target the contracts with the more erosive soils to meet the erosion objective.

This analysis demonstrates a method of evaluating the impacts of policy alternatives for CRP lands on a specific area. Even though these results are study area specific, they may be applied to counties in the THPR with similar crop production systems and soil types.

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