Economic and Environmental Impacts of Planting Flexibility and Conservation Compliance: Lessons from the 1985 and 1990 Farm Bills for Future Farm Legislation

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The interaction of the planting flexibility and conservation compliance provisions from the 1985 and 1990 farm bills was evaluated using an integrated systems model. Results showed that flex and compliance policy in combination reduced net returns and government costs, diluted environmental benefits of conservation compliance, and increased grower responsiveness to market signals, compared with conservation compliance alone. Strict compliance and higher flex levels were the most detrimental to farm income and environmental goals. Decoupling in current and future policy proposals will promote conservation goals. Budgetary reductions in future farm policy could reduce conservation incentives.

Government farm commodity programs have long been recognized as influencing farmers' production decisions and, in return, profitability (e.g., Heady 1948). Over the past fifteen years, concerns about adverse effects of the farm program have attracted public attention, leading to program changes. Some have argued that the unintentional impacts of earlier farm programs included intensively farming highly erodible land to build crop acreage base (CAB), excessive use of agrichemicals, emphasis on program crops discouraging use of alternative crops in soil conserving rotations, and high program costs (Gardner 1995, pp. 250–52; Cochrane and Runge 1992, p. 82; Huang 1989; US-GAO 1983).

To alleviate these problems, farm bill reforms have tied eligibility for commodity program payments to soil and water quality conservation and have provided more planting flexibility. Conservation compliance was introduced with the Food Security Act of 1985 (FSA85), also called the 1985 Farm Bill (P.L. 99-198). Farmers were required to develop conservation plans to reduce erosion or lose their eligibility for federal farm program benefits. Flexible base acres became a part of farm programs under the Food, Agriculture, Conservation and Trade Act of 1990 (FACTA90), also called the 1990 Farm Bill (P.L. 101-624), and the Agricultural Reconciliation Act of 1990 (ARA90) (Title 1 of the Omnibus Budget Reconciliation Act of 1990, P.L. 101-508). Under these acts, up to 25% of a farm's base acreage could be planted to alternative crops without losing their status as base acres. Of this 25%, the government would not make deficiency payments on 15% of the CAB.

These reforms are expected to encourage farmers to adopt conservation practices and to enable farmers to produce alternative nonprogram crops on flex acres without losing future eligibility for government payments because of reduced CAB. Rather than lose commodity program and other federal benefits, growers will have an incentive to develop and implement conservation plans. The flex policy should promote the use of soil-conserving crops in rotations. The flex provisions are also intended to reduce the influence of program benefits on crop choice, thus providing greater cropping responsiveness to market incentives (Westcott 1991). Finally and certainly not least important for policymakers, unpaid flex acres are designed to reduce government farm program costs.

In spite of dramatic changes in 1996 farm legislation, analysis of the impact of conservation

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compliance and flex acres is still important. The 1996 Farm Bill contains as cornerstones conservation compliance and planting flexibility from the 1985 and 1990 farm bills. Farm program participants are still required to meet conservation compliance to be eligible for market transition contract payments. The new legislation also allows planting flexibility on all contract acreage. Whether the farm program is elimnated as planned at the end of year 2002 or is continued in some form depends on the sequence of economic and political events over the next five years. When the temporary 1996 legislation expires in 2002, new legislation must be enacted or the permanent 1949 legislation with high support prices and possible mandatory production control becomes effective again. It is likely that legislators and policymakers will revisit the policy issues explored in this paper at that time.

It is not clear how flex provisions interact with conservation compliance to affect agricultural policy objectives such as improving farm profitability and enhancing environmental quality (Chien and Leatham 1994; Painter and Young 1995). This paper uses an integrated systems model to assess the economic and environmental effects of flex alternatives in conjunction with various conservation compliance standards in a north Idaho watershed. We test hypotheses about profitability and environmental damage with different policies and glean lessons for future farm policy formulation. This study provides evidence on how alternative planting flexibility and conservation compliance policies together affect farm income, taxpayer cost in terms of government deficiency payments, farmer responsiveness to market incentives, erosion, environmental damage, and farm program participation.

Major contributions of this paper are an important policy analysis of the interaction between conservation compliance and flex acres within the context of the farm commodity program that is relevant for future farm policy debate, and the consideration of onsite erosion and offsite sediment damage under alternative policies. The focus is Idaho's Tom Beall watershed, which provides an ideal study area because of its high vulnerability to erosion, onsite productivity loss, and offsite sediment damage.

Literature Review

Conservation compliance and flex policy have been evaluated separately but to the best of our knowledge not jointly. For instance, Richardson et al. (1989) reported that compliance with an approved conservation plan in the Southern High Plains of Texas resulted in no reduction in farm income. Thompson et al. (1989) studied the effect of conservation compliance on regional comparative advantage. Hoag and Holloway (1991) showed that high farm program participation would increase the effectiveness of conservation compliance. Govindasamy and Huffman (1993) demonstrated that the tradable coupon system for conservation compliance not only is efficient, but will also bring more land under soil conservation. Prato and Wu (1996) reported that conservation compliance standards on a field level were more resource-conserving but less efficient than limits on average erosion for a watershed.

Several recent studies attempted to provide empirical evidence on the effects of flex provisions on farm profitability and environmental quality. Westcott (1991) examined the impact of various flex alternatives on planting choice by using break-even analysis. He found that if deficiency payments are linked to specific crops, then target prices and farm program payment yields still affect net returns and planting choice. To remove planting distortions, deficiency payments under a flex acre policy must be separated from the planting decision. In another study, the ability to maintain existing base, regardless of the crop planted on base acres, was a very important factor influencing Midwest participants' choices of crops to plant on flex acres (Coombs, Dicks, and Just 1994).

Chien and Leatham (1994) examined the value of planting flexibility provisions to Texas farmers. Their results showed that gains from added planting flexibility did not offset the mandatory loss in deficiency payments for program participants. However, Duffy, Cain, and Young (1993) found that the 1990 Farm Bill with flex acres resulted in higher whole-farm income to cotton farms in Alabama because of the elimination of cross-compliance provisions and the change to a shorter base calculation period. These results revealed regional variation in policy impacts, which underscores the importance of regional evaluations of national policies.

An interregional comparison of economic and environmental impacts with six policy scenarios was made by Painter and Young (1995). Three scenarios regarding planting flexibility were examined: allowing 15%, 40%, and 100% flex acres with no deficiency payments. They found that moving toward more flexible agricultural policies would permit substantial economic and environmental gains in a North Carolina Coastal Plain region. By contrast, the lack of alternative cropping systems prevented economic and environmental gains in the highly erodible Washington-Idaho Palouse region. The availability of economically feasible and environmentally sound management alternatives is necessary to realize environment benefits with policy reform.

This review of studies on conservation compliance and flex provisions reveals a need for evaluating the joint impacts of conservation compliance and planting flexibility on profitability and environmental quality. We will examine how various levels of flex acres in combination with conservation compliance alternatives affected model projections of farm income, farm program participation, environmental quality, and crop mix decisions.

The Integrated Modeling Framework and Analytical Procedures

An Integrated Systems Model.

Data gathered since the implementation of FSA85 and FACTA90 indicate progress toward policy goals. As a result of flex policy, about 10.4 million acres normally planted to commodity programs crops were planted with alternative crops in 1994, of which 8.5 million acres were on normal flex acres and 1.9 million acres were on optional flex acres (USDA 1995). In response to conservation compliance, more than 149 million acres of highly erodible land in 1994 were included in farm conservation plans with the Natural Resource Conservation Service (NRCS) (Magleby et al. 1995). As a result, cropland acres eroding at more than the tolerance level decreased from 24.3% of cropland in 1982 to 22.5% in 1987 and to 19% in 1992 (USDA-SCS 1994). According to the national resources inventories, annual cropland erosion declined one million tons between 1982 and 1992, or by nearly one-third (USDA-SCS 1984 and 1994).

While these response data seemed encouraging, we still needed a modeling analysis of these policies because we were interested in other, unpublished response variables: income impacts, practice changes at the field level, and environmental impacts. We also wanted to evaluate impacts from other compliance standards and flex levels than those enacted in the legislation in order to study the interaction between these policy components with an eye toward future policy options.

The framework used in this study integrates spatial information on watershed characteristics with environmental protection policies and an economic programming model to project the economic and environmental effects of participation in the farm program under various conservation compliance requirements and planting flexibility alternatives. The integrated systems model included a geographic information system (GIS), an economic optimization model with a policy component, and an erosion damage simulation model. The approach provided a means to examine changes in farm income, government cost, erosion, environmental damage, program participation, and crop mix decisions with different policy alternatives.

The response of agricultural producers to alternative policy scenarios was projected using a mixed integer programming (MIP) model. The database for the MIP model was developed and maintained by a GIS. The database includes coverages or maps of watershed and field boundaries, soil types, land use, topography, and stream channels. To project physical impacts of agricultural practices by fields, the model required physical/spatial information for use in the universal soil loss equation, or USLE (Wischmeier and Smith 1978). A field, which is the basic management unit, is a fairly homogenous area managed by a grower using a single management practice. A management practice is defined as a specific combination of rotation, tillage system, and conservation practice. The seven rotations evaluated were wheat/pea, wheat/barley, wheat/barley/pea, wheat/barley/fallow, wheat/pea/wheat/fallow, wheat/wheat,[1] and summer fallow. The tillage options considered were conventional tillage and reduced tillage where the chisel plow replaces the moldboard plow. The two conservation practices were contour farming and divided slope farming. The general form of the MIP is:

$$(1) \qquad \max_{x,y} J = \mathbf{cx} + \mathbf{zy}$$
$$s.t.\ \mathbf{A}\begin{bmatrix}\mathbf{x} \\ - \\ \mathbf{y}\end{bmatrix} \leq \mathbf{b}$$
$$\mathbf{x} \geq \mathbf{0}$$
$$\mathbf{y} \in \{0,1\},$$

where J is net farm income, $\mathbf{x}$ is a vector of continuous variables for cropping system acreage, $\mathbf{y}$ is a vector of binary farm program variables, $\mathbf{c}$ and $\mathbf{z}$ are vectors of objective function coefficients, $\mathbf{A}$ is a matrix of technical coefficients, and $\mathbf{b}$ is a vector of constraint values. The MIP maximizes net farm

[1] In contrast to the Palouse, a major wheat region to the north of our study area, in our area recropping wheat is common because more favorable weather conditions (lower moisture and warmer temperature during the winter) allow wheat to be replanted with minimal disease problems. There are economic incentives for recropping wheat where possible. The price and net returns are higher for wheat than for alternative crops such as barley.

income in the watershed subject to constraints on land use, farm program provisions, and conservation compliance requirements. Onsite erosion damage was not considered in the objective function, although it was estimated with an accounting row in the model for environmental analysis.[2]

When determining whether to participate in farm commodity programs, growers consider the potential benefits: government deficiency payments, nonrecourse Commodity Credit Corporation (CCC) loans, CRP payments, federal crop insurance, etc. In modeling this grower decision, we included deficiency payments but not the other, less important benefits in order to keep the model manageable. According to a four-region study conducted by Coombs, Dicks and Just (1994), more than 75% of growers participated in deficiency payments, the major benefit of the farm commodity program. Participation in the CRP program ranged between 18% and 28% by region in the Coombs study. In the study watershed, participation in the CRP involved less than 100 acres so we omitted this benefit in the model. According to Coombs, Dicks, and Just, participation in nonrecourse loans was even lower, ranging from 2.4% to 18.7%. The nonrecourse loans effectively establish a minimum price received by growers; if the market price drops below the loan rate, farmers merely surrender their crops to the government as payment of the loan (Cochrane and Runge 1992, p. 68). During our study period, market prices were always above the loan rate, so even with the subsidized interest, there was little benefit from CCC loans for the growers in our study area. Participation in federal crop insurance ranged from 3.6% to 66.7% in the Coombs study. In the Idaho study area, participation is in the lower half of this range because crop failure is not a great risk. Therefore, in modeling grower participation in farm commodity programs, we included deficiency payments, which are the only significant program benefit in our study area.

The discrete choice involved in modeling farm program participation decisions is best handled by the use of binary variables (Perry et al. 1989; Young, Walker, and Kanjo 1991; Duffy, Cain, and Young 1993). Commodity program participation status was modeled with two mutually exclusive zero-one variables: *PGP* and *NPGP*. A value of one for *(N)PGP* denotes (non)participation in the commodity program. A constraint forcing the two variables to sum to one ensures that they are mutually exclusive. The participation variable was linked to constraints imposing conservation compliance and flex requirements. Conservation compliance and flex policies were enforced by the following constraints:

$$(2)\quad -d{*}NPGP_i + \sum_{t=1}^{T}\sum_{r=1}^{R}\sum_{p=1}^{P} \gamma_{ijtrp}X_{ijtrp} \leq E \qquad i = 1,\ldots,N,\ j = 1,\ldots,M$$

$$(3)\quad -d{*}NPGP_i + CRAC_{ik_l} \leq (1 - \lambda_{k_l}){*}BASE_{ik_l} + \sum_{k_s=1}^{K}(\alpha + \beta){*}BASE_{ik_s} \qquad i = 1,\ldots,N,$$

where d is an arbitrarily large positive number; γ_{ijtrp} is the erosion rate for field j in farm i with tillage t, rotation r, and practice p; E is the erosion limit; α is normal flex acres percentage; β is optional flex acres percentage; λ is set-aside acres percentage; $CRAC_{ik_l}$ is acreage for program crop k_l in farm i; and $BASE_{ik_l}$ and $BASE_{ik_s}$ are base acreage for program crop k_l and k_s, respectively, in farm i (k_l and $k_s = 1, \ldots, K$; $k_s \neq k_l$).

Constraint (2) prohibited erosion from exceeding the established soil erosion limit for each field in a farm that participates in the commodity program ($NGPG_i = 0$). The presence of nonparticipation variables in the solution relaxed the conservation compliance constraints for nonparticipating farms ($NGPG_i = 1$ and $-d$ is a very large negative constant). Reduced tillage was imposed on all fields when conservation compliance was interpreted to require reduced tillage for commodity program participation. Under the flex provisions, the maximum acreage that could be planted for a program crop equaled the reduced crop base (adjusted for set-aside) plus normal and optional flex acres of other program crops, as shown in constraint (3). For example, the maximum acreage that can be planted for wheat by farm i cannot be greater than reduced wheat base acreage plus wheat on barley normal and optional flex acres. The flex-acre equations allowed wheat to be overplanted on barley flex and barley to be overplanted on wheat flex. Accordingly, an additional constraint was required to restrict total planted acres in program crops to be less than or equal to the sum

[2] Theoretically, the onsite productivity effects of erosion should be fully incorporated into the production decision-making process. However, the empirical evidence provided by Miranda (1992) indicated that "with exception of the Farm Belt, farmers either do not understand or are failing to act on the onsite productivity effects caused by soil erosion." Possible reasons why they may not, include divergent reactions to uncertainty about future land demands, substitutability of technologies for land, understated long-run social value of agricultural land by market prices, incomplete information about the true costs of the onfarm productivity losses and conservation practices, and different private and social discount rates (Crosson and Stout 1983).

of reduced bases for all program crops. The participation status variables were also used to link to receipt of deficiency payments by program participants.

Another set of zero-one variables was used in constraints forcing each rotation, tillage, and practice variable to sum to one. This ensured that only one management practice could be implemented per field. For this study the rotation constraints were relaxed, allowing two rotations per field to fulfill the set-aside requirement. Set-aside acres were placed in fallow with no compensation. A detailed description of this MIP model and data requirements was given by Walker, Wu, and Brusuen (1995) and Wu et al. (1995).

Field-scale erosion rates and related environmental damage were estimated for tillage-rotation-practice systems and were used for policy analysis in the MIP model. The environmental damage impacts from alternative practices were measured by the costs of onsite and offsite damage due to erosion. Erosion-induced onfarm damage was determined on the basis of field and management practice using the erosion damage model (Walker 1982). The model computed onsite productivity loss as the present value of yield loss due to erosion based on yield response functions. Yield response functions accounted for topsoil depth and the rate of technical progress in crop yields:

$$Y_{\text{wheat}} = (47.00 + 33.34(1\text{-}0.92^{D}))*e^{0.0142(t)}$$
$$Y_{\text{barley}} = (2043.39 + 1440.06(1\text{-}0.92^{D}))*e^{0.0040(t)}$$
$$Y_{\text{pea}} = (1140.39 + 1431.48(1\text{-}0.96^{D}))*e^{0.0075(t)},$$

where t is time, a proxy for technical progress, and D is topsoil depth. Topsoil was used as a proxy for soil properties (like organic matter) that correlate with topsoil depth and, in turn, with crop yield. A seventy-five-year evaluation period and a 4% real discount rate were used. This time horizon captured 95% of the present value of erosion damage into perpetuity. An offsite sediment damage cost of \$0.77 per ton of soil eroded was used based on Dailey's (1994) study for this watershed. Dailey included estimates of damage from navigation impairment, flood control, municipal and industrial water treatment, roadside ditch maintenance, and the steelhead fishery.

Policy Analysis Framework

The MIP model was developed to project farmer response to alternative policy scenarios. The conservation compliance provisions of the FSA85 and the FACTA90 aimed to reduce soil erosion by fields. Farmers had to adopt cropping production systems approved by the NRCS for reducing erosion to be eligible for farm program benefits. Conservation compliance was continued in the Federal Agricultural Improvement and Reform Act (FAIR) of 1996 and is likely to remain a feature of farm policy. Conservation compliance requires implementation of an approved conservation plan, not reduction to a specified level of T. Here T equals erosion of 5 tons/acre/year (TAY), the tolerance level at which production can be sustained. Erosion at twice that rate would be 2T. We chose to model conservation compliance in terms of T-levels for two reasons. First, the original NRCS goal for conservation compliance was to achieve erosion reduction to 1T or less (Magleby et al. 1995, p. 22). Second, we wanted to model erosion reduction under conservation compliance to the 1T level and alternative levels, including the less stringent erosion reduction that the NRCS had approved to encourage more participation. It seemed useful to define these alternative standards for conservation compliance in terms of 1T and relaxed standards of 1.5T and 2T for ease of quantification and clarity of expression. In this study, we examined no conservation compliance and four alternative forms of conservation compliance: the erosion limits of 1T, 1.5T, and 2T, as well as a requirement for reduced tillage. Under the reduced tillage conservation compliance standard, farmers were required to meet a specified residue level on their fields by employing reduced tillage.

With regard to flex policy, the 0–25 program in the 1990 Farm Bill allowed producers to plant up to 25% of their base acreage to an alternative crop without losing their status as base acres. The ARA90 placed further restrictions on this 25% flex acres, specifying that no deficiency payments would be made on 15% of the CAB. This acreage has been termed normal flex acres (USDA-ERS 1991, p. 35). The remaining 10% of the CAB from 0–25 program flex acres are known as optional flex acres. Growers received deficiency payments on optional flex acres, if they planted program crops. Growers received no deficiency payments on any normal flex acres or on optional flex acres that they cultivated to alternative crops. They were eligible to receive nonrecourse loans for program crops on normal flex acres and optional flex acres. The flex acres retained their status as base acres under the farm program whether they were planted in program crops or not. Planting decisions on normal flex acres would be based purely on expected returns from the marketplace. This study evaluated the 1990 flex acre provisions as well as three additional alternatives for normal flex acres: 25%, 40%, and 50% of CAB. Also evaluated was zero flex, which represents the case without normal or optional flex acres. Under all policy scenarios, set-aside acreage was 5% for wheat and 7.5% for barley, the average values during the 1990 Farm Bill. Policy mixes and their characteristics are defined in table 1.

The baseline scenario in this study included government deficiency payments without conservation compliance and planting flexibility. For policy analysis, the 1T, 1.5T, and 2T and reduced tillage conservation compliance standards were sequentially imposed on the model. Policies with 15%, 25%, 40%, and 50% normal flex acres were simulated next. The difference between the baseline result and the alternative policy result measures the impact of implementing conservation compliance alone or flex policy alone. The difference in net farm income between the baseline outcome and the alternative policy result is the farmer cost of meeting the policy restriction. The change in government spending between the baseline outcome and the policy option is the taxpayer cost of implementing the policy. The changes in soil erosion and environmental damage represent the environmental impacts of the alternative policies. Farmers' responsiveness to market incentives is measured by net farm revenue. Net farm revenue reflects the net proceeds from producing and selling a crop excluding deficiency payments, i.e., net farm revenue equals net farm income minus deficiency payments. Finally, flex alternatives together with each compliance standard were evaluated with the model. The incremental effect of flex policy in conjunction with conservation compliance is measured by comparing each flex level jointly with a compliance standard against the conservation compliance standard alone.

Watershed Application

Study Area

The MIP model was applied to determine the profit-maximizing production systems for farm

Table 1. Policy Combinations and Their Characteristics

Policy Options	Planting Flexibility (%)[a]					Com. Prog.	Conservation Compliance[b]				
	0	15	25	40	50		NO	1T	1.5T	2T	RT
NOPF00[c]	x					x	x				
T1PF00	x					x		x			
T5PF00	x					x			x		
T2PF00	x					x				x	
RTPF00	x					x					x
NOPF15		x				x	x				
NOPF25			x			x	x				
NOPF40				x		x	x				
NOPF50					x	x	x				
T1PF15		x				x		x			
T1PF25			x			x		x			
T1PF40				x		x		x			
T1PF50					x	x		x			
T5PF15		x				x			x		
T5PF25			x			x			x		
T5PF40				x		x			x		
T5PF50					x	x			x		
T2PF15		x				x				x	
T2PF25			x			x				x	
T2PF40				x		x				x	
T2PF50					x	x				x	
RTPF15		x				x					x
RTPF25			x			x					x
RTPF40				x		x					x
RTPF50					x	x					x

[a]The numbers indicate the fraction of crop acreage basis that is normal flex. In all scenarios except zero flex, optional flex is 10% of the crop base acreage.
[b]NO = no conservation compliance requirement, 1T = conservation compliance in the form of the 1T erosion limit, 1.5T = conservation compliance in the form of the 1.5T erosion limit, 2T = conservation compliance in the form of the 2T erosion limit, and RT = conservation compliance in the form of requiring reduced tillage. Here T equals the tolerance level.
[c]NOPF00 is the baseline.

managers under alternative policies in the Tom Beall Creek watershed. The watershed is located at the lower end of Lapwai Creek near the Clearwater River in northern Idaho, upstream from Lewiston, Idaho, the county seat, and Clarkston, Washington. The 11,000-acre watershed contains 7,471 acres of cropland, which is distributed among 14 farms and 94 fields. The watershed is used primarily for dryland farming. Winter wheat, spring barley, and dry peas are the main crops. Winter wheat is grown on approximately 60% of the farm land every year. Precipitation in this area averages about 15 inches per year. The watershed is characterized by dry summers and windy, humid winters. Since most precipitation occurs in the winter months on the planted seedbed, winter wheat is quite vulnerable to erosion. Rain and snowmelt on partially frozen soil lead to particularly severe erosion as the soil cannot absorb this moisture. Elevations ranging from 510 feet to 2,150 feet result in steep field slopes. The two dominant soil types are Naff-Palouse complex and Thatuna-Naff complex, which together account for approximately 65% of the watershed. They are very fertile but also highly erodible because of their silt loam texture. The combination of inherent soil erodibility, steepness of slope, wet and cool winters, and little vegetative cover in the winter makes the hazard of erosion a primary concern. Seventy-five percent of the watershed was classified as highly erodible (Prato and Wu 1991; Walker and Painter 1994). The proximity to the Clearwater River and to Lewiston and Clarkston, about 10 miles downstream, contributes to significant offsite impacts from agriculture in the watershed.

Study Results

Policy analysis with the model was conducted using GAMS (Brooke, Kendrick, and Meeraus 1988). Farmer response to policies was projected with the model solutions. Net farm income, government expenditures, net farm revenue, erosion, onsite and offsite erosion damage, and program participation rates in terms of farm numbers and cropland in the farm program from the different scenarios are summarized in table 2. Acres in different cropping systems from the optimal solutions are illustrated in table 3. We discuss first the impacts of conservation compliance alone, then flex acres alone, compared with the baseline. Finally, we discuss the impacts of conservation compliance and flex alternatives in combination compared with no flex in each conservation compliance scenario. It should be noted that results in this study were based on a situation where crop price and target price produced deficiency payments near the threshold level, i.e., deficiency payments were just high enough to encourage participation. Results could be different if deficiency payments were larger or smaller.

For the baseline case (no conservation compliance, no planting flexibility), net farm income, taxpayer cost, and net farm revenue averaged \$25.78, \$37.67, and –\$11.89 per acre, respectively. The watershed-level erosion rate averaged 13.3 TAY. Resultant environmental damage (onsite erosion damage and offsite sediment damage) was \$17.02 per acre annually. Farmers in the watershed planted 4,506 acres of wheat, 670 acres of barley, and 1,999 acres of peas. About 297 acres of farm land were idled to satisfy the set-aside requirement in the farm program. With no environmental quality restrictions imposed on the model, all farms in the watershed participated in the commodity program.

Conservation Compliance. Compared with the baseline, imposing conservation compliance without planting flexibility reduced net farm income and improved environmental quality by reducing erosion, onsite productivity loss, and offsite sediment damage. Early interpretation of conservation compliance called for a strict erosion limit of 1T. This scenario in the model, T1PF00, resulted in net farm income and erosion decreasing 51% and 17%, respectively, to \$12.69 per acre and 11.1 TAY. Environmental damage decreased 14% to \$14.72 per acre. Grower participation in the farm program declined from 100% in the baseline to 29% of the farmers, with 21% of the cropland enrolled.

Less restrictive compliance standards resulted in less income loss and greater environmental quality gain because more growers participated in the farm commodity program. The 1.5T erosion limit (scenario T5PF00) reduced net farm income 46% to \$13.96 per acre and enjoyed a greater environmental effect by reducing erosion by 27% to 9.7 TAY. Environmental damage decreased by 20% to \$12.71 per acre. The grower participation rate in the farm program was 57%, with 52% of cropland enrolled.

The least restrictive erosion limit that we examined, 2T (scenario T2PF00), reduced net farm income the least, by 19% to \$20.81 per acre, and reduced erosion the most, by 37% to 8.4 TAY. Erosion decreased when the erosion limit was relaxed to 2T because of higher program participation. With higher participation rates, more acres were subject to conservation compliance and set aside. Environmental damage decreased by 36% to \$10.85 per acre. Participation in the government program was at 86% for growers and included 89% of the cropland. Relaxing the compliance standard from the 1T to 2T erosion limit increased the use of reduced tillage and divided slope farming. More

Table 2. Computational Results from the Mixed Integer Programming Model

Policy Option	Net Farm Income ($/acre) (1)	Taxpayer Cost ($/acre) (2)	Net Farm Revenue[a] ($/acre) (3)	Soil Erosion (TAY)[b] (4)	Onsite Erosion Damage ($/acre) (5)	Offsite Sediment Damage ($/acre) (6)	Farm Program Participation: Farms (%) (7)	Farm Program Participation: Cropland (%) (8)
NOPF00	25.78	37.67	−11.89	13.3	6.76	10.26	100	100
T1PF00	12.69	9.52	3.17	11.1	6.18	8.54	29	21
T5PF00	13.96	18.08	−4.12	9.7	5.23	7.48	57	52
T2PF00	20.81	33.85	−13.04	8.4	4.41	6.44	86	89
RTPF00	20.78	37.67	−16.89	6.8	3.48	5.23	100	100
NOPF15	21.39	32.71	−11.33	13.4	6.95	10.33	100	100
NOPF25	18.47	28.31	−9.85	13.3	6.99	10.22	93	95
NOPF40	14.35	20.55	−6.19	13.1	7.08	10.07	71	80
NOPF50	11.17	13.01	−1.84	12.6	6.88	9.72	43	58
T1PF15	11.28	6.80	4.48	11.3	6.30	8.69	21	17
T1PF25	10.46	5.95	4.51	11.3	6.33	8.71	21	17
T1PF40	9.50	3.15	6.35	11.3	6.34	8.72	7	10
T1PF50	8.94	2.58	6.36	11.3	6.34	8.73	7	10
T5PF15	12.52	16.32	−3.80	9.8	5.29	7.53	57	52
T5PF25	11.44	14.58	−3.14	9.9	5.43	7.66	50	49
T5PF40	10.27	10.43	−0.15	10.1	5.58	7.79	21	38
T5PF50	8.97	2.58	6.39	11.4	6.38	8.76	7	10
T2PF15	17.21	29.52	−12.31	8.4	4.42	6.43	86	89
T2PF25	14.67	26.66	−11.99	8.7	4.66	6.71	86	89
T2PF40	11.86	16.21	−4.35	9.9	5.39	7.68	50	60
T2PF50	9.93	9.06	0.87	10.9	6.01	8.39	29	40
RTPF15	16.57	29.97	−13.40	7.2	3.80	5.53	86	91
RTPF25	13.90	24.34	−10.45	7.9	4.30	6.09	71	80
RTPF40	10.79	15.68	−4.89	9.2	4.97	7.08	43	58
RTPF50	9.15	3.40	5.75	11.1	6.17	8.51	21	14

[a]Net proceeds from sale of crop excluding deficiency payments, or (3) = (1) − (2).
[b]Tons/acre/year.

wheat acreage was shifted to barley and pea production. Acreage in set-aside increased too because more farmers participated in the farm program. Wheat/pea and wheat/wheat were the two dominant rotations for 1T conservation compliance. However, wheat/barley/pea became the third dominant rotation for 2T compliance.

These results illustrate the danger of overly restrictive erosion limits for conservation compliance with a voluntary farm commodity program: erosion could increse if growers leave the program. Furthermore, relaxing conservation compliance increased grower dependence on government deficiency payments. Deficiency payments averaged $9.53 per acre with 1T, $18.08 per acre with 1.5T, and $33.85 per acre with 2T. Relaxing conservation compliance also reduced farmer responsiveness to market price signals. Net farm revenue decreased from $3.17 per acre with 1T to −$4.12 per acre with 1.5T, and to −$13.04 per acre with 2T.

We looked at an alternative form of conservation compliance, requiring reduced tillage (scenario RTPF00). This resulted in very nearly the same net farm income as the 2T erosion limit, $20.78 per acre or 19% below the baseline. The reduction in erosion with reduced tillage compliance was even greater than with the 2T erosion limit, a 49% decrease to 6.8 TAY. Erosion was lower because of a higher program participation rate, 100%. Environmental damage decreased 49% to $8.71 per acre. Accordingly, reduced tillage was the most physically effective form of conservation compliance, although it did entail slightly higher government cost than the 2T erosion limit. But the government cost was no higher than the baseline. Net farm revenue was −$16.89 per acre, lower than with the 2T erosion limit. Reduced tillage and contour farming were applied to all watershed cropland. This scenario resulted in less wheat acreage and more barley, peas, and set-aside acreage, compared with conservation compliance in the form of erosion limits.

These results indicate that with less restrictive conservation compliance, within the range of

Table 3. Cropping Systems from the Optimal Mixed Integer Programming Solutions

Policy	Tillage		Practice		Crop Rotations							Crops			
Option	CT	RT	CF	DS	WP	WB	WBP	WBF	WPF	WW	SF	Wht	Brl	Pea	Flw
								(acres)							
NOPF00	7,471	——	7,471	—	3,015	248	1,363	274	147	2,255	168	4,506	670	1,999	297
T1PF00	6,310	1,162	7,399	73	504	26	338	—	100	6,466	37	6,893	126	390	62
T5PF00	4,386	3,086	7,296	175	1,248	8	836	65	212	5,014	87	6,049	305	956	162
T2PF00	3,482	3,989	7,138	333	1,759	216	1,162	154	852	3,184	145	4,936	547	1,580	409
RTPF00	——	7,471	7,471	—	3,103	301	1,274	284	91	2,239	180	4,506	670	1,999	297
NOPF15	7,471	——	7,471	—	3,315	159	944	288	115	2,479	172	1,684	490	2,001	296
NOPF25	7,471	——	7,471	—	3,226	126	680	310	116	2,860	153	4,924	393	1,869	286
NOPF40	7,471	——	7,471	—	2,748	96	316	215	111	3,844	141	5,499	225	1,507	241
NOPF50	7,471	——	7,471	—	1,820	3	232	158	144	5,028	87	6,142	131	1,023	175
T1PF15	6,607	865	7,471	—	413	—	159	—	173	6,717	9	7,063	53	303	52
T1PF25	6,607	865	7,471	—	510	—	135	—	19	6,762	46	7,071	45	305	50
T1PF40	6,739	733	7,471	—	135	—	48	—	127	7,162	—	7,308	16	115	32
T1PF50	6,739	733	7,471	—	142	—	37	—	127	7,165	—	7,312	12	115	32
T5PF15	4,386	3,086	7,287	185	1,538	12	461	214	119	5,070	58	6,129	231	952	159
T5PF25	4,541	2,930	7,359	112	1,483	1	417	105	199	5,200	66	6,216	175	930	151
T5PF40	4,887	2,584	7,359	112	1,013	—	219	57	282	5,876	25	6,615	92	650	114
T5PF50	6,785	686	7,471	—	230	—	——	37	—	7,185	20	7,312	12	115	32
T2PF00	3,482	3,989	7,138	333	1,759	216	1,162	154	652	3,184	345	4,936	547	1,430	559
T2PF15	3,327	4,145	7,386	86	2,226	238	941	114	718	3,062	171	5,005	471	1,606	389
T2PF25	3,577	3,894	7,376	96	2,271	70	811	185	675	3,268	191	5,108	367	1,575	422
T2PF40	5,102	2,369	7,386	86	1,633	10	520	59	274	4,861	115	6,102	198	1,058	203
T2PF50	6,128	1,343	7,471	—	1,142	3	149	94	120	5,902	62	6,615	82	651	123
RTPF15	700	6,772	7,471	—	2,840	161	794	341	135	3,059	142	5,005	459	1,718	289
RTPF25	1,501	5,970	7,411	—	2,627	142	531	177	23	3,786	186	5,418	307	1,496	251
RTPF40	3,148	4,323	7,471	—	1,863	85	260	150	—	4,982	130	6,093	179	1,018	180
RTPF50	6,409	1,063	7,471	—	249	26	28	56	—	7,081	31	7,247	41	134	49

[a]CT = conventional tillage, RT = reduced tillage, CF = contour farming, DS = divided slope farming, WP = wheat/pea, WB = wheat/barley, WBP = wheat/barley/pea, WBF = wheat/barley/fallow, WPF = wheat/pea/wheat/fallow, WW = wheat/wheat, SF = summer fallow, Wht = winter wheat, Brl = spring barley, Pea = dry peas, and Flw = summer fallow.

meaningful erosion limits that we examined, net farm income was higher but net farm revenue was lower. Thus, farmers were more responsive to government policy incentives and less responsive to market signals. Growers engaged in less profitable (through the marketplace) but more conserving farming practices motivated by government deficiency payments tied to conservation compliance.

Planting Flex Policy. Cropping on paid flex acres (the optional flex acres in the 1990 farm legislation) is fairly rigid. With usual prices farmers will not switch to an alternative crop because the price-supported program crop is more profitable, as it historically has been. Only if an alternative crop enjoys an unusual price increase would we expect crop substitution to occur on paid flex acres.

Cropping choice on normal flex acres (unpaid flex) is more flexibile. With the loss of deficiency payments for program crops on unpaid flex acres, alternative crops are more competitive in terms of profit. In our region, farms that remained in the program planted wheat on barley flex. This flex acreage effect increased erosion and environmental damage slightly. Farms that left the program replaced wheat/pea with wheat/wheat when free of base acreage limits and set-aside requirements. This base acreage effect reduced erosion and environmental damage slightly. On balance, the latter effect was slightly greater and flex policy alone slightly reduced erosion and environmental damage. Erosion decreased to 12.6 TAY and environmental damage decreased to $16.60 per acre. In other regions environmentalal damage could increase under flex acre policy alone if the substitute crops on flex acres and on disenrolled program acres are more erosive than program crops.

Compared with baseline, planting flexibility alone reduced government deficiency payments and net farm income. Net farm income decreased from $25.78 per acre with no flex (scenario NOPF00) to $11.17 per acre with 50% flex (scenario NOPF50), reflecting the decrease in deficiency payments on flex acres and the exodus of growers from the government program. Planting flex alone increased net farm revenue as growers responded more to market price signals. The growing responsiveness to market prices came both from growers remaining in government commodity programs on their flex acres and from growers who left the program. Farms remaining in the program responded to market price signals by planting wheat on barley flex. Farms that left the program responded to market incentives by replacing wheat/pea with wheat/wheat upon leaving set-aside requirements and base acreage limits on production.

Examining results by farm size reveals that government payments for farms with smaller base acreage were reduced by the same fraction as the planting flexibility percentage. Planting flex policy had less economic impact on farms with larger base acreage, where the $50,000 payment limit was a binding constraint. Because of the $50,000 payment limit, not all base acreage on some large farms receives deficiency payments. With the introduction of planting flex, government deficiency payments to larger farms with excess base acreage will not decline proportionately, because some or all the unpaid flex acres come from unpaid base acreage. These same results would be expected to hold for similar provisions in future farm programs.

Conservation Compliance Combined with Flex Policy. Planting flex by itself is not as interesting as planting flex in combination with conservation compliance. With conservation compliance in the farm program, there is concern about base building that defeats conservation goals. The desire to maintain or expand base acres in commodity program crops encourages planting on marginal acres that are highly erodible and discourages the use of conservation crops in rotations. The flex acres policy was proposed with the 1990 Farm Bill in order to counteract base building, to reduce government deficiency payments, and to increase farmer responsiveness to market price signals. We explored how planting flexibility would interact with conservation compliance in promoting soil and water quality goals by examining farmer response to increasing flexibility under each conservation compliance standard.

When planting flexibility was added to conservation compliance policies, erosion and environmental damage increased compared with conservation compliance alone. In addition to the base acreage effect and flex acreage effect, discussed in the previous section, there is another, larger effect operating with joint policies, the compliance effect. When unpaid flex policy is added to conservation compliance, growers exit the farm program because of reduced government payments, and they may drop conservation practices when no longer bound by conservation compliance. In the Idaho study area under joint implementation, conservation compliance by farmers decreased and environmental damage increased compared with conservation compliance policy alone.

Conservation compliance alone reduced erosion because soil-conserving tillage and practices were adopted to satisfy compliance. Planting flexibility, added to conservation compliance, increased erosion because growers left the farm program and regressed to more erosive tillage and practice options. The cropping changes that occurred with planting flexibility reduced erosion, but not as much as the tillage/practice changes increased erosion. Therefore, environmental benefits from conservation compliance were offset as planting flex policy was implemented along with conservation compliance. With the 1T erosion limit for conservation compliance and 50% flex, for instance, erosion increased 1.8% and environmental damage increased 2.4% compared with no flex. With this strict IT erosion limit, erosion and environmental damage increased only slightly with flex acres because strict conservation compliance by itself eliminated many growers from the farm program, and reduced erosion slightly. Thus, there was not much erosion control lost when flex acres reduced program participation a little more.

With the 2T erosion limit for conservation compliance, erosion and environmental damage responded more to flex acres because farm program participation was high and conservation compliance alone reduced erosion significantly. The addition of flex acres reduced program participation and increased erosion more markedly than in the 1T scenario. In the 2T scenario, erosion increased by 30% to 10.9 TAY with 50% flex, compared with no flex. Environmental damage increased 30% to $14.40 per acre. Environmental quality impacts with the 1.5T erosion limit fell in between the 1T and 2T erosion limits at all flex levels. Under reduced tillage conservation compliance, erosion increased by 63% to 11.1 TAY with 50% flex, compared to no flex. Environmental damage increased 60% to $14.68 per acre. With these higher flex levels, more growers left the farm program, and erosion and environmental damage increased because of expanded use of conventional tillage.

In this region, flex acre policy in conjunction with conservation compliance decreased net farm income. With the 1T standard, net farm income decreased from 11% with 15% flex to 30% with 50% flex compared with T1PF00. In the 2T scenario, net farm income decreased from 17% with

15% flex to 52% with 50% flex compared with T2PF00. With the reduced tillage standard, the decrease was from 20% with 15% flex to 56% with 50% flex compared with RTPF00. Net farm income decreased because of a reduction in federal deficiency payments on flex acres and because growers left the farm program. With the stricter 1T erosion limit, net farm income responded less to higher flex acres because, with many growers out of the farm program as a result of strict conservation compliance requirements, there were fewer flex acres affected by reduced deficiency payments and there was a smaller incremental exodus from the program.

Planting flexibility reduced government spending on deficiency payments and increased farmer responsiveness to market price signals. With the strict 1T conservation compliance, average deficiency payments in the watershed decreased from $9.52 per acre with no flex to $6.80 per acre with 15% flex and to $2.58 per acre with 50% flex. Net farm revenue increased from $3.17 per acre with no flex to $4.48 per acre with 15% flex and to $6.36 per acre with 50% flex. Results were similar for the 1.5T, 2T, and reduced tillage conservation compliance standards.

When planting flexibility and conservation compliance policies were jointly implemented in the watershed, the impacts of the strict conservation compliance standard dominated the impacts of flex policy because farmers were already discouraged from farm program participation by strict conservation requirements. Few participating farmers would be further discouraged with high flex acres and would leave the farm program. In the relaxed conservation compliance scenarios, planting flexibility could be coutnerproductive, since cutting deficiency payments via flex acres could drive more farmers out of the farm program and would increase environmental damage.

Summary and Policy Implications

In spite of dramatic recent changes in farm legislation, analysis of the impact of conservation compliance and flex acres is still important. The 1996 Farm Bill continues conservation compliance and planting flexibility from the 1985 and 1990 farm bills. We evaluated how the incremental change in flex acres under various conservation compliance alternatives affected important economic and environmental variables. We used an integrated systems model that includes a geographic information system, an economic optimization model with a policy component, and erosion and erosion damage simulation models. This approach provided a means to project the joint policy impact on profitability, erosion, onsite erosion damage, offsite sediment damage, taxpayer cost, program participation, and crop mix decisions. Farm program alternatives evaluated in this study included 15%, 25%, 40%, and 50% normal flex acres. Four conservation compliance scenarios were assessed: 1T, 1.5T, and 2T erosion limits and requiring reduced tillage.

Even though scheduled to end in 2002, farm programs, after almost seventy-five years, may not be totally eliminated. Rather, their future depends on the sequence of economic and political events over the next five years. In this study, the interaction between federal commodity programs, conservation compliance policy, and flex-acre provisions was examined with an eye toward future policy development. These results will be useful for policymakers through 2002 and perhaps beyond as these policies are revisited during the farm program debate.

Results from this integrated model showed that conservation compliance policy alone enhanced environmental quality by reducing erosion and sedimentation. The more relaxed standards, such as 2T and reduced tillage, improved environmental quality more by including more farmers in the program. Conservation compliance standards that are too strict can be self-defeating. With greater farm program participation, program benefits to farmers were also greater than with strict compliance standards. In formulating future policy, farmers and the environment would benefit from the more relaxed conservation compliance standards examined here. However, the more relaxed standards have high taxpayer cost and do not promote farmer responsiveness to market price signals.

In this region, flex acre policy alone also reduced erosion and environmental damage, but only slightly. In combination with conservation compliance, flex policy increased both erosion and environmental damage, compared with conservation compliance alone. Growers left the farm program and reverted to more erosive tillage when no longer bound by conservation compliance.

Higher flex acres in combination with conservation compliance also reduced net farm income and taxpayer cost and increased net farm revenue in all conservation compliance scenarios compared with no flex because program participation decreased. The stricter conservation compliance and higher flex acres reduced taxpayer cost the most. Requiring reduced tillage in all flex acre scenarios was the most physically effective measure to improve environmental quality.

Flex acre policy had an uneven economic impact on participating farms. Government payments to farms with smaller base acreage were reduced by the same fraction as the flex acre percentage. Government deficiency payments to farms with larger base acreage, where the $50,000 payment limit was binding, declined less than proportionately because some or all the unpaid flex acres came from unpaid base acreage.

The benefits of flex acre policy illustrated in this study included lower taxpayer cost for deficiency payments and greater crop planting responsiveness to market signals, which reduces crop planting distortions from the farm program. On the cost side, higher flex levels were detrimental to farm income and environmental quality. Future consideration of flex-acre provisions should evaluate this tradeoff between reduced taxpayer cost and increased environmental damage. Also relevant when considering future policy impacts is the information that government payments have been an important part of net returns to farmers. Reducing deficiency payments with policy restrictions would result in substantial loss of net farm income.

The results of this study suggest that the lack of profitable and environmentally sound alternative crops in the watershed could limit the gains with policy changes alone. The lack of alternative crops could be due partly to long-standing farm program incentives, which caused farmers to focus on a few subsidized program crops. Policy reform with simultaneous investment in the development and adoption of alternative crop rotations and soil-conserving tillage would be required to realize environmental benefits.

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