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Abstract

The level of government program benefits was reduced in the newly passed 1996 Farm Bill. One concern about this reformed farm policy was how policy changes in the 96FAIR will affect farm profitability and environmental quality. Will changes in planting flexibility or reduced program benefits reduce program participation or diminish erosion control? How will cropping decisions respond to market price signals? Using an integrated systems model, this study evaluated the efficiency and effectiveness of conservation compliance under the 1996 farm commodity program in terms of private and social benefit, taxpayer cost or government payments, and environmental quality performance.

The results showed that private and social benefits increase as conservation compliance and farm commodity policy jointly become less restrictive. Relative to the 1990 farm program, net farm income increased 2.23%, 2.34%, 4.77%, and 5.94%; taxpayer costs decreased 7.24%, 14%, 10%, and 7.11%, net social benefit increased 5.8%, 22%, 73%, and %, respectively, for 1T, 15T, 2T, and reduce tillage compliance with the new farm program. Environmental benefit of conservation compliance was slightly diluted with the new farm program except for reduced tillage compliance. Relative to the 1990 farm program, soil erosion increased 0.01%, 0.24%, 0.36% for 1T, 1.5T and 2T erosion limit compliance but decreased 3.73% for reduced tillage compliance.

KEYWORDS: farm program, conservation compliance, erosion damage, and cost-effectiveness.

*[1]Shunxiang Wu, David J. Walker, and Merlyn A. Brusven are, respectively, a research fellow and a professor in the Department of Agricultural Economics and Rural Sociology, and a professor in the Department of Plants, Soil and Entomology, at the University of Idaho, Moscow, Idaho.

The Efficiency and Effectiveness of Conservation Compliance under the 1996 Farm Bill

The conservation compliance program, one of the landmark conservation provisions initiated in the 1985 Food Security Act (85FSA) and continued in the 1990 and 1996 Farm Bills, translates public environmental quality concerns into conservation actions by targeting 59 million ha (146 million ac) of U.S. highly erodible land (HEL). Cropland is designated as highly erodible if it has an erodibility index of eight or greater. The erodibility index is a ratio of the inherent erodibility of a soil unprotected by any ground cover or conservation practice to the soil's erosion tolerance level known as T-value. Here T equals erosion of 11.2 metric tons per hectare per year (THY) (5 tons per acre per year or 5 TAY), the tolerance level for erosion at which long-term productivity can be sustained. Erosion at twice that rate would be 2T.

To be eligible for federal commodity programs and related benefits, the 85FSA required that growers who participate in the farm program and continue to farm HEL must apply a USDA-approved conservation plan on that land (Section 1212, P.L. 99-198). The conservation options on HEL include environmentally beneficial crop rotations, tillage systems, and land treatment practices together with land retirement programs for protecting soil and water resources. Producers were required to develop the conservation plans by 1990 and to fully implement them by January 1, 1995.

The conservation compliance provision in the 85FSA was modified in the 1990 Food, Agriculture, Conservation, and Trade Act (90FACT). For example, penalties were reduced for violations of compliance standards if the farmer was acting in good faith in trying to meet compliance standards. The 1996 Federal Agricultural Improvement and Reform Act (96FAIR) made further changes in the operation of conservation compliance. For example, farmers are encouraged to maintain records of residue measurement. County committees are authorized to provide relief in cases of undue economic hardship. Federal crop insurance is no longer linked to compliance.

In 1996, the eligible program cropland, 85 million ha (210 million ac), 98.8% was contracted under the new farm program (FSA, 1996). These response data seemed to indicate no adverse impact of the new farm bill on farmers' participation decision. However, it is not clear how changes in program participation incentives and requirements from the 90FACT to the 96FAIR will affect farm profitability and environmental quality. If growers decide to switch to alternate crops due to greater planting flexibility under the 1996 Act or not to participate in the program later due to reduced program benefits, however, much of the current leverage for farming in environmentally sound ways could be compromised. Many environmental benefits of the farm program could be diminished. Accordingly, there is a need for analysis of changes in farm and conservation policies from the 90FACT to the 96FAIR because few observations on how these changes will affect policy efficiency and effectiveness are available.

The purpose of this paper is to evaluate how newly reformed farm commodity policy in conjunction with conservation compliance affects private and social benefits, farmers' responsiveness to market price signals, and environmental quality performance. This study addresses these issues with an integrated systems model that allows us to take the interaction of commodity and conservation policy into account simultaneously. Private benefit was measured by net farm income. Social benefit was measured by net social benefit that equals net farm income minus government payments and environmental damage. The main hypothesis evaluated in this study is that private and social benefits increase as farm commodity policy becomes less restrictive, but with the cost of greater environmental damage. Further, with respect to conservation compliance, social benefit and environmental damage decrease as conservation compliance becomes less restrictive, but private benefit increases. As a result, private and social benefits increase as farm commodity policy and conservation compliance jointly become less restrictive, but with little change in environmental damage.

The organization of this paper is as follows. The next section reviews studies on the economic and environmental performance of conservation compliance and on the impacts of the new farm program, followed by section 3 which describes the study watershed. Section 4 discusses the economic model for the analysis. Section 5 outlines the policy scenarios. Section 6 presents the modeling results for an agricultural watershed. The final section provides a brief summary and conclusions of this study.

Literature Review

Economic and environmental benefits of conservation compliance have been widely recognized. The conservation programs were expected to include more than 1.2 million U.S. producers if those conservation plans that have been developed are fully applied (U.S. House of Representatives, 1992). In 1995, 56 million ha (139 million ac) of HEL were included in farm conservation plans approved by USDA (NRCS, 1996). It was estimated that national environment (water and air quality) and productivity benefits of conservation compliance average \$38.26 per ha (\$15.95 per ac) and the estimated national cost was \$17.81 per ha (\$7.21 per ac), yielding a benefit/cost ratio of over two (Canning, 1994). This is, each dollar invested in the conservation compliance program generates over two dollars of benefits on average.

Focusing conservation efforts on HEL is not only economically sound but also effective in reducing soil erosion. Between 1982 and 1992, estimated soil erosion on U.S. cropland declined by an average rate of 6.3 THY (2.8 TAY), while estimated erosion on cropped HEL declined at an even higher rate, 13.2 THY (5.9 TAY) (USDA, 1994). In 1995, the implemented conservation systems reduced average soil erosion to the T-level or less on 18 million ha (44 million ac) of HEL subject to conservation compliance (NRCS, 1996). Adoption of various conservation systems on HEL has saved the nation more than one billion tons of soil a year, of which conservation compliance alone reduced soil loss by 408-680 million metric tons (450-750 million tons) (Magleby et al., 1995).

Richardson et al. (1989) observed that compliance with an approved conservation plan in the Southern High Plain of Texas resulted in no reduction in net farm income. Thompson et al. (1989) examined the relationship between conservation compliance and regional comparative advantage. The conservation compliance standard of 11.2 THY reduced erosion by 30% to 60%, while shifts to conservation tillage and other erosion reducing practices increased production cost by 2% to 5%. They concluded that regional comparative advantage would not be substantially distorted even if implementing stricter compliance standards than those currently used by the States. Lee (1990) reported that participation in the government commodity program increased net farm returns by over 100% relative to nonparticipation in the Southern High Plains.

Hoag and Holloway (1991) showed that the effectiveness of conservation compliance relied upon the rate of participation in the government commodity programs. With conservation compliance requirements, erosion was reduced by 66% at the high participation rate and only 1% at the low participation rate. When coupons to a ton of soil loss as compliance requirement were issued to producers, Govindasamy and Huffman (1993) found that the marginal opportunity cost of controlling erosion between soil types differs substantially. Social benefits would increase \$5.00 per acre by assigning one ton of erosion to Downs (5-15%) rather than Clarion (2-5%) in Iowa. They concluded that the tradable coupon system under conservation compliance is not only efficient, but will also bring more land under soil conservation.

Walker et al. (1996) demonstrated the dissimilar economic and environmental effects of various conservation compliance alternatives in the context of 1990 farm program. The gains in environmental benefits would offset the losses in farm income with less restrictive conservation compliance standards, such as requiring reduced tillage, in the highly erodible Tom Beall watershed, Idaho. Prato and Wu (1996) reported that conservation compliance targeting on a field level was more resource conserving but less efficient than targeting on the watershed level. As the level of targeting for conservation compliance increased from the field to farm to watershed, net private and social benefits increased but at a decreasing rate. Efficient cropping systems for achieving the 1.5T compliance standard provided higher total net returns and net social value than both baseline and the efficient system for achieving the T compliance standard (Prato an Wu, 1994). Wu et al. (1997) showed the danger of overly restrictive erosion limits for conservation compliance with a voluntary farm program: erosion could increase.

Studies (e.g., Lee, 1990; Duffy et al., 1994) have found that landowners were most likely to satisfy compliance requirements in order to not forgo program benefits. Nonparticipation in the farm program was viewed as an occasion to change planting patterns and expand the base of profitable crops for increasing program benefits in the future. Further, the early government commodity programs undermined the potential of soil conservation programs by discouraging alternative crops in soil conserving rotations, reduced farmers' response to market incentives, and involved high program expenditures (CAST, 1992; Cochrance and Runge, 1992; Gardner, 1995, pp. 250-252; Heimlich and Claassen, 1998).

The newly passed 1996 Farm Bill addresses the first two concerns by decoupling government payment from specializing program crops and from prices, and addresses the third concern by phasing out the farm program at the end of year 2002. During this transitional period, the new Farm Bill establishes production flexibility contract payments based on the contract acreage, the contract yield, the contract payment rate, and the contract payment limit. Farmers who enroll in the new farm program will enjoy greater flexibility in planting decisions. The ARPs (acreage reduction programs) were no longer a mandatory requirement of conservation compliance. However, participating farmers have to comply with unpaid planting flexibility and conservation requirements. The level of farm program benefits for participants is reduced by continuing the unpaid flex acre option, gradually lowering the contract payment rate over the next 7-year period, and downsizing the contract payment limit from $50,000 to $40,000 per farm annually. In so doing, the 96FAIR Act expands the market-oriented policies of the previous two major Farm Bills, which have gradually reduced the government's influence in production decision making through traditional farm commodity programs (Young and Westcott, 1996).

Young and Westcott (1996) forecasted that, under the new farm program, producers may change the crop mix on their farms, likely altering regional production patterns. Farm income could become more variable in response to supply and demand shocks. Consequently, farmers will face greater income volatility. The changes in farm policy are also expected to affect farm capital asset markets. The combined effect of farm income and capital asset can substantially alter the amount of debt for Louisiana cotton-soybean farms (Vandeveer et al., 1998). Koo and Duncan (1996) anticipated that cropland prices in North Dakota would fall 18.5% under the 90FACT and a cumulative 19.8% under the 96FAIR. Cash rental rates were projected to follow cropland prices closely. Economic impacts of the 96FAIR on individual crop growers have been investigated by Chen and Fletcher (1997) for peanuts and by Stinson (1998) for corn.

This review of studies on conservation compliance and the newly reformed farm program reveals a need for evaluating the impacts of conservation compliance, in the context of the new farm program, on profitability and environmental quality. We will examine how changes in farm commodity policy in conjunction with conservation compliance alternatives affect model projections of farm income, environmental quality, crop mix decision, and in turn policy efficiency and effectiveness.

The Study Watershed

The study focuses on the Idaho Tom Beall watershed which provides an ideal study area because of its high vulnerability to erosion, onsite productivity loss, and offsite sediment damage. The 4,452-ha (11,000-ac) watershed contains 3,024 ha (7,471 ac) of cropland which is distributed among 14 farms and 94 fields. A field, which is the basic management unit for current conservation compliance policy, is a fairly homogenous area managed by a grower using a single cropping system. A cropping system is a specific combination of crop rotation, tillage system, and conservation practice. The possible cropping systems which were obtained from the local Natural Resource and Conservation Service (NRCS) included seven crop rotations (wheat/pea, wheat/barley, wheat/barley/pea, wheat/wheat, wheat/pea/fallow, wheat/peas/wheat/fallow, and summer fallow), two tillage systems (conventional tillage and reduced tillage), and two conservation practices (contour farming and divided slope farming). In this area, recropping wheat is common because of economic incentives and favorable weather conditions. For instance, the price and net returns are higher for wheat than for alternative crops such as barley. Lower moisture and warmer temperature in the winter allow wheat to be replanted with minimal disease problems.

Land in the watershed is used primarily for agricultural purposes. Winter wheat and barley are two important program crops in the watershed. Approximately 73% of watershed is covered by program crops, of which winter wheat alone accounts for about 63% (Table 1). Few alternate crops are available in this watershed. Annual precipitation in this semi-arid area averages 0.30 m (15 inches) per year. Elevation ranges from 376 m (1,232 feet) to 626 m (2,055 feet). Land slopes average 9.8% ranging from a maximum of 15.3% to a minimum of 4.0%. Naff-Palouse complex and Thatuna-Naff complex are dominant soil types in the watershed. Table 1 reports selected farm-level characteristics in the watershed.

Due to steep topography, silt loam texture soils, and intensive farming practices, approximately 75% of the watershed was ranked as highly erodible (Prato and Wu, 1991; Walker and Painter, 1994). The estimated field-level erosion rates in the watershed range from 1.1 THY (0.5 TAY) for wheat/barley/pea with reduced tillage and divided slopes to 85 THY (38 TAY) for wheat/pea/wheat/fallow with conventional tillage and contour farming. The estimated field-level onsite erosion damage varies from \$0.32 per ha (\$0.13 per ac) for wheat/barley/fallow with reduced tillage and divided slopes to \$54.34 per ha (\$22 per ac) for wheat/pea with conventional tillage and contour farming. The estimated offsite damage due to sediment from Tom Beall watershed was approximately \$0.85 per metric ton (\$0.77 per ton) of soil eroded (Dailey, 1994). This offsite cost accounted for navigational channel dredging, municipal water treatment, industrial water treatment, roadside ditch cleaning and maintenance, and steelhead fishery impacts. More characteristics about the study watershed are provided in Table 1.

Economic Model

The efficiency and effectiveness of conservation compliance within the context of the reformed farm program were evaluated using an integrated systems model. This framework has been used successfully to evaluate the interaction of flex and conservation policies by Wu et al. (1997). The systems model includes a geographic information system (GIS), physical simulation model, and an economic optimization model with a policy component. In this integrated systems model, the database was managed with the GIS-IDDRIS (Eastman, 1990). Soil erosion was calculated at the field level for each cropping system via GIS operations based on USLE relationship (Walker and Painter, 1994). Field-level erosion estimates for each cropping system were used for calculating the costs of onsite productivity loss by applying the present value approach to the estimated damage function for each crop. The damage function measures the effect of topsoil loss on current and future crop yields and was reported elsewhere (Wu et al., 1997; Walker and Painter, 1994). Starting topsoil depth at the field level was obtained from soil maps using vectorized field boundaries.

A mixed integer programming (MIP) model was used to maximize net farm income subject to constraints on cropland use, participation in federal commodity program, planting flexibility provisions, ARP requirement, and conservation compliance policy. Net farm income was net farm revenue plus government deficiency payments. Net farm revenue reflects the net proceeds from producing and selling a crop in the market excluding deficiency payments. Binary program participation decisions and mutually exclusive cropping system choices were endogenized using zero-one integer variables. The participation variable was linked to constraints imposing flex acre requirement in the 90FACT and conservation compliance. The flex constraint states that 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. The conservation compliance constraint prohibits soil erosion from exceeding erosion limits (or imposes reduced tillage) on all fields. The participation status variables were linked to receipt of government deficiency payments or production flexibility contract payments for participating farmers. The model also incorporated the maximum program payment limits. The presence of nonparticipation variables removed the flex and compliance requirements for nonparticipating farmers.

The integrated systems model was applied for the Tom Beall Creek watershed, Idaho, to determine the profit-maximizing cropping systems for growers. Government payments or taxpayer costs, net farm income, erosion, costs of onsite productivity loss, and offsite sediment damage were calculated from the profit-maximizing results. Taxpayer costs included government deficiency (contract) payments only. Administrative costs and social welfare opportunity costs of financing the government farm programs were not considered due to data limitation. Farmers' responsiveness to market incentives was measured by net farm revenue. Environmental damage was measured in terms of onsite productivity loss and offsite sediment damage. With onsite and offsite erosion damage costs included in the MIP along with farm production costs, the model gives a full social accounting of the true resource cost of agricultural production in the watershed. Onsite erosion damage was not endogenized in the objective function because as Miranda (1992) observed, farmers in the United States, except for Farm Belt, neither understand nor act on the onsite productivity effects of erosion.

This study assumes that all noncropland was fixed in amount and location. The contract acreage for each farm was the sum of existing acreage bases for all program crops. Payment yields were the proven yields that were used to claim deficiency payments for farmers in the watershed. When determining whether to participate in the farm program growers consider the potential benefits such as government deficiency or contract payments, nonrecourse CCC loans, and CRP payments. In modeling this grower decision we included deficiency or contract payments but not the other, less important benefits for farmers in this watershed in order to keep the model manageable (see Wu et al., 1997, for more explanation).

The Policy Scenarios Analyzed

Various policy scenarios evaluated in this study include the 1990 farm program without compliance requirement that serves as the baseline, the 1990 farm program with conservation compliance alternatives, the 1996 farm program without conservation compliance requirement, and the 1996 farm program with conservation compliance alternatives.

The 1990 farm program scenario contained a set-aside rate of 5% for wheat and 7.5% for barley under the ARP, a deficiency payment rate of $0.039 per kilogram ($1.05 per bushel) for wheat and $0.024 per kilogram ($21.67 per ton) for barley, 15% normal flex acres (unpaid flex), 10% optional flex acres, and $50,000 payment limit per farm per year. Farmers received deficiency payments based upon target price, proven yield, and crop base acreage contingent upon meeting conservation compliance rules. Deficiency payments were the difference between farm price and target price or a loan rate whichever is the highest.

The 1996 farm program scenario included no ARP requirement, an estimated contract payment rate of $0.034 per kilogram ($0.92 per bushel) for wheat and $0.021 per kilogram ($19.16 per ton) for barley, 15% unpaid flex acre, and $40,000 payment limit per farm per year. Farmers received production flexibility contract payments based upon contract acreage, contract yield, contract payment rate, and contract payment limit contingent upon meeting conservation compliance rules.

Conservation compliance policy was continued in the 96FAIR and is likely to remain a feature of farm policy. This study evaluated no conservation compliance and four alternative forms of conservation compliance standards: 1T, 1.5T, and 2T erosion limits as well as reduced tillage requirement. Originally, conservation compliance under the 85FSA was interpreted to require reducing soil erosion to the 1T-level by using a conservation practice. As implemented, however, relaxed compliance standards are also accepted if the alternative results in a significant reduction in erosion without placing undue financial hardship on farmers. In the study watershed, the significant erosion reduction was achieved by increasing residue on fields. For ease of quantification and clarity of expression we express conservation compliance requirements in terms of T-level erosion limits. Reduced tillage was also examined as an alternative compliance standard because farmers achieve NRCS-specified residue levels on their fields typically through reduced tillage in this watershed. Various compliance standards were examined in the evaluation of 1996 versus 1990 commodity policy change because we want to reveal the sensitivity of modeling results to different compliance standards. However, readers should be cautious of comparing percentage change between compliance standard scenarios because of different bases.

Results and Discussions

Table 2 summarizes the results from optimization with the model for various policy scenarios analyzed, which were obtained using GAMS. Policy results include watershed-level net farm income, government payments, environmental damage, soil erosion, and program participation rate in terms of farm numbers and cropland enrolled for alternative policy scenarios. Table 3 reports marginal values of or changes in various policy variables above as well as net farm revenue and net social benefit. Table 4 presents optimal crop systems and land use in the watershed.

The results of columns 8 and 9 in Table 2 revealed that changes in farm policy between 1990 and 1996 did not alter farmers' participation decision as modeled in this watershed under all conservation compliance scenarios. Farmers already in the 1990 farm program were projected to reenroll in the new program under the alternative erosion limit compliance standards. With reduced tillage compliance, farmer participation increased to 93% under the new farm program from 86% under the 1990 farm program. The corresponding cropland enrolled was 95%. The rate of program participation was unchanged or higher because the combined effects of ARP elimination and decoupling offset the impact of the reduced program benefit rate and payment limit under the 96FAIR. Of course, participation with both policies decreased under stricter conservation compliance requirement. For instance, the number of farmers who participated in the 1996 farm program decreased from 100% in the baseline of no compliance requirement to 86%, 57%, and 29%, respectively, at 2T, 1.5T, and 1T erosion limit compliance. The corresponding cropland enrolled was 89%, 52%, and 21%. This is because few alternate crops available in this watershed can satisfy the more restrictive compliance standards.

Under the new farm program, taxpayer costs or government payments to farmers were lower by 7.24%, 14%, 10%, and 7.11%, respectively, at 1T, 1.5T, 2T, and reduced tillage compliance relative to the 1990 farm program (column 2 in Tables 2 and 3). Reduced taxpayer costs resulted directly from the fact that the program benefit rate and payment limit were reduced under the 96FAIR Act. The results from this study showed that reduced payment rate and unpaid flex policies affect small farms more than large farms in this watershed. Small participating farms have smaller production flexibility contract acreage with total payments per farm less than the maximum payment limit of $40,000. Therefore, the reduced payment rate and unpaid flex policy were binding constraints but not the downsized payment limit. On the other hand, downsized payment limit affects large farms more than small farms. Larger participating farms have large production flexibility contract acreage in excess of payment limit. Some or all unpaid flex acres come from unpaid contract acreage and benefits lost due to the reduced payment rate offset by conversion of unpaid contact acre into paid acres. As a result, the downsized payment limit was a binding constraint but not the reduced payment rate and unpaid flex policy. Taxpayer costs were higher for reduced tillage compliance than for 2T erosion limit compliance because of greater program participation, an increase to 93% with 95% land enrolled under the 1996 farm program.

Despite reduced government payments, however, newly reformed farm policy enhanced private benefits measured by net farm income under all the compliance scenarios (column 1 in Tables 2 and 3). Relative to the 1990 farm program scenario, net farm income increased 2.23% to $86,309 at the 1T erosion limit, 2.34% to $93,988 at the 1.5T erosion limit, 4.77% to $138,049 at the 2T erosion limit, and 5.94% to $129,787 at reduced tillage compliance with the new farm program. These results indicated that in this watershed, private benefit indeed increased for less restrictive farm commodity policy. Private benefit increased even more with the new policy for less restrictive conservation compliance.

Greater farm profitability under the 96FAIR resulted partially from the elimination of the ARP requirement and in turn the expansion of total crop acreage. Compared with the 1990 farm program scenario, total acreage cropped in the watershed increased 0.86%, 2.12%, 3.84%, and 3.67% for 1T, 1.5T, 2T, and reduced tillage compliance under the 1996 farm program (Table 4). The conversion of ARP land into crop production was higher for less restrictive conservation compliance. This was because more land was taken out from production under the 1990 farm program. The other reason enhanced profitability includes the relaxision of planting restrictions. Under the 96FAIR, any crop may be planted on production flexibility contract acreage except for fruits and vegetables. Decoupling permits farmers to grow the most profitable crops and still receive government payments though the level of contract payments were reduced. In this watershed, this means the expansion of wheat acreage because wheat is the most profitable crop. Compared with the 1990 policy scenario, wheat acreage cropped in the watershed increased

0.84%, 3.87%, 6.66%, and 6.98% for 1T, 1.5T, 2T, and reduced tillage compliance under the 1996 farm policy scenario. On balance, the farmer benefits from conversion of ARP land into crop production and decoupling offset the reduced farm benefits due to the downsized benefit rate and payment limit. Consequently, net farm income increases.

The results of the column 3 in Tables 3 showed that decoupling payments from production and from prices indeed enhanced farmer responsiveness to market price signals by increasing net farm revenue. Net farm revenue is the net farm income excluding government payments. Relative to the 1990 farm program scenario, net farm revenue under the new farm policy increased respectively by \$6,364, \$19,373, \$29,651, and \$23,780 at the 1T, 1.5T, 2T and reduced tillage compliance standards. Less restrictive erosion limit compliance was associated with higher net farm revenue. For instance, average change in net farm revenue per farm was \$1,591 at the 1T erosion limit, \$2,422 at the 1.5T erosion limit, and \$2,471 at the 2T erosion limit, respectively. Thus, farmers were less responsive to government policy incentives and more responsive to market signals because contract payments under the 96FAIR do not decline even when prices rise.

Under the erosion limit compliance standards, environmental damage and soil erosion were slightly higher with the 1996 policy scenario than that with the 1990 policy scenario. Specifically, marginal soil erosion was, respectively, 10 mt (0.01%) at the 1T soil erosion limit, 155 mt (0.12%) at the 1.5T erosion limit, and 207 mt (0.11%) at the 2T erosion limit. Respective marginal environmental damage was \$88 (0.08%), \$844 (0.89%), and \$710 (0.84%). Higher soil erosion and environmental damage resulted from the crop acreage shift from barley to wheat. Relative to the 1990 farm program, barley acreage was expected to decrease by 2.70%, 36%, and 21% at the 1T, 1.5T, and 2T erosion limit compliance standards with the 1996 farm program (Table 4). Barley is less erodible than wheat in this watershed. Under the reduced tillage compliance standard, the new farm program improved environmental quality by reducing environmental damage and soil erosion. Relative to the 1990 farm program, environmental damage and soil erosion decreased 2.2% and 1.0% with the new farm program, even though barley acreage decreased 48%.

These results suggested that environmental quality is impaired slightly as farm commodity policy becomes less restrictive under the erosion limit compliance standards. When reduced tillage conservation compliance was imposed, however, the environment was better off under the new farm program. Under reduced tillage compliance, more farmers participated in the farm program and thus were bound by the conservation compliance requirement. As a result, environmental damage and erosion were reduced more relative to the erosion limit compliance standards. Accordingly, reduced tillage conservation compliance in this watershed was more effective.

The efficiency of the new farm program was also evaluated by using net social benefit and a benefit-cost ratio. Net social benefit equals net farm income minus government payments and environmental damage. Net social benefit rose in all the conservation compliance scenarios with the new farm program. Relative to the 1990 farm program scenario, marginal net social benefit was, respectively, $6,276, $18,529, $28,941, and $25,337 at 1T, 1.5T, 2T, and reduced tillage compliance (column 6 of Table 3). On average, net social benefit per farm increased $1,569, $2,316, and $2,412 respectively for 1T, 1.5T and 2T erosion limit compliance.

An alternative assessment of the policy efficiency used in this study was the cost-effectiveness, which was measured by a hybrid incremental benefit-cost (IBC) ratio. A hybrid IBC ratio equals the change in net social benefit, net farm income, or taxpayer cost per unit change in erosion. Whereas, a conventional IBC ratio measures benefits and costs in monetary units. The hybrid IBC ratio measures benefits in monetary units and costs in physical units or vice versa (Prato and Wu, 1996). Instead of presenting the results for each IBC ratio under each policy scenarios, we report changes in the IBC ratios between the 1990 and 1996 farm program scenarios for each compliance standard in the last three columns in Table 3.

Relative to the 1990 farm program scenario, the cost of reducing one ton of erosion for farmer was lower, respectively, by 2.47%, 2.61%, 23%, and 24% at 1T, 1.5T, 2T, and reduced tillage compliance with the 1996 farm program. The new farm program decreased taxpayer costs for reducing one ton of erosion by 2.41%, 14%, 93%, and 70% at the1T, 1.5T, 2T, and reduced tillage compliance standards. Consequently, the new farm program would save society additional 4.69%, 21%, 68%, and 52% at the respective compliance standards if soil erosion was reduced by one ton. These results indicated that the new farm program enhances the efficiency by increasing the cost-effectiveness of erosion control. In this watershed, the efficiency gain was greater as a relaxed conservation compliance standard was associated with the new farm policy.

As conservation compliance became less restrictive, private and social benefits increased more and so did taxpayer cost because of greater rates of program participation. Environmental damage and soil erosion were lower because more farmers were bound by the conservation compliance requirement. For instance, moving toward less restrictive erosion limit compliance, such as 2T, from the stricter 1T criterion with the new farm program, net farm income, social benefit, and taxpayer cost were increased respectively by \$51,740, \$70,171, and \$146,891, while environmental damage was reduced by \$24,981(Table 3). Such a change in policy would save farmer 84%, taxpayer 94%, and society 85% more if soil erosion was reduced by one ton. Moving away from erosion limit compliance, such as 2T, toward reduced tillage compliance would further improve environmental quality by reducing damage by \$15,869. Such a change in policy would save additional 4.50% for farmer, 65% for taxpayer, and 33% for society.

These results illustrated the danger of overly restrictive compliance standards with a voluntary farm program. Setting compliance standards too stricter for "green" payment can be costly in this watershed. Stricter conservation compliance standards are the most detrimental to farm income and environmental goals. They contribute to lower cost-effectiveness of erosion control for all parties.

Summary and Conclusions

The 1996 Farm Bill reduces incentives for participation in the government farm programs for growers by continuing unpaid flex option, lowering contract payment rate, and downsizing contract payment limit. In return, program participants enjoy greater freedom for crop planting choices and no restriction on acreage reduction. One concern about these policy changes is that environmental benefit from the farm program could be compromised if participating farmers opt to change their cropping patterns due to planting flexibility and/or leave the program due to reduced benefits.

In this study, we used an integrated systems framework to model how farm policy reforms in the 1996 Farm Bill and conservation compliance alternatives jointly affect private and social benefits and environmental quality in a highly erodible Idaho agricultural watershed. Changes in farm commodity policy considered in this study were the unpaid flex option along with the reduced program benefit rate and payment limit. Conservation policy evaluated in this study included the 1T, 1.5T, and 2T erosion limit and reduced tillage compliance standards. The hypothesis evaluated is that private and social benefits increase as farm policy and conservation compliance jointly become less restrictive, but with little change in environmental damage.

The results of this study provided evidence on the success of the Agricultural Market

Transition program in the 1996 Farm Bill. Farm commodity policy reforms did not alter farmers' participation decision in this watershed. The new farm program increased private and social benefits, enhanced farmer responsiveness to market incentives, and reduced taxpayer costs. However, the benefits of conservation compliance were slightly diluted by increasing environmental damage when conservation compliance was in the form of erosion limit standards. Specifically, farm income increased 2.23%, 2.34%, and 4.77%; net social benefit increased 8.34%, 28%, and 50%; net farm revenue increased 28%, 56%, and 31%; taxpayer costs decreased 7.24%, 14%, and 10%; and environmental damage increased 0.08%, 0.89%, and 0.84%; respectively, for 1T, 1.5T, and 2T erosion limit compliance with the new farm program. Under reduced tillage compliance, net farm income, net social benefit, net farm revenue, and taxpayer cost increased 5.94%, 51%, 22%, and 7.11%, while environmental damage and soil erosion decreased 2.19% and 1.02% with new farm program. All are compared with the 1990 farm program scenario.

Policy changes in the 1996 Farm Bill diluted the benefit of conservation compliance policy slightly under erosion limit compliance. In this watershed, few cropping systems can meet stricter conservation compliance requirement. Those practices that meet the stricter compliance criteria are generally less profitable. As a result, farmers opted to leave the farm program when the stricter compliance standards were imposed. The lack of profitable and environmentally sound alternative crops could limit the scope for gains with farm policy reform alone. Policy reforms with simultaneous investment in development and adoption of alternative crop rotations would be required to realize environmental gains in this watershed.

Evidence from this study strongly supports the hypothesis that the private and social benefits increase as the farm and conservation policy becomes less restrictive, but with little change in erosion and environmental damage. Farmers, taxpayers and society would benefit from the new farm commodity policy in conjunction with the alternative conservation compliance standards examined in this study. Those benefits are much greater under the relaxed conservation compliance standard than under the stricter compliance standard in this watershed.

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Table 1. Farm-Level Characteristics, The Tom Beall Creek Watershed, Idaho

Farm Code	Crop Land[a] (ha.)	Field (#)	Base Acreage Wheat (ha.)	Base Acreage Barley (ha.)	Total Base Acre (ha.)	Non-Base Acre (ha.)	Proved Yield Wheat (kg/ha)	Proved Yield Barley (kg/ha)	Top Soil Depth (meter)	Avg. Land Slope (%)	Avg. Elev-ation (meter)
1	180	6	125	2	127	53	617	437	0.40	12.81	488
2	136	10	66	16	82	54	760	769	0.41	9.91	546
3	63	4	35	24	59	4	650	506	0.41	15.26	376
4	405	11	252	34	287	118	650	554	0.48	13.41	452
5	15	1	10	1	12	3	650	554	0.41	13.09	431
6	67	3	29	15	44	23	1,013	728	0.58	4.00	598
7	204	7	109	37	146	59	672	445	0.56	11.52	522
8	120	4	62	23	85	35	738	611	0.54	6.39	595
9	230	9	134	52	187	43	782	631	0.46	9.53	506
10	71	4	59	8	67	4	562	575	0.54	14.17	494
11	779	17	514	55	569	210	771	478	0.58	6.94	572
12	147	3	91	1	92	54	628	445	0.41	4.60	626
13	296	4	235	15	250	47	771	445	0.41	5.02	586
14	311	11	195	9	203	108	870	409	0.44	11.10	534
Total	3,024	94	1,917	292	2,209	814	-	-	-	-	-
%	-	-	63.4	9.7	73	27	-	-	-	-	-
Avg.	216	7	137	21	158	58	724	542	0.47	9.84	523
Max.	779	17	514	55	569	210	1,013	769	0.58	15.26	626
Min.	15	1	10	1	12	3	562	409	0.40	4.00	376
Std.	196	-	132	18	143	56	118	112	0.07	3.82	71

[a]Base acreage and proved yield were obtained from the local Natural Resource Conservation Service county office and the remaining data were from the GIS database developed for this study.

[b]Land acres account for cropland acres in the watershed only.

Table 2. Computational Results from the Mixed Integer Programming Model

Policy Option[a]	Net Farm Income ($) (1)	Government Payments ($) (2)	Environmental Damage[b] ($) (3)	Soil Erosion[c] Total (mt) (4)	Soil Erosion[c] Average (thy) (5)	Participation Rate by Farm # (%) (6)	Participation Rate by Acre (%) (7)
NOP90	158,602	253,284	128,957	90,693	30.2	100	100
NOP96	166,533	225,439	128,564	89,059	29.5	100	100
1TP90	84,428	61,943	110,175	75,254	24.9	29	21
1TP96	86,309	57,460	110,263	75,264	24.9	29	21
5TP90	91,835	126,225	95,410	66,047	21.1	57	52
5TP96	93,988	109,005	96,254	66,202	21.9	57	52
2TP90	131,764	227,717	84,573	58,175	19.3	86	89
2TP96	138,049	204,351	85,283	58,382	19.3	86	89
RTP90	122,506	231,894	70,971	49,464	16.5	86	91
RTP96	129,787	215,395	69,414	47,617	15.7	93	95

[a]NO = require no conservation compliance for farm program participation, 1T = require the 1T erosion limit for conservation compliance on all fields in a farm for farm program participation, 5T = require the 1.5T erosion limit for conservation compliance on all fields in a farm for farm program participation, 2T = require the 2T erosion limit for conservation compliance on all fields in a farm for farm program participation, and RT = require reduced tillage for conservation compliance on all fields in a farm for farm program participation.

P90 = the 1990 farm commodity program with 15% normal flex acres, 10% optional flex acres, $50,000 deficiency payment per farm per year, and acreage set-aside requirement (5% for wheat and 7.5% for barley). P96 = the 1996 production flexibility contract program with 15% unpaid flex acres, $40,000 program payment per farm per year, no acreage set-aside requirement, and the estimated contract payment rate for wheat and barley.

[b]Environmental damage includes the costs of onsite erosion damage and offsite erosion damage.

[c]mt = metric tons and thy = metric tons per hectare per year.

Table 3. Marginal Value of Selected Policy Variables and Cost-Effectiveness of Erosion Control[a]

Policy Option	Marginal Value of: Net Farm Income ($) (1)	Government Payments ($) (2)	Net Farm Revenue[b] ($) (3)	Environmental Damage ($) (4)	Soil Erosion (mt) (5)	Net Social Benefit[c] ($) (6)	Cost-effectiveness[d]: Farmer (%) (7)	Gov't (%) (8)	Social (%) (9)
The 1996 vs. 1990 Farm Program for Each Compliance Standard									
NOP96	7,931	-27,845	35,776	-393	-1,634	36,169	-	-	-
1TP96	1,881	-4,483	6,364	88	10	6,276	2.47	-2.41	4.69
5TP96	2,153	-17,220	19,373	844	155	18,529	2.61	-14.27	20.51
2TP96	6,285	-23,366	29,651	710	207	28,941	22.93	-92.62	68.20
RTP96	7,281	-16,499	23,780	-1,557	-1,847	25,337	23.59	-69.54	51.72
Change from One Compliance Standard to Alternatives under the 1996 Farm Program									
1.5T *vs* 1T	7,679	51,545	43,866	-14,009	-9,062	29,857	45.42	-58.17	56.64
2.0T *vs* 1T	51,740	146,891	95,151	-24,980	-16,882	70,171	84.03	-94.35	84.78
RT *vs* 2T	-8,263	11,044	19,307	-15,869	-10,765	3,437	4.50	-64.74	33.07

[a]In the first block of this table, positive (negative) numbers in columns (1) through (6) indicate increase (decrease) relative to the 1990 farm program scenario under a given compliance option. For example, net farm income of $1,881 = $86,309 (1TP96) - 84,428 (1TP90), where $86,309 and $84,428 are reported in Table 1. In the second block, positive (negative) numbers in columns (1) through (6) indicate increase (decrease) relative to 1T (or 2T) erosion limit compliance under the 1996 farm program scenario.

[b]Net farm revenue equals net farm income minus government payments.

[c]Social benefits equals net farm income minus government payments and environmental damage.

[d]Cost-effectiveness was measured by the relative change of the incremental benefit-cost (IBC) ratios for the farm programs between 1996 and 1990 under a given conservation compliance standard. An IBC ratio was calculated based on the difference in social benefit (or net farm income or government payments) between the baseline (NOP90) and alternative policy scenarios relative to the difference in soil conserved. The numbers in the last three columns represent relative changes in the IBC ratios between the 1990 and 1996 farm program scenarios for each compliance standard. For example, 2.47% = (4.80 - 4.69)/4.80*100% where $4.69 per metric ton is the IBC ratio for 1TP96 relative to the baseline and $4.80 per metric ton is the IBC ratio for 1TP90 relative to the baseline, respectively. Cost-effectiveness in the second block was calculated in the same way as above except that NOP96 was used as the baseline.

Table 4. Optimal Cropping Systems and Landuse, the Tom Beall Watershed

Policy Option[a]	Acreage in Optimal Cropping Systems														
	Tillage		Practice		Crop Rotation							Land Use			
	CT	RT	CF	DF	R1	R2	R3	R4	R5	R6	R7	Wht	Brly	Pea	Flw
	(hectares)														
NOP90	3,024	0	3,024	0	1,359	95	337	115	74	981	63	1,895	198	810	120
NOP96	3,024	0	3,024	0	1,439	42	279	0	0	1,263	0	2,096	113	812	0
1TP90	2,554	470	2,994	30	225	0	109	3	34	2,637	16	2,803	37	157	26
1TP96	2,554	470	2,995	29	256	16	91	0	0	2,661	0	2,827	38	158	0
5TP90	1,775	1,249	2,949	75	570	5	222	51	106	2,049	21	2,480	93	385	64
5TP96	1,775	1,249	2,953	71	649	1	179	0	6	2,189	0	2,576	59	385	2
2TP90	1,482	1,541	2,989	35	1,061	21	402	63	99	1,308	70	2,053	166	689	116
2TP96	1,496	1,528	2,989	35	1,162	29	356	0	0	1,477	0	2,190	132	698	0
RTP90	283	2,741	3,024	0	1,204	95	286	130	20	1,227	63	2,025	186	702	111
RTP96	136	2,887	3,024	0	1,365	42	229	0	0	1,387	0	2,166	97	758	0

Note: CT = conventional tillage, RT = reduced tillage, CF = contour farming, DF = divided slope farming, R1 = wheat/peas, R2 = wheat/barley, R3 = wheat/barley/peas, R4 = wheat/barley/fallow, R5 = wheat/peas/wheat/fallow, R6 = wheat/wheat, R7 = summer fallow, Wht = winter wheat, Brly = spring barley, Pea = spring peas, and Flw = summer fallow.

[a]See footnote a in Table 1 for definition of policy option.