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Water Pollution Control Strategies
for an Agricultural Watershed

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Erosion control is the major policy objective underlying the conservation compliance provision of the Food Security Act (FSA). This provision requires farmers to develop and implement a conservation plan for reducing excessive erosion on highly erodible fields or lose eligibility for most USDA farm programs. Conservation compliance has been criticized because it is not targeted to areas generating high offsite erosion damages. Proponents of conservation compliance argue that it will significantly reduce offsite damages. Empirical evidence on which to judge the merits of these contrasting viewpoints is lacking. This paper compares the effectiveness and efficiency of two conservation compliance strategies and a water pollution control strategy for an agricultural watershed.

Previous Research

Strobehn (1986) concluded that the offsite benefits of USDA erosion control programs account for about two-thirds of the benefits of these programs. He recommended that conservation programs should emphasize both the reduction in offsite damages and maintenance of soil productivity. Strobehn (1986) and Ribaudo (1986) indicated that conservation programs designed to control erosion are not necessarily

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cost effective in reducing offsite damages. Due to the spatial and temporal discontinuities between on-farm erosion control and downstream sediment delivery, Crosson (1988) argued that attention should be shifted from reducing erosion on fields to reducing edge-of-field sediment delivery. Milon (1987) indicated that, lacking the ability to determine the socially optimal level of water pollution control, the selection of nonpoint source controls should be based on their cost effectiveness or economic efficiency.

Several studies have evaluated the cost effectiveness of alternative end-of-field treatments for reducing sediment and/or nutrient pollution of water (Fitzsimmons et al. 1978, Lindeborg et al. 1975, Walker et al. 1986). None of these studies considered the on-site damages of soil erosion. Crowder and Young (1985) used the AGNPS model to evaluate soil and nutrient losses and cost effectiveness of conservation practices for typical fields in the Conestoga Headwaters rural clean water program. Braden and Johnson (1985) developed the SEDEC model to identify land management practices that minimize the cost of reducing sediment deposition in a small agricultural watershed. Pope et al. (1983) found that conservation tillage with contour farming was the most economical system for reducing soil erosion on most Iowa soils. Shi (1987) found that minimum tillage with contour farming was the most profitable practice for reducing soil erosion in Idaho's Tom Beall watershed. Setia et al. (1988) concluded that conservation tillage was the most cost effective practice for reducing sediment and nutrient loadings to Illinois' Highland Silver Lake.

Study Area

The Tom Beall watershed is located in the lower end of Idaho's Lapwai Creek drainage. The watershed contains 4,563 hectares of cropland divided into 62 fields. Primary crops are winter wheat, barley, peas and forage crops, and grazing land. Eighty percent of the cropland in the watershed is eroding in excess of the soil loss tolerance (T = 11.2 tons per hectare per year, THY) due primarily to the steepness of the land and extensive use of conventional tillage (Shi 1988). Most of the erosion in the watershed is caused by snowmelt runoff and winter rains in January and February. The estimated average annual erosion rate for the watershed is 27.8 THY with conventional tillage, contour farming and a wheat-pea rotation. Cropland erosion results in runoff which carries large quantities of sediment and nutrients to Tom Beall Creek.

Procedures and Assumptions

The following procedures were used. First, average erosion rates and net returns per hectare for each field and resource management system (RMS) were estimated. Second, the most profitable (optimal) RMSs for each field and management strategy were identified. Third, the water quality effects of each management strategy were evaluated. Fourth, the effectiveness and efficiency of alternative management strategies were compared.

Two conservation compliance strategies and a water pollution control strategy were simulated. The first conservation compliance strategy selects the RMS that maximizes annualized net return per hectare and has an erosion rate less than or equal to 1T (T=11.2 THY). The 1T limit is used by the Idaho Soil Conservation Service (SCS) in developing FSA conservation plans for farmers. The second conservation compliance strategy is similar to the first except that the field erosion limit is 1.5T which is the maximum erosion rate allowed by the Idaho SCS for conservation compliance. The 1.5T rate is used whenever the 1T rate imposes an economic hardship on farmers.

The conservation compliance strategies were evaluated for good and poor vegetative cover on non-cropland areas. Non-cropland areas include the creek, trees and shrubs, and non-cropped riparian areas adjacent to the creek. Tom Beall watershed currently has poor vegetative cover on riparian areas. Good vegetative cover can be established by planting grass, trees or shrubs. The riparian strategy uses permanent vegetation on all fields adjacent to the creek, good vegetative cover on non-cropland areas and the most profitable RMSs on all remaining fields.[1] Since the riparian strategy retards the movement of sediment and nutrients through riparian areas to receiving waters, it is a water pollution control strategy.

Eleven RMSs were analyzed: CTUD = conventional tillage with up-and-down hill cultivation; CTCS = conventional tillage with cross slope farming; CTCF = conventional tillage with contour farming; CTDS = conventional tillage with divided slope farming; MTCS = minimum tillage with cross

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1. Vegetative filter strips 20 to 30 meters wide next to a stream, creek or lake are eligible for the CRP. Since the widths of the fields adjacent to the creek exceed 30 meters, only a portion of these fields would qualify for the CRP.

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slope farming; MTCF = minimum tillage with contour farming; MTDS = minimum tillage with divided slope farming; NTCS = no till with cross slope farming; NTCF = no till with contour farming; NTDS = no till with divided slope farming; and PV = permanent vegetation. Minimum and no tillage were selected because they are the most effective alternatives to conventional tillage in the study area (Veseth et al. 1986). Cross slope, divided and contour farming are the most practical land treatment practices for the watershed. Since CTCF is the most common RMS used in the watershed, it was selected as the baseline RMS. A fixed wheat-pea rotation was used because this is the dominant rotation in the watershed. All RMSs were assumed to have the same fertilizer application rates, namely, 56 kg N/hectare and 22 kg P/hectare. Soil erosion rates were estimated with the Universal Soil Loss Equation or USLE (Wischmeier and Smith 1978).

Variable and fixed costs per hectare for a given RMS were assumed to the same for all farms in the watershed. Unit costs were estimated for an average size farm in the watershed (405 hectares) using the microcomputer budget management system (McGrann 1986). A 3% yield penalty was assumed for minimum tilled wheat and a 15% yield penalty for no tilled wheat. The minimum till yield penalty is based on a survey of farmers in the watershed and the no till yield penalty is based on work by Taylor and Young (1986). Since farmers do not use reduced tillage on peas, peas were assumed to be conventionally tilled. The price of wheat equaled the 1987 target price of 16 cents/kg and the price of peas equaled the 1987 market level of 18 cents/kg. Real prices and costs were assumed to remain constant.

Annualized net returns per hectare for each RMS were estimated using the erosion planning (EROPLAN) model with a 20-year evaluation period and a 4% real discount rate (Dept. of Agr. Econ. 1987). The EROPLAN model subtracts the on-site soil erosion damages from net returns. On-site damages are calculated assuming an inverse linear relationship between crop yield and topsoil depth. As a result of the on-site damage adjustment, annualized net return per hectare decreases with respect to topsoil depth and erosion rate. All land in PV was assumed to have an annualized net return of $148/hectare which equals the current Conservation Reserve Program (CRP) rental rate in northern Idaho.

Changes in water quality at the outlet of the watershed were evaluated for each management strategy with the AGNPS model (Young et al. 1987). This model simulates erosion, runoff, eroded and delivered sediment, nitrogen, phosphorus and chemical oxygen demand in runoff for individual storm events and land use practices. The AGNPS model has been used in several watershed studies (Crowder and Young 1985, Frevert and Crowder 1987, Prato et al. 1989 and Setia et al 1988).

Results and Discussion

While MTCF is the most profitable RMS, it does not achieve the soil erosion limits on all fields. Of the 62 fields in the watershed, 48 exceeded the 1T limit and 36 exceeded the 1.5T limit with MTCF. Twenty-five fields exceeded the 1T limit and 11 exceeded the 1.5T limit with no tillage. All fields satisfied both erosion limits when PV is used.

Although no tillage and PV meet the erosion limits more often than minimum tillage, they have a lower net return per hectare than conventional or minimum tillage. Net returns were higher with minimum tillage than with conventional tillage because minimum tillage has lower per unit production costs and lower on-site erosion damages than conventional tillage.

Table 1 shows the cropland area in each RMS for the three management strategies. Forty-four percent of the total area in the watershed is in PV for the 1T limit, 17% for the 1.5T limit and 15% for the riparian strategy. The remaining cropland area under the riparian strategy is treated with MTCF because it provides the highest annualized net return per hectare of all RMSs.

Table 2 gives erosion and net farm income for the three management strategies. Total erosion decreases 77% with the 1T limit, 62% with the 1.5T limit and 47% with the riparian strategy. Reducing erosion on all fields to 1T causes net farm income to decline by 19.8% without cost sharing and 17.6% with cost sharing.[2] When field erosion rates are limited to 1.5T, net farm income decreases 12.2% without cost sharing and 9.2% with cost sharing. Under the riparian strategy, net farm income decreases 4.5% without cost sharing and 1.1% with cost sharing. Net farm income is 9 to 20% higher, but total erosion is 39 to 131% greater with the riparian strategy than with the erosion control

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2. Cost sharing rates in northern Idaho are a maximum of $35 per hectare for minimum tillage and $49 per hectare for no tillage for a maximum of two years. One-time cost sharing payments are $20 per hectare for contour farming, $21 per hectare for divided slope farming and $82 per hectare for PV.

strategies. Net farm income is higher with than without cost sharing, however, total erosion is the same.

The last column of Table 2 shows the efficiency of erosion reduction for each management strategy. Erosion reduction efficiency is defined as the decrease in net farm income (without cost sharing) divided by the decrease in total erosion relative to the baseline. The riparian strategy is the most efficient strategy for reducing erosion because it gives the lowest reduction in net farm income per kilogram of erosion reduction. However, the riparian strategy is less equitable than the conservation compliance strategies because net income would decrease for farms with fields adjacent to the creek whereas net income would increase for farms with fields away from the creek. Since net farm income is lower with the riparian strategy than with current practices, it is not possible to improve the total welfare of farmers by redistributing income.

The effects of the three management strategies on water quality were analyzed by comparing the levels of total sediment, total nitrogen, total phosphorus and soluble chemical oxygen demand (COD) for four storm events, 10, 25, 50 and 100 years. Sediment, nitrogen, phosphorus and COD levels increase with storm intensity, but at a decreasing rate. The percentage decrease in pollution is greatest for the 10-year storm event and smallest for the 100-year storm event, and about 10 percentage points higher with good than with poor vegetative cover of non-cropland areas. Percentage reductions in pollution are highest for sediment followed by nutrients and COD. Average reduction in all four pollutants is 49% with poor vegetative cover and 70% with good vegetative cover at 1.5T and 68% with poor cover and 80% with the good cover at 1T.

The riparian strategy reduces average water pollution by 61%, which is less than the reduction for both conservation compliance strategies with good vegetative cover. Pollution levels decline more with the riparian strategy than with the 1.5T strategy when vegetative cover is poor (61% vs. 49%). Since all three strategies reduce runoff more than they reduce pollution loads, pollutant concentrations are uniformly higher with the three management strategies than with current practices.

Table 3 compares the decrease in net farm income per unit reduction in water pollution (pollution reduction efficiency) for the three management strategies. Pollution reduction efficiency is greater for the riparian strategy than for the 1T or 1.5T strategy, and greater for the 1.5T strategy than for the 1T strategy. The 1T strategy is the least efficient strategy because net farm income declines proportionately more than pollution levels.

Summary and Conclusions

This paper compares the effectiveness and efficiency of two conservation compliance strategies and a water pollution control strategy in reducing cropland erosion and sediment/nutrient pollution of surface water in Idaho's Tom Beall watershed. Conservation compliance was simulated by observing the impacts of reducing erosion rates on all fields to either 1T or 1.5T (T = 11.2 tons/hectare/year). The 1T erosion limit results in a 77% reduction in erosion, an 80% decline in average water pollution and an 18% (with cost sharing) to 20% (without cost sharing) decrease in net farm income. Limiting field erosion rates to 1.5T causes a 62% reduction in erosion, a 70% decline in average water pollution, and a 9% (with cost sharing) to 12% (without cost sharing) decrease in net farm income.

The water pollution control or riparian strategy uses permanent vegetation on all fields adjacent to Tom Beall Creek and minimum tillage with contour farming on all remaining fields. The riparian strategy gives the smallest decrease in erosion (47%), average water pollution (61%), and net farm income (1% with cost sharing and 4.5% without cost sharing). It is 65% more efficient than the 1.5T strategy and 75% more efficient than the 1T strategy in reducing average water pollution in Tom Beall Creek.

In conclusion, the two conservation compliance strategies cause less total erosion and sediment/nutrient pollution of receiving water than the water pollution control (riparian) strategy. The latter strategy is more efficient in reducing cropland erosion and water pollution than the conservation compliance strategies. All three strategies reduce net farm income relative to current practices. The loss in income is more evenly spread among farmers with the conservation compliance strategies than with the water pollution control strategy.

References

Braden, J.B., and G.V. Johnson. Efficiency of Sediment Control Policies. Agricultural Economics Staff Paper, Series E, Department of Agricultural Economics, University of Illinois, Urbana-Champaign, 1985.

Crosson, Pierre. Pollution of Water from Agriculture: Socio-economic and Political Issues. Invited address, International Symposium on Water Quality Modeling of Agricultural Nonpoint Sources, Utah State University, Logan, June 19-23, 1988.

Crowder, Bradley M., and C. Edwin Young. Modeling Agricultural Nonpoint Source Pollution for Economic Evaluation of the Conestoga Headwaters RCWP Project. ERS Staff Report No. AGES850614, Economic Research Service, U. S. Department of Agriculture, Washington, D.C., September 1985.

Department of Agricultural and Resource Economics, Oregon State University. EROPLAN, Erosion Planning Model. 1987.

Fitzsimmons, D.W., J.R. Busch, R.B. Long, K.H. Lindeborg, G.M. McMaster, C.E. Brockway, L.R. Conklin, G.C. Lewis, C.W. Berg, and E.L. Michalson. Evaluation of Measures for Controlling Sediment and Nutrient Losses from Irrigated Areas. Idaho Agricultural Experiment Station, University of Idaho, Moscow, 1978.

Frevert, Kathleen, and Bradley M. Crowder. An Analysis of Agricultural Nonpoint Pollution Control Options in the St. Albans Bay Watershed. Staff Report AGES870423, Economic Research Service, U.S. Department of Agriculture, Washington, D.C., June 1987.

Lindeborg, K.H., L. Conklin, R.B. Long, and E.L. Michalson. "Economic Analysis of On-Farm Methods for Controlling Sediment and Nutrient Losses." In Effects of On-Farm Water Management Practices on the Water Quality in the Boise Valley. Fitzsimmons, et al. (ed.). Idaho Agricultural Experiment Station, University of Idaho, Moscow, December 1975.

McGrann, James M., Kent D. Olson, Timothy A. Powell, and Ted R. Nelson. Microcomputer Budget Management System User Manual. Department of Agricultural Economics, Texas A&M University, College Station, September 1986.

Milon, J. Walter, "Optimizing Nonpoint Source Controls in Water Quality Regulation." Water Resources. Bull., 23(1987):387-396.

Pope, C. Arden III, Shashanka Bhide, and Earl O. Heady. The Economics of Soil and Water Conservation Practices in Iowa: Results and Discussion. CARD Report 109, Center for Agricultural and Rural Development, Iowa State University, Ames, February 1983.

Prato, Tony, Ron Rhew, Hongqi Shi, and Merlyn Brusven. Controlling

Erosion and Nonpoint Source Pollution in Idaho's Tom Beall Watershed. Idaho Agricultural Experiment Station Bulletin 687, University of Idaho, Moscow, 1989.

Ribaudo, M. O.. Reducing Soil Erosion: Offsite Benefits. Agricultural Economics Report No. 561, Economic Research Service, U.S. Department. of Agriculture, Washington, D.C., 1986.

Setia, Parveen, Richard S. Magleby, and David G. Carvey. Illinois Rural Clean Water Project: An Economic Analysis. Staff Report AGES880617, Economic Research Service, U.S. Department of Agriculture, Washington, D.C., 1988.

Shi, Hongqi. Assessment of Soil Erosion and Water Quality in Idaho's Tom Beall Watershed. M.S. thesis, Department of Agricultural Economics, University of Idaho, Moscow, 1987.

Strohbehn, Roger (ed.). An Economic Analysis of USDA Erosion Control Programs: A New Perspective. Agricultural Economics Report No. 560, Economic Research Service, U.S. Department of Agriculture, Washington, D.C., 1986.

Taylor, Daniel B., and Douglas L. Young. "The Influence of Technological Progress on the Long Run Farm Level Economics of Soil Conservation." West. J. Agr. Econ. 10(1985):63-76.

Walker, David J., Paul E. Patterson, and Joel R. Hamilton. Costs and Benefits of Improving Irrigation Return Flow Water Quality in the Rock Creek, Idaho, Rural Clean Water Program. Research Bulletin, Idaho Agricultural Experiment Station, University of Idaho, Moscow, 1986.

Veseth, Roger, James Vomocil, Bob McDole, and Carl Engle. Effective Conservation Farming Systems. Pacific Northwest Extension Publication 275, University of Idaho, Oregon State University, Washington State University and U.S. Department of Agriculture, October 1986.

Wischmeier, W.H., and D.D. Smith. Predicting Rainfall Erosion Losses. Agricultural Handbook No. 537, Science and Education Administration, U. S. Department of Agriculture, Washington, D.C., 1978.

Young, Robert A., Charles A. Onstad, David D. Bosch, and Wayne P. Anderson. AGNPS, Agricultural Nonpoint Source Pollution Model: A Watershed Analysis Tool. Conservation Research Report 35, Agricultural Research Service, U.S. Department of Agriculture, December 1987.

Table 1. Cropland Area in Resource Management Systems for Alternative Management Strategies

	Conservation Compliance Strategies					
	T		1.5T		Riparian Strategy	
System	Area (ha)	Percent	Area (ha)	Percent	Area (ha)	Percent
MTCF	684	19.22	1,561	43.86	3,018	85.82
MTDS	500	14.05	296	8.33	--	0
NTCF	673	18.91	808	22.72	--	0
NTDS	145	4.07	283	6.82	--	0
PV	1,556	43.75	610	17.14	540	14.18
Total	3,558	100	3,558	100	3,558	100

Table 2. Total Erosion, Net Farm Income and Erosion Reduction Efficiency of Alternative Management Strategies

Strategy	Total Erosion[a] (tons)	Net Farm Income: With Cost Sharing	Net Farm Income: Without Cost Sharing	Efficiency[b] ($/kg)
		($)	($)	
Baseline[c]	134,014	795,092	789,974	--
T	30,591	655,003	633,232	1.84
1.5T	50,884	722,138	693,706	1.40
Riparian	70,666	786,297	760,648	0.56

[a]Calculated with USLE.

[b]Change in net farm income (without cost sharing) divided by change in total erosion relative to baseline.

[c]Conventional tillage with contour farming.

Table 3. Pollution Reduction Efficiency of Alternative Management Strategies

Pollutant	Storm Event	Conservation Compliance Strategies T	Conservation Compliance Strategies 1.5T	Riparian Strategy
Sediment ($/ton)	10	14.52	9.63	3.35
	25	9.58	6.38	2.27
	50	7.99	5.35	1.92
	100	6.74	4.54	1.65
Nitrogen ($/kg)	10	10.23	7.24	2.62
	25	7.30	5.21	1.94
	50	6.36	4.55	1.72
	100	5.57	4.00	1.52
Phosphorus ($/kg)	10	20.64	14.17	5.13
	25	14.70	10.25	3.78
	50	12.74	8.87	3.32
	100	11.20	7.85	2.95
COD ($/kg)	10	5.90	4.51	1.34
	25	4.42	3.54	1.04
	50	3.94	3.21	0.94
	100	3.54	2.93	0.86