A FARM LEVEL FINANCIAL ANALYSIS OF ALTERNATIVE SOIL LOSS CONTROL POLICIES

by

William G. Boggess, James M. McGrann, Earl O. Heady, and Michael Boehlje

William G. Boggess is a doctoral student in economics and a Research Economist with the Center for Agricultural and Rural Development, Iowa State University.

James M. McGrann is Assistant Professor, Department of Economics, Iowa State University.

Earl O. Heady is Distinguished Professor of Economics and Director of the Center for Agricultural and Rural Development.

Michael Boehlje is Professor of Economics, Iowa State University.

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ABSTRACT

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A farm firm level model is used to analyze the impacts of alternative soil loss control policies. Adjustments in farm management practices required by the alternative control policies are discussed. In addition, the analysis investigates the impacts of soil loss controls on farm financial characteristics including income generation, cash flows, asset values, and debt servicing capacity.

A Farm Level Financial Analysis of Alternative Soil Loss Control Policies

Recent increased social awareness of environmental quality has led to concern about the impacts of soil erosion on water quality. This concern is embodied in legislation such as the Iowa Conservancy Law and the Federal Water Pollution Control Act Amendments of 1971.[1] These acts provide the framework within which soil erosion control policies can and will be formulated. The particular form that these regulations will take is unknown, but even greater uncertainty surrounds the nature of the resulting impacts these environmental regulations will have on the agricultural community.

Previous studies in this area have concentrated on the macro level impacts of soil erosion controls including national studies by Nicol, Heady, and Madsen, and riverbasin studies by Alt and Heady and by Narayanan, Lee, Gunterman, Seitz and Swanson. These studies investigated the aggregate impacts of soil loss controls on production practices, environmental quality, regional incomes, and regional distribution of production.

This study concentrates on the impact of soil loss controls at the farm firm level. The farm analyzed is typical of the Monona-Ida-Hamburg Soil Association in west central Iowa. Soils of the association are subject to severe sheet and gully erosion. However, the loess soils are very deep and if erosion is held to

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[1]The Iowa Conservancy Law extends the authority of the soil conservation district commissioners to allow them to (1) classify land based on its erodibility, (2) establish soil loss limits for each land class, and (3) require landowners to make the necessary adjustments to meet the established limits (Code of Iowa). The 1972 Federal Water Pollution Control Act Amendments specify in Section 208 of PL 92-500, "that states develop a process to identify if appropriate, agriculturally and silviculturally related nonpoint sources of pollution, including runoff from manure disposal areas, and from land used for livestock and crop production, and set forth procedures and methods (including land use requirements) to control to the extent feasible such sources."

reasonable rates productivity can be maintained over time.

The analysis investigates the impact of alternative soil erosion policies on several farm response variables. The working hypothesis of this analysis is that the ability to adopt various control strategies and adapt to alternative policies depends upon the financial as well as resource characteristics of the firm. Policy alternatives analyzed include maximum gross soil losses of 5, 10, and 15 tons per acre, taxes per ton of gross soil loss consistent with the 5, 10, and 15 ton levels of total farm soil loss, a 75 percent terracing cost subsidy, and a 75 percent interest subsidy for borrowed terracing capital. The primary response variables considered are income, cash flow, soil loss levels, and imputed land values. Specific objectives of this analysis include: (1) illustrating an integrated farm level model designed to analyze the impacts of soil loss regulations, (2) comparing the relative impacts of alternative control approaches, and (3) investigating the impacts of environmental controls on farm financial characteristics, specifically income generation, cash flows, asset values, and debt servicing capacity.

The Model

A linear programming model of a 330 acre[2] farm typical of the Monona-Ida-Hamburg Soil Association of west central Iowa was developed. The forty crop rotations specified reflect possibilities ranging from current practices to rotations satisfying a 5 ton per acre maximum soil loss restriction. A range of reduced soil loss levels can be achieved through a combination of alternative

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[2]Farm consists of 330 acres, 10 acres are removed for farmstead, roads, and ditches, and an additional 32 acres are left in permanent grass.

crop sequences,[3] tillage practices,[4] and conservation practices[5] applied to the dominant soil types of the association[6]. The model is applied to two alternative farm types, a cash grain farm and a grain livestock farm.

The model maximizes after-tax cash flow subject to land, labor, and capital availability and to the agronomic crop production relationships embodied in the rotations. Land resources were specified for each of the four dominant soil types in the Monona-Ida-Hamburg Soil Association. Labor was constrained to 3000 hours of operator labor. Capital was assumed available in unlimited quantities at a 9 percent rate of interest. However, the farm was required to generate sufficient cash flow to pay the yearly interest and principal charges. Four types of capital were defined operating, intermediate (7 year loan), long term, and terracing capital. A second formulation incorporating livestock production was specified for comparisons of alternative farm types. Livestock production activities include hog farrow to finish, cow-calf production, and cattle feeding options. All assumptions regarding resource availability were held constant for both farm types.

The model maximizes cash flow rather than net income. Net income is calculated as total revenue minus total fixed and variable expenses. After-tax cash flow is calculated as cash revenues minus cash expenses including income taxes due. The treatment of depreciation and the inclusion of the tax structure are the major differences between the two approaches. Cash flow

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[3]Crop rotations include corn-soybeans, continuous corn, corn-oats-meadow combinations, and continuous meadow.

[4]Spring tillage with residue management and spring tillage without residue management.

[5]Straight row, contouring, and terracing.

[6]Napier silt loam, Ida silt loam, Monona silt loams with 5-9% slopes, and Monona silt loams with 9-14% slopes.

maximization implies that due to uncertainty, future investment decisions should be based on capital budgeting procedures at the time of investment and should not affect the current operation of the business. In addition, the special tax consideration of investments such as soil and water conservation expenses can be explicitly built into the objective function. Therefore maximization of after-tax cash flow as defined here is consistent with short-run firm optimization. The model maximizes the decision maker's returns after all out-of-pocket fixed and variable costs including taxes have been paid. The remaining funds are available for consumption, savings, or investment purposes.

The calculation of net cash flows is based entirely on cash returns and cash expenses (including cash operating expenses, taxes, and debt servicing). The federal income tax structure is incorporated endogenously in the model[7] including the deduction for soil and water conservation expenses.[8] Tax calculations were based on taxable income generated. Cash requirements for servicing operating, intermediate, and terracing capital debt were included endogenously in the model. The objective function cash flow is available for consumption, savings, further investment, or other debt servicing such as mortgage payments. Consumption expenditures were calculated exogenously[9] based on the after-tax cash flows generated under each alternative.

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[7]The tax structure was modeled using the approach outlined by Vandeputte and Baker. The 1977 tax tables for a family of four filing a joint return were used.

[8]Soil and water conservation expenditures can be deducted up to a maximum of 25% of the taxable income from farming (Internal Revenue Service).

[9]Consumption expenditures were calculated using the following equation adapted from Brake:

$$C = 22.96P^{.41}I^{.59}S^{.163}$$

where

C = consumption expenditures
P = ratio of current to 1961 prices
S = family size (assumed a family of four)
I = after-tax cash income

Results

Table 1 reports the impacts of each of the policy alternatives on several financial variables and on per acre soil losses. Table 2 reports the modifications in farm operation induced by the alternative soil loss controls.

One of the more obvious results illustrated in Table 1 is the impact that livestock production has on income and cash flow. Adding livestock to the farm organization increases net income and cash flow by approximately 200 percent compared to the cash-grain farm.[10] The increased income of the livestock farm was generated through the production of 20 cows and their calves and approximately 130 litters of hogs. The 20 cows were forced into the solution to reflect the diversity of the typical livestock farms in the area. Hog production entered the solution to a maximum level constrained by labor availability. The reduction in income and cash flow as a result of alternative soil loss controls is also substantially mitigated by inclusion of the livestock production options. However, it should be noted that operator labor usage differs significantly between the two types of farms. The livestock farm uses all 3000 hours of operator labor available, whereas the cash grain farm uses only approximately 700 hours. If off-farm employment is available to the cash-grain farmer, part of the income difference could be offset through off-farm work.

Alternatives 2 through 9 in Tables 1 and 2 reflect the impacts of alternative policy approaches to reduce soil erosion. Per acre regulations concerning maximum allowable gross soil loss levels are perhaps the most common approach discussed. This study investigates three alternative maximum allowable loss levels 15, 10, and 5 tons per acre. The reduction in soil losses under the per acre limits were accomplished primarily through reduced acres of row crops, the use of residue management, and contouring.

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[10]Relative prices between livestock and grain prices were set at the 1970-77 average. Actual prices used were corn at $2.25/bu., soybeans at $5.85/bu., hogs at $42.00/cwt., and beef cattle at $49.00/cwt.

Table 1. Financial Variables and Soil Loss Level Results for Cash Grain and Livestock Farms Under a Variety of Soil Loss Control Alternatives.

Alternative	Taxable Income ($)	Cash Flow ($)	Land Rents[a] ($)	Repayment Capacity[b] ($)	Labor Shadow Price ($)	Per Acre Soil Loss (tons)	Soil Loss Taxes ($)
Cash Grain Farm							
(1) Base	18635	16573	83.93	5172	0	18.85	-
(2) 15 Ton Limit	14822	13540	77.91	3421	0	11.99	-
(3) 10 Ton Limit	14377	13179	76.65	3220	0	9.53	-
(4) 5 Ton Limit	12617	11873	72.12	2508	0	4.90	-
(5) Tax-15 Ton Level	17317	15799	68.91	4715	0	11.99	2596
(6) Tax-10 Ton Level	16203	14845	68.91	4161	0	9.53	2040
(7) Tax-5 Ton Level	12617	11873	56.77	2508	0	4.90	2267
(8) 75% Cost Share	18708	16562	82.13	5165	0	18.92	-
(9) 75% Interest Sub	18455	16647	87.20	5216	0	18.57	-
Livestock Farm							
(1) Base	36372	29483	92.69	13467	2.91	17.73	-
(2) 15 Ton Limit	33214	27257	57.24	11966	5.89	9.76	
(3) 10 Ton Limit	32736	26906	61.31	11732	5.39	8.62	-
(4) 5 Ton Limit	31378	25951	62.95	11097	4.96	4.85	-
(5) Tax-15 Ton Level	34393	28087	59.37	12523	4.90	9.76	2223
(6) Tax-10 Ton Level	33852	27699	59.37	12262	4.90	8.62	1960
(7) Tax-5 Ton Level	31382	25954	50.12	11099	4.97	4.85	2520
(8) 75% Cost Share	34993	27864	66.19	12373	4.70	10.61	-
(9) 75% Interest Sub	36560	29825	75.42	13700	4.70	17.76	-

[a]Imputed returns to land, management, and risk.

[b]Cash flow available after taxes, consumption, and debt service (except mortgage debt).

Table 2. Farm Management Results for Cash Grain and Livestock Farms Under a Variety of Soil Loss Control Alternatives.

Alternative	Acres Terraced	Acres Residue Management[a]	Acres Contoured[a]	Acres Row Crops	Bushels Corn Sold	Bushels Soybeans Sold	Corn Bought
Cash Grain Farm							
(1) Base	2	0	0	208	11316	2708	-
(2) 15 Ton Limit	0	245	245	193	15026	864	-
(3) 10 Ton Limit	0	288	245	164	12630	864	-
(4) 5 Ton Limit	0	230	230	104	7614	864	-
(5) Tax-15 Ton Level	9	7	7	180	9616	2619	-
(6) Tax-10 Ton Level	4	68	68	156	8624	2230	-
(7) Tax-5 Ton Level	0	187	187	104	7614	864	-
(8) 75% Cost Share	0	0	0	207	11196	2724	-
(9) 75% Interest Sub	13	0	0	212	11849	2637	-
Livestock Farm							
(1) Base	42	2	2	224	0	2407	0
(2) 15 Ton Limit	34	211	211	164	693	864	0
(3) 10 Ton Limit	38	249	206	164	0	864	0
(4) 5 Ton Limit	32	230	230	112	0	864	3438
(5) Tax-15 Ton Level	35	97	97	166	0	2220	3511
(6) Tax-10 Ton Level	34	124	124	156	0	2035	3767
(7) Tax-5 Ton Level	32	187	187	113	0	864	3435
(8) 75% Cost Share	124	0	0	220	0	2270	0
(9) 75% Interest Sub	42	0	0	224	0	2436	69

[a]Includes all acres in a rotation including oats and rotation meadow.

The first option is to shift to more extensive rotations incorporating small grains and meadow with corn and soybeans. Table 2 indicates that the 5 ton per acre soil loss limits result in a drop in the number of acres of row crops to approximately half the base levels. The second option is the use of residue management tillage. The use of residue management increased from essentially no acres in the base models to 70 percent or more of the cropped acres in the per acre limit alternatives. The use of residue management also increased under the tax alternatives but at more moderate levels than for the per acre limits. The third option available to managers is to shift from straight row to conservation practices including contouring and terracing. The increases in contouring match almost exactly the increases in residue management since the most common adjustments made in the model to reduce soil loss was the shift to less extensive rotations with contour tillage and residue management practices. As expected the lower soil losses were obtained at the expense of reduced income and cash flows. However, because of the tax structure, cash flow is not as severely impacted as is income. Furthermore, the impact of the regulations is less severe for the livestock than for the cash grain farm.

The second policy option considered was a tax on soil losses. The tax was designed to obtain the same total soil loss for the farm as is obtained under the 5, 10, and 15 tons per acre limits. However the tax approach allows the farmer to decide how the total farm soil loss limit is to be met. For instance, one field may lose 20 tons per acre and another only 2 tons as opposed to the per acre limits which specify a maximum per acre soil loss. Taxes sufficient to induce the desired reductions in total soil loss ranged from \$1.19 to \$3.29 per ton.[11] Comparison of cash flows generated under a tax

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[11]The required tax on soil losses is equal to the shadow price of the soil loss constraint row. The soil loss constraint was set equal to the total soil losses obtained under the corresponding per acre limit.

approach with those generated under a per acre limit approach indicates the greater efficiency of a tax approach. However, the advantage of the tax approach declines as the soil loss restrictions become more limiting. For example, for the cash grain farm 17 percent more cash flow is generated using a tax approach equivalent to a 15 ton per acre limit, but the cash flows generated are identical for the 5 ton level. The differences between the two approaches are much smaller for the livestock farm. When the soil loss taxes are deducted from cash flows, the farmer is much worse off financially under the tax approach.

The final policy approach considered was a subsidy program. In this analysis two alternative subsidy programs are analyzed. The first is a 75 percent terracing construction cost subsidy and the second a 75 percent interest subsidy for borrowed capital for terracing. These policies had little effect on cash flow or soil loss with the exception of the 75 percent terracing cost subsidy on the livestock farm. Here soil loss was reduced by 40 percent compared to the base situation as the expense of a 4 percent reduction in cash flow. The reduced soil loss was the result of nearly three times the number of terraced acres compared to the base model.

Surprisingly terracing is not used in the model as a soil conserving tool. For the livestock farm terraced acres correspond directly with the amount that qualifies for the 25 percent deduction from taxable income. For the cash grain farm there is very little terracing in any of the alternatives. The results reported in Table 2 are based on financing the terracing construction costs with a seven year, 9 percent loan. Runs were also made using the assumption that the terraces would be financed over the life of the terrace which was assumed to be 45 years with proper maintenance. This assumption resulted in terracing consistent with the 25 percent deduction for all alternatives. The tax law allows for soil and water conservation expenses above 25 percent of taxable income to be carried into future years as a deduction from taxable income, an option that we were unable to include within the single period analysis.

One of the major objectives of this analysis was to investigate the impacts of soil loss controls on farm-level financial characteristics. The impact of alternative policies on income and after-tax cash flows has been discussed above. Usage of debt varies only slightly among the various alternatives. There is however a significant difference in usage between the cash grain and the livestock farm. The cash grain farm uses approximately $6000 of operating and $59,000 of intermediate capital. The livestock farm uses approximately $37,000 of operating, $111,000 of intermediate, and $11,000 of terracing capital. The model endogenously services these sources of debt but the absolute levels coupled with any mortgage debt could be a problem if a farmer faces a credit limit. In addition, the impact of soil loss controls on asset values as implied by land rents and debt servicing capacity can also be evaluated. The imputed land rents reported in Table 1 are the residual returns to land, management, and risk as measured by the shadow prices. The changes in imputed land rents provide an indication of the effects that these policies could have on capitalized land values and on the profit margin for farmers paying fixed cash rents.

The restrictions on land usage under the various soil loss control alternatives reduce the imputed land rents. The reductions in imputed land rents to the degree that they reflect possible changes in capitalized land values have important equity implications for land owners. Reductions in equity not only reduce the farmer's net worth but also affect the debt-equity position of the firm. In general, the reductions in land rents are greater for the livestock than for the cash-grain farm. In addition, the more restrictive control alternatives limit the feasibility of corn production which in turn constrains the amount of home-grown feed available for livestock production. Labor availability is the primary factor limiting the number of litters of hogs produced, but as corn production falls in response to the soil loss controls the imputed value of labor falls and instead is reflected in the return to land on which corn can be grown. Thus under the per acre limits while hog production remains relatively constant (Table 2) the imputed returns to labor decline and the imputed returns to land increase (Table 1) as the per acre limits become more restrictive. The increased flexibility in production allowed under a tax approach reverses the direction of the change in land rents. In this case the model produces as many soybeans as possible given the total farm soil loss limit and makes up the feed deficit by buying corn. As a result, the imputed returns to labor increase and the imputed returns to land decrease as the soil loss levels become more restrictive.

The repayment capacity values in Table 1 reflect the cash available for mortgage debt servicing after taxes, consumption, and servicing of operating intermediate, and terracing debt. The relative impact of soil loss policies on repayment capacity is greater for the cash grain than for the livestock farm. The reductions in repayment capacity are directly related to the restrictiveness of the soil loss policies. The 5 ton limit policies reduce repayment capacity by approximately 50 percent for the cash grain farm and approximately 20 percent for the livestock farm. The reductions in repayment capacities before soil losses taxes are deducted are smaller under a tax approach than under the per acre limit approach. After soil loss taxes are deducted, however, the reductions are much larger under the tax approach. For the 5 ton tax level after soil loss taxes are deducted repayment capacity is reduced 95 percent for the cash grain farm and 40 percent for the livestock farm. These reductions in repayment capacity can have important implications for farmers with mortgage payments or paying fixed cash rents. Assuming a standard 25 year, 20 percent down, 9 percent mortgage the yearly payments per acre per dollar of purchase price are $.0814. In the absence of soil loss control policies a cash grain farmer could service the debt on approximately 50 acres and livestock farmers approximately 130 acres purchased for $1250.[12] Farmers who purchased land in 1970 for $500 per acre could service the debt on two and one-half times the number of acres purchased currently for $1250. Similarly, the imposition of 5 ton per acre soil loss limits would reduce the number of acres on which the debt could be serviced by half for a cash grain farmer and by 20 percent for a livestock farmer. The same type of impacts hold for farmers paying fixed cash rents as for those making mortgage payments. These impacts underline the important relationships between tenure, soil loss control policies, land values, and debt servicing capacity.

Policy Implications

The results of this analysis have important policy implications. The first is that a firm level analysis is needed to adequately assess the impacts of and expected response to alternative soil loss controls. For example, the results presented here suggest that different responses are expected for cash grain versus livestock farms. These different responses suggest that the increased flexibility provided by livestock production enterprises along with the various incentives and implications of the current tax laws have

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[12] Land values in this area averaged approximately $1250 in November 1977 (Harris, Lord, and Groves).

important ramifications with respect to the impacts of soil loss controls.

The second implication is that the particular policy approach used may not be as important as economic efficiency arguments might suggest. Economists normally argue that a tax approach provides more flexibility than does a regulatory approach. As a result of the greater flexibility the required adjustments to soil loss control policies are assumed to be made with lower costs to the firm. The results in Table 1, however, indicate that the difference between the two approaches at the firm level are relatively insignificant with the exception of the 10 and 15 ton limits on the cash grain farm. When soil loss taxes are deducted from cash flows the farmer is significantly worse off under a tax approach than under a per acre limit especially at the 5 ton levels. This suggests that especially as soil loss controls become more restrictive that other policy issues such as enforcement, political feasibility, administrative costs, and equity issues may dominate efficiency aspects in the determination of the optimal policy approach.

A third implication is that environmental policies need to be specified with concern for the farmer's entire financial situation. Income generation is an important part of but not the entire picture. The effects of environmental regulations on land values and debt servicing capacity could have important ramifications for farmers with large mortgage payments or other debt obligations.

Conclusions

The model utilized in this paper appears to be a useful approach for evaluating the firm impact of environmental policy alternatives. The analysis clearly indicates the importance of considering alternative farm types and the impact that tax laws can have on firm response. The results of this particular analysis are limited to parts of western Iowa, similar analyses need to be completed for typical farms in other areas to adequately assess the overall impacts of wide-scale soil loss control policies. For example, farmers in the Clarion-Nicollet-Webster Soil Association in north central Iowa are presently achieving soil losses consistent with an average of 5 tons per acre but with approximately twice the income of similar sized farms in the Monona-Ida-Hamburg Soil Association.

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