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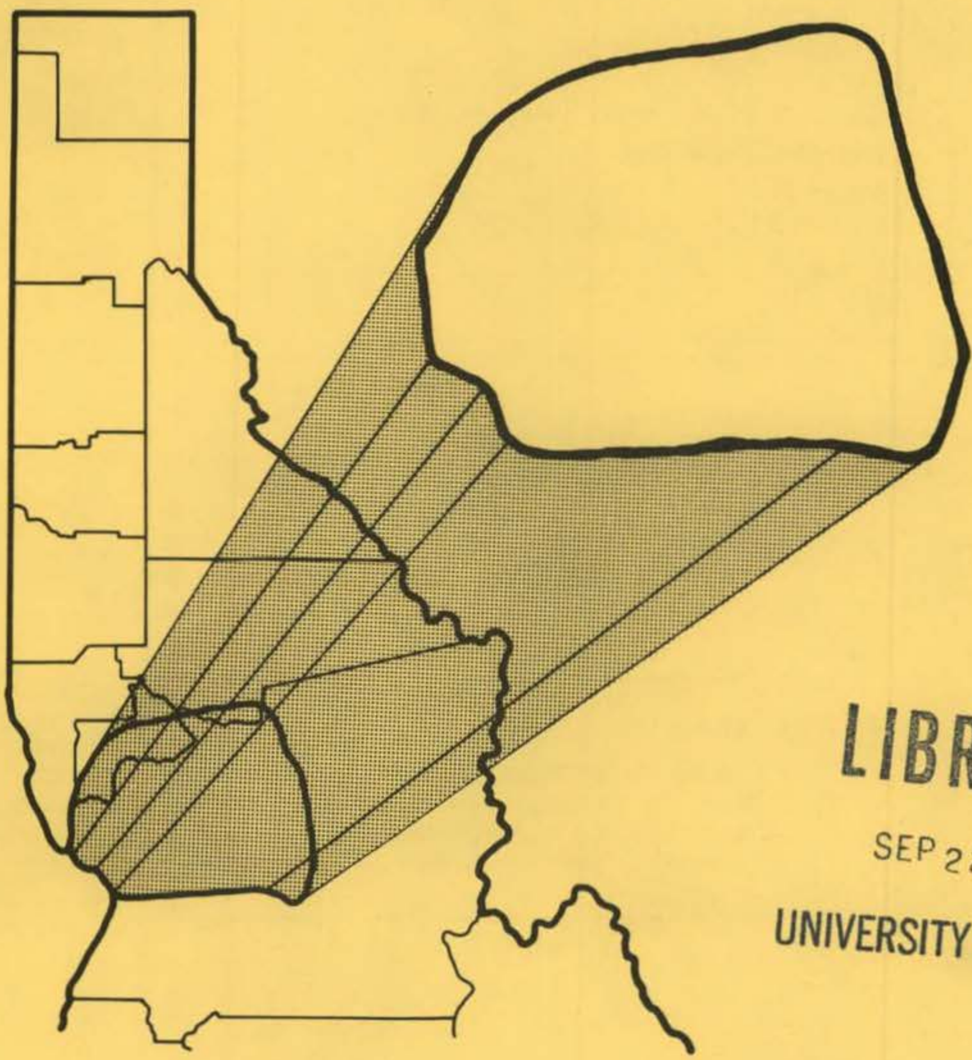
The Economic Impacts of Best Management Practices on the Camas Prairie, Idaho



Robert O. Brooks and Edgar L. Michalson

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University of Idaho
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About the Authors

Robert O. Brooks is a former research associate, and Edgar L. Michalson is professor of agricultural economics, both in the Department of Agricultural Economics, University of Idaho, Moscow.

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Introduction

The conservation of our soil resource has been a major concern of policy makers, growers and concerned citizens since the 1920s. Programs designed to encourage soil conservation have not met with unanimous support. Over the years, many programs have been implemented and dismantled. Currently, two major federal conservation programs are instrumental in promoting soil conservation on the Camas Prairie. The Agricultural Conservation Program (ACP) provides cost share funds for qualifying practices up to 75 percent of the practice's cost. Congress also allocated monies for the Conservation Operations Program (COP). This program authorizes the Soil Conservation Service, in cooperation with local soil and water conservation districts, to provide technical assistance to farmers installing conservation practices.

The Camas Prairie, located in north-central Idaho (Fig. 1), is one of Idaho's more productive dryland wheat producing areas. Seventeen percent of Idaho County (223,600 acres) is in cropland. Winter wheat, spring barley, spring peas and Austrian winter peas are the main cash crops. The soils on the Camas Prairie are generally deep, loamy soils with clay subsoil that restricts downward water movement. This barrier causes spring planting problems during wet years. Annual average precipitation is 22 to 24 inches with 50 percent falling from April to September.

Soil erosion is a major problem on the area's farmland. Soil losses on wheat-fallow ground has exceeded 20 tons per acre during bad erosion events. Although technology has increased yields through improved varieties, fertilizers and herbicides, potential yields are lower because of the eroded soils. An acre inch of topsoil weighs between 130 and 150 tons depending on soil type. Average annual soil loss for a winter wheat-fallow rotation using conventional tillage is about 12 tons per acre. With no changes in management or tillage, it takes 11 to 13 years to lose 1 acre inch of topsoil.

Yield losses vary depending on topsoil depth. On topsoil 24 inches in depth, each acre inch of soil eroded off reduces winter wheat yield 3 to 5 bushels per acre. This yield loss increases as topsoil depth decreases. On topsoil 12 inches in depth, an acre inch of soil eroded off reduces potential winter wheat yield 10 to 12 bushels per acre (Walker and Young 1982). To maintain the long run productivity of this valuable farm ground, farmers need to implement management practices that prevent the loss of the soil resource while maintaining their short run economic viability.

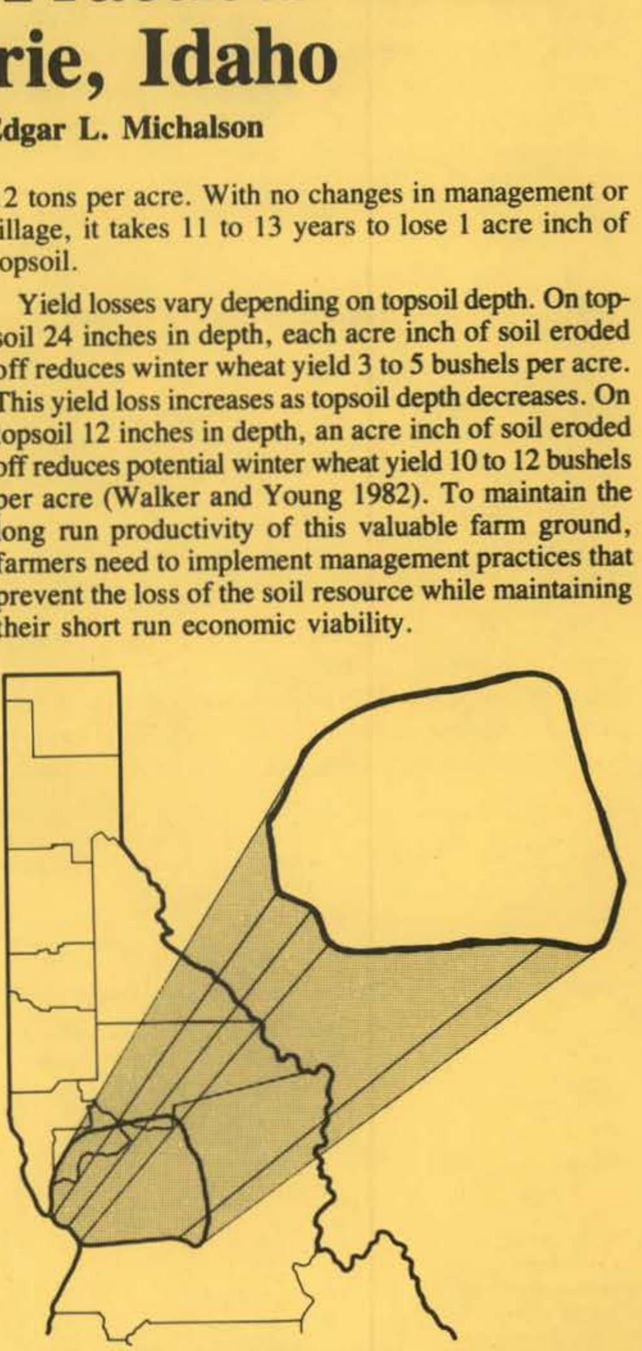

Fig. 1. Vicinity map of the Camas Prairie, north-central Idaho.

Objectives and Methodology

To accomplish this goal, two best management practices (BMPs) that are currently being adopted on the Camas Prairie were examined to determine their effectiveness in reducing soil loss and their impact on net farm income. The determination of costs associated with terraces and use of crop residue management was accomplished using crop enterprise budgeting and the Field Tillage Simulation Program[1] (FTS) (Miller 1978). The Oklahoma State University Crop Budget Generator (Walker and Kletke 1972) was used to develop the crop enterprise budgets in this study. This program estimated the input and equipment costs for the crops grown on the Camas Prairie using conventional and minimum tillage systems. The information provided by the enterprise budgets and FTS program was used in a linear programming (LP) model designed to maximize profits given certain crop rotations, soil loss constraints and BMPs. The soil loss estimates for the crop rotations and BMPs were calculated using the Universal Soil Loss Equation modified for the Pacific Northwest by D. K. McCool, USDA, Pullman (McCool et al. 1976) (Table 1).

The FTS program simulates farming a field with any type of tillage or harvest equipment. The results generated estimate fuel consumption, total farming time, total turning time and other data related to a particular operation. The FTS also simulates farming terraces that permits a comparison of the costs of farming between terraces vs. over terraces.

Data

The information needed to construct the crop enterprise budgets for this study was provided by the Idaho County Cooperative Extension Service, Grangeville, and local farmers interested in the study. Data on crops, yields, equipment complements, inputs and farm size were discussed. A representative farm operation was then budgeted based on the crop rotations for the Camas Prairie.

Typical crops grown in the area are winter wheat, dry field peas, spring barley, Austrian winter peas and alfalfa. A variety of crop rotations are used by the farmers in the area depending upon weather conditions, governmental programs and current economic conditions. The usual rotations are: winter wheat-spring peas, wheat-fallow, wheat-spring barley-Austrian winter peas and winter wheat-spring barley-fallow.

Soil Conservation Service personnel provided technical data on terraces, total amount of terracing installed and the costs. Crop residue requirements for the area were also provided.

[1]This program has been extensively modified by Leroy Stodick, programmer, Department of Agricultural Economics, University of Idaho.

Table 1. Soil loss estimates, Camas Prairie, north-central Idaho, 1983.

Crop	Conventional tillage	Crop residue management
	(tons per acre)	
Winter wheat-fallow	12.0	10.0
Terraced*	10.3	8.6
Wheat-barley-Austrian winter peas	5.8	3.7
Terraced*	4.9	3.2
Winter wheat-spring barley-fallow	6.0	4.0
Terraced*	5.2	3.4

*Terraces — USLE P factor for terraces based on 4 percent slope and 180 to 225 foot spacing.

Crop Residue Management

Crop residue management (CRM) is an effective erosion control practice. Leaving residue on the soil surface benefits the farmer many ways. The residue in and on the soil surface not only reduces soil erosion but increases the soil's infiltration capabilities and water holding capacities. Organic matter and soil structure are also improved. These benefits allow the soil an opportunity to conserve the moisture needed for the crop.

To maintain a minimum level of residue on the soil surface requires the farm operator to minimize the number and type of tillages. Table 2 gives residue incorporation factors for the general types of farm tillage equipment. Minimum crop residue levels of 1,500 pounds per acre are necessary to effectively control soil erosion. Wheat and barley provide ample residue to maintain this level.

Table 3 presents the crop residue production for the different crops based on their yield. As this table shows, peas and lentils produce very little residue and require excellent tillage management to maintain the minimum 1,500 pounds of residue on the soil surface.

The tillage costs associated with CRM are lower than for conventional tillage. This results in fewer tillage operations for seedbed preparation. Fuel, oil, lubrica-

Table 2. Percent of the crop residue incorporated into the soil.

Type of equipment	Percent residue incorporation
Moldboard plow (8-inch or deeper)	80 to 100
Moldboard plow (5- to 7-inch deep cut)	60 to 80
Power disk	60
Tandem or offset disk	50
One-way disk	50
Chisel (2-inch chisels, 12 inches apart)	25
Field cultivator (16- to 18-inch sweeps)	20
Deep furrow (shovel or disk-opener)	20
Sweeps (24 to 36 inches)	15
Rodweeders, with semichisels or shovels	15
Semideep furrow	15
Rodweeders, plain rod	10
Conventional (double and single disk opener)	10
Fertilizer (anhydrous)	10

tion, repair and labor costs are less for each crop rotation. Herbicide and fertilizer costs are the same for either tillage system. Yield reductions associated with this management practice vary depending on the level of management. A 2.5 percent yield penalty was assessed in this study, although recent data indicate that this penalty may be high. Tillage cost savings, yield penalties and the net benefits of this management practice are shown in Table 4.

Terraces

Terraces provide farm operators with a structural means to reduce runoff and erosion by breaking long slopes into shorter segments. Terraces can be either graded or level. Graded terraces are constructed in those areas where surface moisture is a problem, a perched water table exists or infiltration is a problem. Level terraces are usually constructed in low rainfall areas and have no outlet, allowing collected runoff to infiltrate the soil. Terraces installed on the Camas Prairie are of the graded type because of the soil characteristics. Their relatively shallow topsoil and clay subsoil results in a perched water table in the spring causing problems with working the ground during this time.

The terraces are usually constructed so that the bottom of the terrace exposes the clay subsoil. This allows the excess water perched on top of the clay to be diverted off the field. This practice is applied on slopes ranging from 4 to 12 percent. Terrace spacing is 180 to 220 feet. Spacing the terraces at this interval provides protection to the ground between each terrace and facilitates farming between them. They are designed so that machinery can be operated on the contour.

The costs associated with terraces are of two categories. The first category includes construction and maintenance costs, while the second deals with the added annual costs of farming terraced ground.

Construction costs were calculated from data supplied by area cooperators and Soil Conservation Service personnel. The average cost of construction was 48 cents per linear foot. An average of 75 feet of terrace per acre was installed for total per acre costs of $36.00. The useful life of gradient terraces installed on the Camas Prairie is estimated to be 10 years.

To evaluate this practice in the linear programming model, it was assumed that the operator borrowed the necessary capital to install terraces at 14 percent interest for 10 years with no down payment. The payment plan for the initial investment and maintenance charges were calculated using the Annual Equivalent Method.

Maintenance costs occurred only once — in the fifth year of the 10 year life — so this cost was discounted to present value before adding it to the initial investment. The annual payment for the terracing (initial investment and discounted maintenance value) was $7.26 per acre at 14 percent for 10 years.

The per acre added costs of farming terraced ground was estimated using the Field Tillage Simulation Program and are shown in Table 5. These added costs occur because of the increased turns and decreased equipment efficiencies involved with farming terraces.

Table 3. Crop residue production based on crop yield.

Crop	Residue produced
Wheat (short straw)	100 lb/bushel
Wheat (long straw)	120 lb/bushel
Barley	140 lb/cwt
Peas	120 lb/cwt
Lentils	150 lb/cwt

Table 4. Estimated added costs of utilizing crop residue management, Camas Prairie, 1983.

Crop	Decreased fuel, lube, oil, repair and labor costs/acre	Yield penalty 2.5% (unit)	($/unit)	Total	Net cost of CRM/acre
Winter wheat-fallow	$1.55[1]	2 bu	$ 3.50	$7.00	$5.45
Spring barley	1.57	.04 tons	95.00	3.56	1.99
Spring peas	1.36	.5 cwt	8.50	4.25	2.99
Austrian winter peas	1.26	.5 cwt	8.50	4.25	2.99

[1]Average costs per acre based on the 2 acre rotation.

Economic Effects of the BMPs On Farm Income Farm Analysis

A profit maximizing LP model was used to estimate the impact terracing and CRM would have on net farm income. The general form of the LP model was:

$$\text{Maximize } Z = C_1 X_1 + \ldots + C_j X_j$$

$$\text{subject to: } \sum_{j=1}^{j} A_{jk} X_j \leq dk$$

$$X_j \geq 0$$

where: Z = net income to the fixed factors of production.

C_j = net revenue per acre from the jth production activity.

X_j = acreage level of the jth production activity.

A_{jk} = total input required by the jth production activity.

dk = total amount of the kth resources available.

The LP model was designed so that both terracing and CRM could be brought into the solution on any of the available crop rotations. Acreage for the production activities is handled by requiring 1 acre for each crop in a rotation. The model handles the BMPs two ways: CRM is incorporated with the rotation while terracing is handled as a separate activity.

Many constraints were imposed on the model. First, the total number of terraced acres could not exceed 500. Second, total soil loss was parametrically reduced from 12 tons per acre to a minimum of 2 tons per acre. The number of acres of available cropland was constrained to 1,000 acres. CRM is applicable on all crops, soils, slopes and compatible with other management practices; consequently this practice was not constrained.

Yield impacts associated with terraces are a point of debate. Several factors are important in determining the magnitude of the yield increase — precipitation zone, terrace design, type of equipment used to construct the terrace and management. This study analyzed the impact improved yields on terraced acres had on farm income and crop rotation. The yield increases ranged from 0 to 10 percent of the base yields.

Table 5. Estimated per acre added operating costs for terraces, Camas Prairie, 1983.

Crop rotation	Fuel, oil, lube and repair costs	Herbicide, fertilizer and seed costs	Labor	Total
Winter wheat-fallow (2 years)	1.00	4.00	.60	5.60
Winter wheat-barley Austrian winter peas (3 years)	2.45	10.72	1.55	14.72

Model Results

The impacts of switching from one crop rotation to another, increasing the yield benefits for terraces and/or implementing a BMP to achieve a specified soil loss constraint are shown in Table 6. The first LP runs assumed no yield benefits on those acres protected by terraces. With no constraint on soil loss, a conventional wheat-pea rotation was chosen, with soil loss at 12 tons per acres and net income of $106,000. Soil loss was then constrained downward parametrically in 2 tons per acre increments. At soil loss levels of 10 tons per acre or less, CRM entered the solution on the 1,000 acres. In addition, spring barley and Austrian winter peas were brought into the solution.

The impact of increasing terrace yield benefits from 0 to 2.5 percent or higher was significant. The crop rotation pattern shifted, with more acres of a conventional wheat-fallow rotation in the solutions at all soil loss levels. This occurred because of the soil saving benefits of this management practice.

Again, soil loss was limited in 2 tons per acre increments. This brought CRM and in most cases, barley and Austrian winter peas into the solution. Terracing was used by the model at all soil loss levels when yield benefits were 2.5 percent and greater except for the unconstrained level (12 tons per acre) at 2.5 percent.

Reducing soil loss from 12 tons per acre to 4 tons per acre caused a reduction in net farm income of about

Table 6. The impact of increasing yield benefits on terraced ground and/or decreasing soil loss on the crop rotations and gross margins of farms on the Camas Prairie, north-central Idaho.

	Crop rotations						
Yield benefits terraces	Soil loss	CWF[1]	CRM[2] W-F	CRM[3] W-B-AWP	Terraces	Critical area seedout	Gross margins
	(tons/acre)	(acre)	(acres)	(acres)	(acres)	(acres)	($)
0%	12	1,000					106,000
0%	10		1,000				103,000
0%	8		683	317			99,709
0%	6		365	635			96,418
0%	4		47	953			93,127
0%	2			648	500	351	61,704
2.5%	12	1,000					106,000
2.5%	10	850	150		500		103,000
2.5%	8	500	293	207	500		100,110
2.5%	6	469		531	469		96,795
2.5%	4	61		939	61		93,176
2.5%	2			648	500	351	64,884
5%	10.3	1,000			500		107,750
5%	10	850	150		500		107,300
5%	8	500	294	206	500		104,111
5%	6	393	107	500	500		100,719
5%	4		86	914	86		93,801
5%	2			648	500	351	68,064
10%	10.3	1,000			500		115,750
10%	8	850	150		500		112,110
10%	6	393	107	500	500		108,689
10%	4		211	789	500		99,799
10%	2			648	500	351	71,244

[1]CWF: Conventional wheat-fallow.

[2]CRM W-F: Crop residue management on wheat-fallow.

[3]CRM W-B-AWP: Crop residue management on wheat spring barley-Austrian winter peas.

12 percent from $106,000 to $93,000. Limiting soil erosion an additional 2 tons per acre significantly impacted the farm operation. Only 648 acres of a wheat-barley-Austrian winter pea rotation were planted, all under CRM and terraces at their upper limit of 500 acres. The remaining 351 acres were seeded out to alfalfa. Net farm income was lowered an additional 34 percent from $93,000 to $61,704. This pattern was true within each yield benefit level. Gross margins increased, in most cases, for a given soil loss level as yield benefits caused by terraces improved from 0 to 10 percent. As an example, if we look at an 8 tons per acre soil loss across the yield benefit range, gross margins increased from $99,709 to $112,110.

Summary and Conclusions

The recent concern over non-point pollution has focused long-needed attention on farming practices. These concerns have centered on the high sediment loss rates that have been a byproduct of the management systems used on the ground to produce the crops grown in this country. Because of these concerns, several BMPs have been recommended by the Soil Conservation Service and local conservation districts to limit soil erosion while maintaining the economic viability of the farm operation.

This study analyzed the impact two recommended practices, crop residue management and terraces, had on a 1,000 acre farm's income and soil loss rates. Crop rotations generally used in the area were budgeted, and soil erosion rates for these rotations and BMPs were estimated using the Universal Soil Loss Equation.

The linear programming model developed for this study parametrically reduced soil erosion rates from a maximum 12 tons per acre down to 2 tons per acre. To meet the soil loss constraint, the model could pick any combination of crop rotation(s) and/or BMPs up to their constrained maximum limit.

The model chose a conventional wheat-fallow rotation when no soil loss restrictions were imposed. As soil erosion was constrained, the crop rotation pattern changed, and CRM entered the solution.

Terraces, because of their cost, were not chosen until the yield benefit from this practice was raised to 2.5 percent or more. This increased yield offset the costs enough that net farm income was higher than the base runs at each soil loss level.

The impact of minimizing soil erosion was a reduction in net farm income. Reducing soil loss 8 tons per acre dropped income 10 to 13 percent. As yields were increased on terraced acres, net income was higher at each soil loss level compared to other yield benefit levels. As soil loss was limited within each yield level though, net income fell approximately 10 to 12 percent.

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