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# An Evaluation of Best Management Practices on Dryland Farms in the Lower Portion of the Upper Snake River Basin of Southeastern Idaho:

## Bannock, Power, Oneida and Cassia Counties



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# Contents



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# An Evaluation of Best Management Practices On Dryland Farms in the Lower Portion of the Upper Snake River Basin of Southeastern Idaho

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## Introduction

Dryland farming in the semiarid region of the Snake River Basin is a high risk enterprise. The low rainfall, high winds and intensive downpours characterizing the climate magnify the challenges always present in agricultural production. Through careful management and technological advances, producers have historically overcome these adversities (Massee 1979).

Traditional farming practices of the region have been accompanied by attendant losses in topsoil. The predominant wheat-fallow cropping system has contributed to the severity of erosion because the soil is left unprotected so much of the time. Excessive erosion occurs on about 44 percent of the dry cropland in the Snake River Basin. Soil losses averaging 8 tons per acre annually have been experienced (USDA 1979). Surface runoff from torrential rain and snowmelt is the primary cause of soil erosion in the Basin.

Continuing erosion of topsoil has been linked to reductions in crop yield responses. Research indicates that per inch of soil eroded, yield loss varies from 3 bushels per acre on soils 24 inches deep to 8 to 10 bushels per acre on soils 12 inches deep in the Palouse area (Walker 1982). If these yield losses are extrapolated to southeastern Idaho, they would correspond to 1 bushel per acre on 24-inch deep topsoils and up to 3 bushels per acre on 12-inch deep topsoils. The potential for significant yield decreases underscores the importance of soil erosion control measures in this area of Idaho.

This study provides an evaluation of Best Management Practices (BMPs) to reduce soil erosion in the lower portion of the upper Snake River Basin. The study area consisted of the dryland farming of Bannock, Power, Oneida and Cassia counties designated as the lower rainfall zone of the upper Snake River Basin. The counties in this zone generally receive less than 16 inches annual precipitation and contain approximately 743,000 acres of dry cropland (USDA 1975). A companion report addresses the upper rainfall zone of the Basin.

## Study Objectives

This research examines the effectiveness and efficiency of selected BMPs to control soil erosion in the lower portion of the upper Snake River Basin of southeastern Idaho. Specific objectives included:

1. Estimate costs and soil loss values for the BMPs in the study region.
2. Analyze the economic impact of adopting the BMPs given alternative cropping choices for three representative sized farms in the Lower Basin.
3. Evaluate the BMPs' effectiveness in reducing soil loss for each model farm.

The following BMPs were examined:

1. Crop residue management.
2. Terracing.
3. Field stripcropping.
4. Grass waterways.

Crop residue management was evaluated using the minimum tillage practices assumed for the farms. Terracing was evaluated in terms of the costs of installing and maintaining terraces as well as the added operating costs of farming terraced fields. Stripcropping was evaluated through the added operating costs associated with this BMP. Grass waterways were evaluated in terms of the installation costs for the waterways.

## Methodology

The techniques used in the analysis were linear programming, enterprise budgeting and field tillage simulation. A linear programming (Lp) procedure was used to estimate the on-farm economic effects of implementing erosion control measures. The Lp models selected profit maximizing activity levels given a selection of crop rotations, tillage systems and BMPs and a series of soil loss constraints. The results of the models were compared to determine the impact on net returns to fixed factors of production for each farm size.

Enterprise budgeting was used to calculate baseline production costs and returns for small grain crops in the region. The budgets, developed through the Idaho Enterprise Budget Generator, summarized the variable costs of production for conventional and minimum tillage systems. The Budget Generator program estimated machinery fuel, lube, repair and labor costs for specified tillage operations.

A Field Tillage Simulation (FTS) program was used to analyze the costs of farming with terraced and stripcropped fields. The FTS program accepts as input the outline of a specific field and graphically simulates tillage operations with an equipment package selected by the user. Field coordinates in the program can be adjusted to incorporate conservation practices such as terracing and stripcropping. The costs of farming with these BMPs were derived using information produced by the FTS.

## Study Area

The study area for this report is the lower precipitation zone of southeastern Idaho, referred to as the lower portion of the upper Snake River Basin. This region includes the dryland farming areas of Bannock, Power, Oneida and Cassia counties. The cropland in this zone receives less than 16 inches of rainfall annually. A map of the study area is shown in Fig. 1.

Small grain crops typify dryland production in this region. Summer fallow has been uniformly adopted to combat the low moisture content of the soil. Crop rotations commonly include some combination of winter wheat-fallow and spring barley or spring wheat.

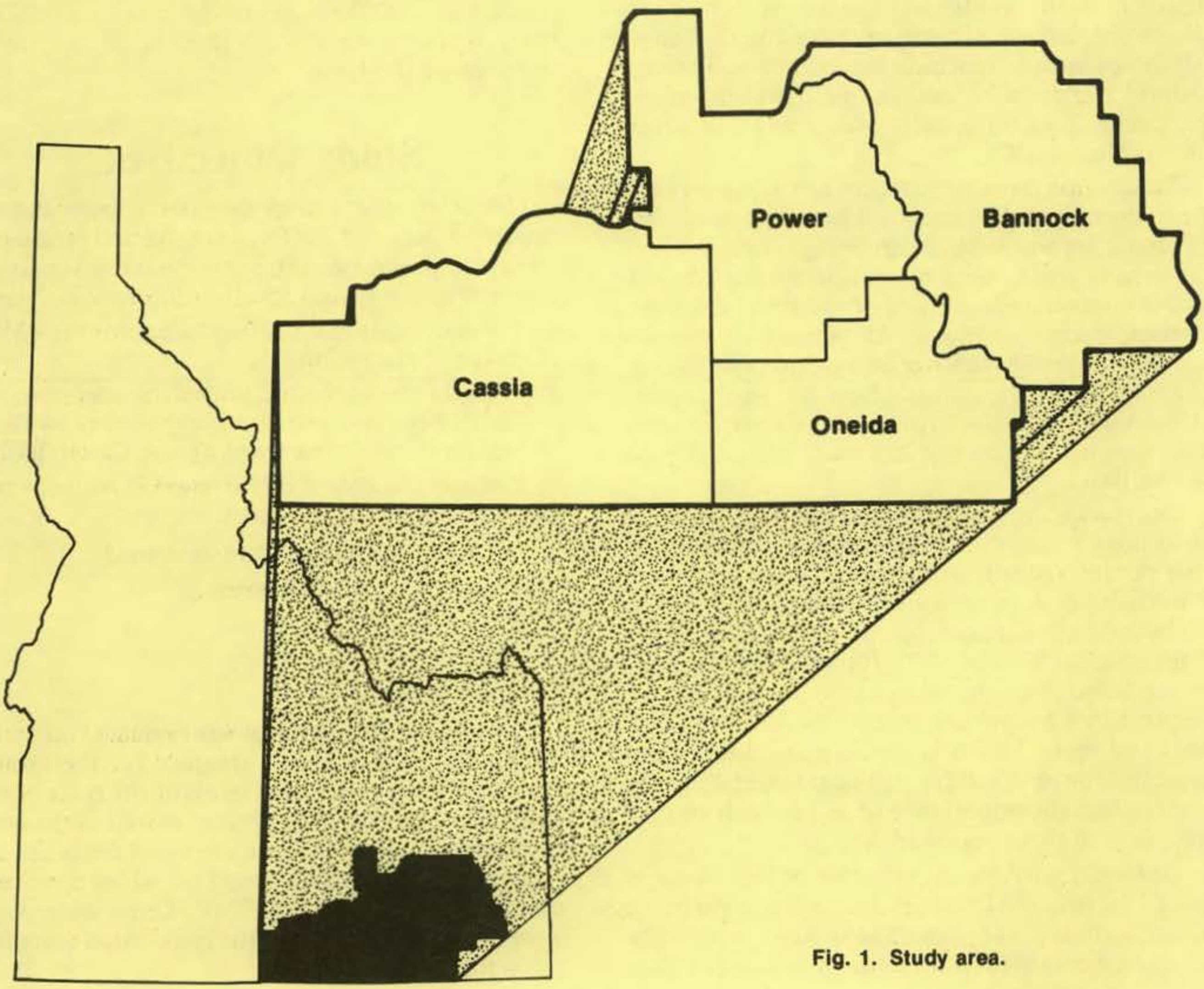


Fig. 1. Study area.

# Data Sources

The data used in this study were obtained from many sources. Fundamental data were provided from a farm survey undertaken in the Snake River Basin in 1979. Ninety-five farmers were interviewed in the survey, and a detailed farm schedule was obtained from each. Information was provided on farm sizes, rotations, machinery complements, tillage systems and conservation practices of the region. These data were updated to reflect 1982 prices for inputs, machinery and revenue items.

Other important sources of data included the Soil Conservation Service (SCS) offices in Boise, Pocatello and Idaho Falls, Idaho. Detailed information on the physical and biological aspects of the BMPs together with cost estimations were provided by these offices. The Agricultural Research Service (ARS), USDA (D. K. McCool) in Pullman, Washington, provided assistance with soil loss calculations for the region. Southeastern Idaho chemical and equipment dealers provided 1982 cost data for the study as did the District 4 Extension agricultural economist for the University of Idaho. Other professionals in the UI College of Agriculture also provided data.

# An Evaluation of BMPs: The General Case

This section describes each BMP in detail and presents the average costs associated with each in the lower portion of the upper Basin. The averages are drawn from specific data developed for the model farms used in this report. Appendix A contains input costs for each farm size.

## Crop Residue Management

Crop residue management, also called minimum tillage, involves maintaining a certain amount of residue above and below the soil surface to help hold the soil in place during critical erosion periods. The distribution of organic matter in and on the soil improves the soil's structure and water holding capacity.

Crop residue management is achieved through reducing the number of tillage practices used to prepare the ground for planting so that breakdown of crop residue is minimized. Conventional tillage incorporates 80 to 100 percent of residue into the soil while minimum tillage leaves at least 30 percent of crop residue on the surface (Michalson 1983). Table 1 presents typical conventional and minimum tillage practices in the study area.

The yield differences attributable to minimum vs. conventional tillage are not well understood. In cases where soil moisture tends to be limiting, as in the lower portion of the upper Basin, the increased moisture retention capacity of the soil accompanying crop residue management tends to contribute to increased crop yields. In cases where soil moisture is not limiting, increased water retention tends to have a negative effect on yields.

For purposes of this study, no change in crop yield was postulated in the short run with minimum tillage. Application of an additional 20 pounds of fertilizer was assumed with minimum tillage to compensate for the slower decomposition of organic matter under residue management.

The effect of these assumptions is to increase the cost of minimum tillage relative to what may actually be experienced on the farm. The weakness of the empirical evidence in this area is a shortcoming to

**Table 1. Minimum/conventional tillage combinations in the Snake River Basin.**

| Crop | Tillage intensity | Chisel plow | Chisel w/sweeps | Disk or f. cultivator | Rod weeder | Double harrow |
|---|---|---|---|---|---|---|
| Winter wheat-fallow | Conventional | 1 | | 2 | 3 | |
| | Minimum | 1 | 1 | | 2 | |
| Spring barley | Conventional | 1 | | 1 | 1 | 1 |
| | Minimum | 1 | 1 | | 1 | |

**Table 2. Effect on cost of crop residue management in the lower zone of the Snake River Basin.**

| Crop | Savings in fuel, oil, lube and repair[1] | Savings in labor | Added fertilizer[2] | Net cost of crop residue management |
|---|---|---|---|---|
| | (costs/acre) | (costs/acre) | (costs/acre) | |
| Winter wheat-fallow[3] | $1.22<br>($2.44) | $0.60<br>($1.20) | $2.10<br>($4.20) | $0.28<br>($0.56) |
| Spring barley | -$0.04 | -$0.22 | $4.20 | $4.46 |

[1]Savings are for the various implements located in Table 1 including the tractor.

[2]Assuming an additional 20 pounds of fertilizer per cropped acre for minimum till.

[3]Figures are presented for a single year. To include both years, see numbers in parentheses.

erosion research. Table 2 indicates the effect on cost of crop residue management for a winter wheat-fallow and a spring barley crop.

## Terracing

Terracing is a widely used BMP in southeastern Idaho. A terrace is an earth embankment or ridge built across a slope. Terraces reduce runoff and soil erosion by breaking up the slope length of a field and add to soil moisture by allowing runoff to stay on the field to be absorbed into the soil. Preliminary experiences with terracing indicate that the added moisture may have a positive effect on yields within the terraced field, but contrary evidence has also been reported. To date no informed consensus exists on the exact effect of terracing on crop yields in either the immediate or long-term case.

Terracing is recommended by the SCS on slope classes between 4 to 12 percent. The SCS office in Pocatello, Idaho, provided construction cost estimates and maps of terraced fields used in this study. Terracing was evaluated on two cost components: (1) the cost of building the terrace and (2) the additional operating cost of farming a terraced field. A further cost may be incurred if land is taken out of production to build the terrace. This cost was not considered in the analysis.

The constructon cost of terraces in the lower portion of the upper Basin, assuming use of a dozer to construct the terrace, was \$1.30 per lineal foot of terrace. The length and spacing of terraces in a field depends on many factors including slope length and steepness, type of soil and farming practices. A representative average of 75 feet of terrace per acre was obtained from sample fields in the study area. Initial construction costs were estimated as \$97.50 per acre of installed terrace (\$1.30 x 75 ft. = \$97.50/acre). A maintenance cost of 10 percent of installation was assumed to occur in the fifth year. The present value of a \$9.75 cost discounted 5 years was \$5.06.

Although the costs of constructing the terrace occur in a one time period, the benefits in terms of reduced soil erosion occur over the useful life of the terrace, a 10-year or greater time period depending on the care of the operator. To address the time lag between costs and benefits and the substantial capital requirements of installation, an annual equivalent cost payment schedule was applied to the investment for implementing terracing. Assuming an interest rate of 14 percent, the annual equivalent cost to the farmer to install an acre of terracing in the lower portion of the upper Basin was \$18.69. The annual equivalent cost for maintenance was 97 cents, resulting in a total annual investment cost of \$19.66.

The additional operating cost of farming a terraced field was calculated using output from the FTS program and enterprise budgeting. The FTS program allows comparisons between a field farmed as a whole and the same field as it would be farmed after terraces had been installed. Figs. 2 and 3 il-

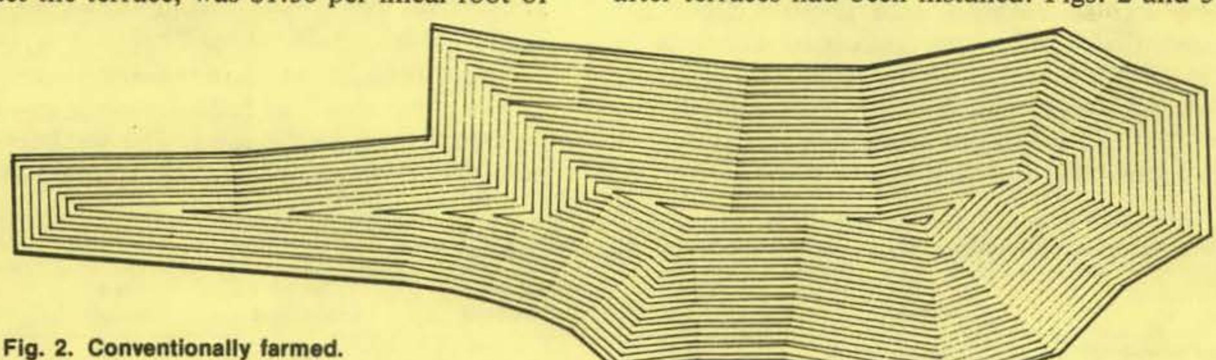

**Fig. 2. Conventionally farmed.**

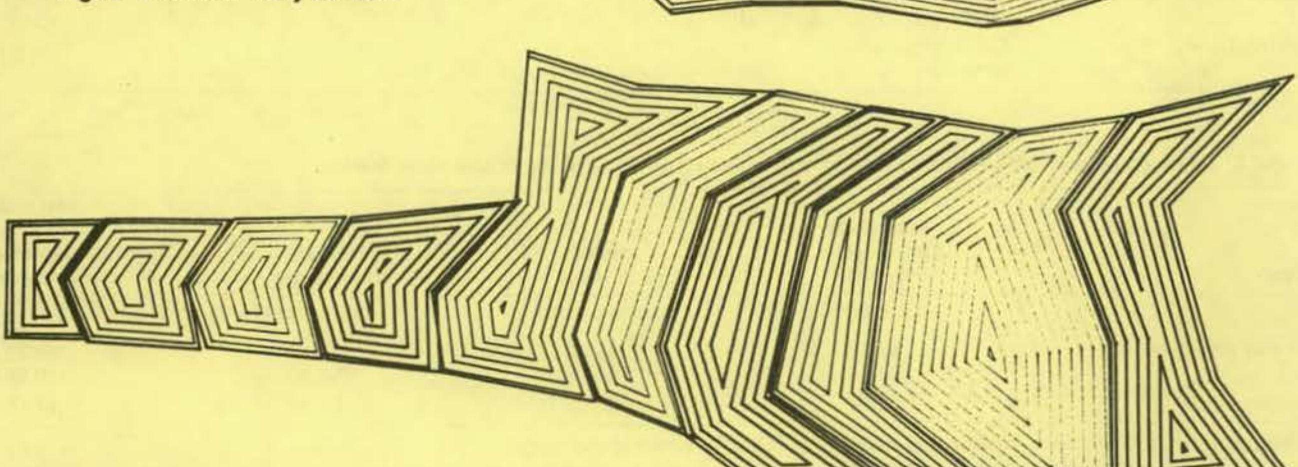

**Fig. 3. Terracing.**

lustrate the FTS interpretation of a field with and without terraces. Inputs to the program include coordinate points defining the field and implement data describing performance factors such as equipment width, speed, draft, fuel and holding capacities where applicable.

The essential output from the program is the elapsed time required to farm the field. Using a representative set of implements for the Basin, the percentage increase in operating time for terraces was 12 percent. This percentage was used to increase certain variable costs of production from the enterprise budgets including labor, fuel, oil, lube and repair costs for tractors, combines and implements. Farming between terraces necessitates increased applications of seed, fertilizer and herbicide because of the additional turning required and the problems of overlap. Those costs were increased by 10 percent. This expense may be partially offset if the excess fertilizer contributed to increased yields. Table 3 presents the additional operating costs of farming between terraces for a winter wheat-fallow and a spring barley crop.

## Field Stripcropping

Field stripcropping is a BMP designed to reduce erosion on long, steep slopes. The slope is divided into sections and planted in such a way that a portion is always in plant cover. Alternating strips of crops with high and low erosion protection provides more stability to the soil during peak erosion months, slows runoff velocity and permits greater water infiltration into the soil. In southeastern Idaho, the SCS recommends field stripcropping on slope classes greater than 12 percent. The SCS office in Malad, Idaho, provided maps of stripcropped fields used in this study.

The costs of stripcropping were calculated using output from the FTS program and enterprise budgeting. The FTS program enables a comparison of how field operations change with the installation of strips. Information describing the field, the corner finishing method and the equipment package is fed into the program, and the FTS produces a graphic simulation of farming the field. Figs. 4 and 5 show a field as farmed by the program before and after stripcropping was implemented.

The costs of stripcropping result from the additional operating time required in the field. Output from the FTS program indicates the time involved in performing field operations. The percentage increase in operating time for stripcropping was 8.46 percent. This increase was directly related to problems of overlap and the fact that stripcropping requires more machine time related to making more turns to farm individual strips.

Certain variable costs from the budgets were increased to reflect the cost of additional machine time. Fuel, oil, lube and repair costs for the tractors, combines and implements were increased by 8.46 percent. Labor costs were increased by 10 percent as were material costs of seed, fertilizer and herbicides. The increased fertilizer cost might be partially offset if the extra fertilizer contributed to higher yields. Table 4 provides the additional operating costs of farming stripcropped fields for a winter wheat-fallow and a spring barley crop.

**Table 3. Additional operating costs of farming with terraces in the lower zone of the Snake River Basin.**

| Crop | Added fuel oil, lube and repair[1] | Added labor | Added herbicide fertilizer and seed | Net added operating cost/acre of terracing |
|---|---|---|---|---|
| | (cost/acre) | (cost/acre) | (cost/acre) | |
| Winter wheat-fallow[2] | $1.80<br>($3.60) | $0.51<br>($1.02) | $0.81<br>($1.62) | $3.12<br>($6.24) |
| Spring barley | $2.19 | $1.19 | $1.88 | $5.26 |

[1]Includes tractors, implements and combines.

[2]Costs are presented for a single year. To convert costs to include both years, see numbers in parentheses.

**Table 4. Additional operating cost of farming with strips in the lower zone of the Snake River Basin.**

| Crop | Added fuel oil, lube and repair[1] | Added labor | Added herbicide fertilizer and seed | Net added operating cost/acre of terracing |
|---|---|---|---|---|
| | (cost/acre) | (cost/acre) | (cost/acre) | |
| Winter wheat-fallow[2] | $1.25<br>($2.50) | $0.51<br>($1.02) | $0.81<br>($1.62) | $2.57<br>($5.14) |
| Spring barley | $2.19 | $1.19 | $1.88 | $5.26 |

[1]Includes tractors, implements and combines.

[2]Costs are presented for a single year. To convert costs to include both years, see numbers in parentheses.

## Grass Waterways

Grass waterways are an effective BMP for controlling waterborne sediment. The waterway, protected by erosion-resistant grasses, is designed to conduct surface water from unprotected cropland. The channel provides a permanent cover for deposition of waterborne sediment, thereby improving water quality. Farm safety may also be improved since the formation of gullies and ditches is prevented by a properly designed waterway.

Construction costs for designing, shaping, sloping and seeding the waterway were estimated as $1,000 per acre. Grass waterways are an expensive BMP. Like terracing, the costs of construction are incurred immediately while the benefits in terms of reduced sedimentation accrue over the 10-year useful life of the waterways. Annual costs of this BMP were estimated by amortizing the initial cost over the life of the practice. Assuming an interest rate of 14 percent, the annual equivalent cost to the farm operator for installing a grass waterway was $191.71 per acre.

# Impacts of BMPs on Farm Income: Analysis by Farmsize

Profit maximizing linear programming (Lp) models were used to analyze the impacts of the BMPs on farm income. Models were developed to represent small, medium and large sized farming operations in the lower portion of the upper Snake River Basin. The linear program solution generates information on the most economical production decisions given the activities and restraints of the model. Profit maximizing rotations are identified and accompanying soil losses disclosed.

The base model activities included the crop rotations under consideration. Each rotation was paired with minimum tillage, with terracing and with stripcropping as a combined activity. Grass waterways were included as an independent activity, not combined with any rotation. The resource constraints included the total acres on the farm, the number of

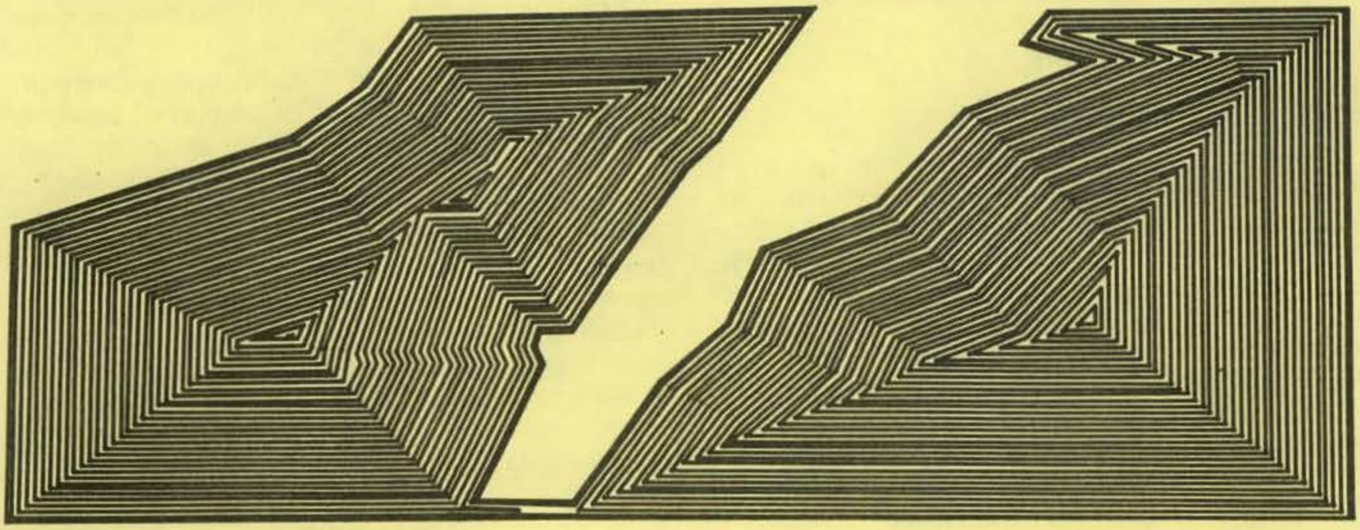

Fig. 4. Conventionally farmed.

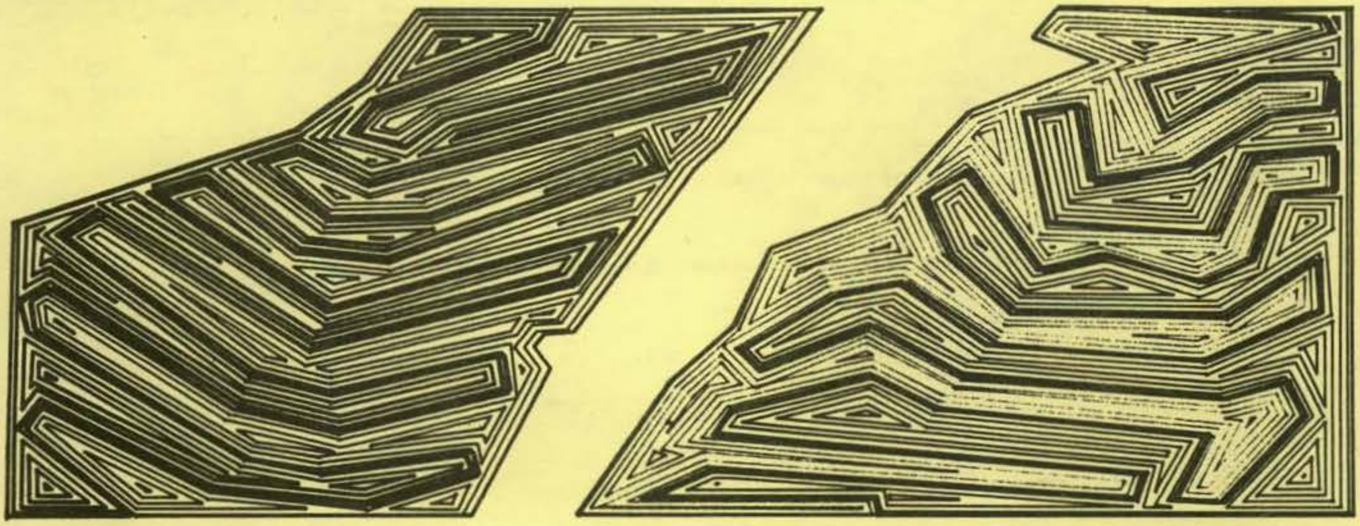

Fig. 5. Stripcropping.

acres available for each BMP and the tons of soil loss. The model was specified so that entry of BMPs caused soil loss to be reduced by the amount of soil savings associated with the BMP and the rotation.

## Model Assumptions

The variable costs and returns for the crop rotations used in the Lp were obtained from the enterprise budgets developed for the study area. The crop rotations included:

1. Winter wheat (50%)-fallow (50%).
2. Winter wheat (25%)-fallow (25%) and spring barley (50%).
3. Winter wheat (33%)-fallow (33%) and spring barley (33%).

The impact of the BMPs on farm income is directly related to the level at which the practice is implemented on the farm. For purposes of this report, the models were constrained to allow a maximum of 41 percent of the farm to be treated by terracing, 33 percent to be treated by field stripcropping and 1 percent to be devoted to grass waterways. Crop residue management was unconstrained in the models; i.e. minimum tillage was permitted on 100 percent of the farm. These constraint levels were based on SCS standards and estimates of slope class distributions in the study area. Soil loss values for the models were computed from the Universal Soil Loss Equation (USLE).

Three series of Lp runs were made. The first analyzed the effects of implementing the BMPs on soil loss and the corresponding impact on net farm income. This series began with an unrestricted model in which no BMPs were included in the solution. In succeeding runs, soil loss was successively constrained until all BMPs had entered the solution at maximum levels. The second series of runs analyzed the effect yield increases for terracing would have on BMP selection in the model. Terracing was accompanied in these runs by yield increases of 2 1/2, 5 and 10 percent for the terraced acres. Finally, subsequent runs analyzed the effect reduced construction costs would have on terracing in the lower portion of the upper Basin.

## Results: Small Farmsize

A farm of 500 acres was used to represent small sized dryland operations in the region. Yields of 30 bushels per acre for winter wheat, 38 bushels per acre for spring barley and 1 ton per acre for any cut grass were assumed. Prices of $3.50 per bushel of wheat, $2.70 per bushel of barley (equivalent to $112.50 per ton) and $50 per ton of grass were used. Soil loss was initially unrestricted at a level of 8.15 tons per acre.

The Lp initially identified the winter wheat-fallow and spring barley rotation as the most profitable. This rotation contained the least amount of fallow and, therefore, contributed more cropped land to income and less unprotected land to the forces of erosion.

Crop residue management was selected as the most economical BMP satisfying preliminary soil loss constraints. At a constraint level of 6 tons of soil loss per acre, 24 percent of the farm was under crop residue management. This increased to 93 percent when soil loss was constrained to 4 tons per acre. When soil loss was most severely constrained, all BMPs were forced into the solution. Crop residue management was selected for 100 percent of the farm, stripcropping for 33 percent, terracing for 41 percent and grass waterways for 1 percent. Soil loss has been lowered from the initial 8.15 tons per acre to 2.28 tons per acre, a 72 percent reduction.

The models highlighted the impact of the BMPs on annual farm income. Net farm income dropped only slightly with the entry of minimum tillage, first by 3 percent and then by another 3 percent. Full implementation of the set of BMPs caused a 34 percent reduction in net farm income from the original level.

The models highlighted the impact of the BMPs on annual farm income. Net farm income dropped only slightly with the entry of minimum tillage, first by 3 percent and then by another 3 percent. Full implementation of the set of BMPs caused a 34 percent reduction in net farm income from the original level.

The models featuring increases in yields for terraced acres were not substantially different from those in which no yield increase was assumed. The predicted rotations, soil losses and BMP mix were the same. The impact on net farm income of adopting the complete package of BMPs was lessened slightly by the additional revenue accompanying the terraced acres. With no yield increase, net farm income for the small farm was $11,016. At a yield increase of 2 1/2 percent for terraced land, net farm income was $11,414. A yield increase of 5 percent for terracing resulted in net farm income of $11,799, and a 10 percent increase provided a net farm income of $12,594.

Lowering of construction costs had little effect on terracing in the region until the lower costs were accompanied by a rather dramatic increase in terraced yields. A scenario of low construction costs and 10 percent yield increases caused terracing to enter the solution at its maximum when soil was at the first constraint level.

Table 5 presents the results of the Lp analysis for the small farm. Net farm income, profit maximizing rotations and BMPs, and soil loss constraints are provided for each model in the series.

## Results: Medium Farmsize

A 1,300-acre farm represented medium sized dryland operations in the study area. Yields of 28 bushels for winter wheat, 32 bushels for spring barley and 1 ton per acre for any cut grass were assumed. Prices of $3.50 per bushel for wheat, $2.70 per bushel for barley and $50 per ton of grass were used in the models. Soil loss for the farm was originally unconstrained at 7.2 tons per acre.

The wheat-fallow and spring barley rotation was again identified as the most profitable. This rotation minimized the amount of fallow, contributing more land to crops and less to erosion.

Stripcropping was initially identified as the most economical BMP satisfying soil loss restraints for the medium sized farm. A soil loss constraint of 5.38 tons per acre caused 33 percent of the farm to be placed under stripcropping, the maximum allowed for this BMP. Crop residue management was specified for 11 percent of the farm in this run. The next constraint level, 3.46 tons of soil loss per acre, extended the application of minimum tillage to 66 percent of the farm in addition to the 33 percent stripcropped.

The final soil loss constraint level of 2.28 tons per acre introduced all the BMPs into the solution at their maximums. Crop residue management was specified for 100 percent of the farm, stripcropping for 33 percent, terracing for 41 percent and grass waterways for 1 percent of the farm. Soil loss had been reduced 68 percent from the original level by inclusion of the full set of BMPs.

The impact on farm income accompanying the application of the BMPs was outlined by the Lp runs. Entry of the first set of BMPs caused a 6 percent reduction in net farm income. Increasing the level of crop residue management in the second set of BMPs resulted in a decrease of 14 percent. Adoption of the final package of BMPs, all at their maximum, caused net farm income to drop by 48 percent from the original level, a decrease of nearly half.

The effects on the BMPs of increasing yields for terraced acres were inconsequential. The only change resulting from increased yields was the impact on net farm income when the full set of BMPs had been adopted since that was the only time terracing was included in the solution. Yield increases of 2 1/2, 5 and 10 percent were tested in the models. Net farm income for the medium sized farm was initially $17,436 when all BMPs were in the solution and no yield increase accompanied terracing. At a yield increase of 2 1/2 percent for terraced acres, net farm income was $18,334. An increase of 5 percent for

**Table 5. Impact of BMPs on net farm income, soil loss and rotations on a representative 500-acre farm in the lower zone of the Snake River Basin.**

| | Original program | Terracing programs | | | | |
|---|---|---|---|---|---|---|
| | | | | | Reduced construction costs for terracing[1] | |
| BMP scenarios Model | No yield increase for terracing | 2½% yield increase for terracing | 5% yield increase for terracing | 10% yield increase for terracing | No yield increase | 10% yield increase |
| Unrestricted model | | | | | | |
| Rotation[2] and BMPs | WF and B<br>None | | | | | |
| Soil loss (tons/acre) | 4,075<br>(8.15) | Same | Same | Same | Same | Same |
| Net farm income | $16,600 | | | | | |
| Level one constraints | | | | | | |
| Rotation[2] and BMPs | WF and B<br>Minimum tillage | | | | | WF and B<br>Terrace/min till |
| Soil loss (tons/acre) | 3,000<br>(6) | Same | Same | Same | Same | 3,000<br>(6) |
| Net farm income | $16,131 | | | | | $16,393 |
| Level two constraints | | | | | | |
| Rotation[2] and BMPs | WF and B<br>Minimum tillage | | | | | WF and B<br>Min till/terrace |
| Soil loss (tons/acre) | 2,000<br>(4) | Same | Same | Same | Same | 2,000<br>(4) |
| Net farm income | $15,639 | | | | | $15,893 |
| Level three constraints | | | | | | |
| Rotation[2] and BMPs | WF and B<br>Minimum tillage<br>Stripcropping<br>Terracing<br>Grass waterways | Same | Same | Same | Same | Same |
| Soil loss (tons/acre) | 1,142<br>(2.28) | | | | | |
| Net farm income | $11,004 | $11,402 | $11,799 | $12,594 | $12,322 | $13,910 |

[1]Construction costs were reduced from $1.30 per lineal foot to $0.48 per lineal foot of terrace. The former cost is based on the use of a dozer, the latter on use of a terracing machine.

[2]Crop rotation: WF and B = winter wheat (25%), fallow (25%) and spring barley (50%).

yields on terraced land caused net farm income to rise to $19,236. At a yield increase of 10 percent, net farm income was $21,040.

Reduced construction costs for terracing in the lower portion of the upper Basin caused an increase in this BMP only if the lowered costs were accompanied by immediate yield benefits. A situation of low construction costs with a 10 percent increase in yield caused terracing to enter the solution at its maximum when soil loss was constrained at the first level.

Table 6 summarizes the results of the Lp analysis for the medium sized farm Profit maximizing rotations and BMPs are identified for each model, soil loss constraints are presented, and the impact on net farm income is shown.

## Results: Large Farmsize

A 2,700-acre farm was used to represent large scale dryland operations in the region. Yields of 32 bushels per acre for winter wheat, 38 bushels per acre for spring barley and 1 ton per acre for cut grass were assumed. Returns were based on prices of $3.50 per bushel of wheat, $2.70 per bushel of barley and $50 per ton for grass if any was harvested. Soil loss was originally unrestricted at 3.95 tons per acre on the large farm.

As with the other representative farms, the winter wheat-fallow and spring barley rotation was selected as the most economical. This rotation contained less erosive ground and more cropped land, particularly more barley, than the other rotations in the analysis, therefore making it the most efficient for all soil loss levels.

The BMP mix which satisfied the first soil loss constraint of 3.52 tons per acre was minimum tillage on 93 percent of the farm and stripcropping on 9 percent. The next soil loss constraint of 2.78 tons per acre caused 100 percent of the farm to be placed under crop residue management. Stripcropping was increased to 33 percent, the maximum allowed for this BMP, and terracing entered at 14 percent. The final constraint level of 2.28 tons of soil loss per acre resulted in application of all the BMPs. Minimum tillage was specified for the entire farm, stripcropping for 33 percent, terracing for 41 percent and grass waterways for 1 percent. Soil loss had been reduced by 43 percent with inclusion of all four BMPs.

**Table 6. Impact of BMPs on net farm income, soil loss and rotations on a representative 1,300-acre farm in the lower zone of the Snake River Basin.**

| | Original program | Terracing programs | | | | |
|---|---|---|---|---|---|---|
| | | | | | Reduced construction costs for terracing[1] | |
| BMP scenarios Model | No yield increase for terracing | 2½% yield increase for terracing | 5% yield increase for terracing | 10% yield increase for terracing | No yield increase | 10% yield increase |
| Unrestricted model | | | | | | |
| Rotation[2] | WF and B | | | | | |
| and BMPs | None | | | | | |
| Soil loss | 9,360 | Same | Same | Same | Same | Same |
| (tons/acre) | (7.2) | | | | | |
| Net farm income | $33,676 | | | | | |
| Level one constraints | | | | | | |
| Rotation[2] | WF and B | | | | | WF and B |
| and BMPs | Stripcropping | | | | | Terrace |
| | Minimum tillage | | | | | Stripcrop |
| Soil loss | 7,000 | Same | Same | Same | Same | 7,000 |
| (tons/acre) | (5.38) | | | | | (5.38) |
| Net farm income | $31,577 | | | | | $32,576 |
| Level two constraints | | | | | | |
| Rotation[2] | WF and B | | | | | WF and B |
| and BMPs | Minimum tillage | | | | | Terrace |
| | Stripcropping | | | | | Stripcrop |
| | | | | | | Min Till |
| Soil loss | 4,500 | Same | Same | Same | Same | 4,500 |
| (tons/acre) | (3.46) | | | | | (3.46) |
| Net farm income | $29,048 | | | | | $30,261 |
| Level three constraints | | | | | | |
| Rotation[2] | WF and B | | | | | |
| and BMPs | Minimum tillage | | | | | |
| | Stripcropping | Same | Same | Same | Same | Same |
| | Terracing | | | | | |
| | Grass waterways | | | | | |
| Soil loss | 2,969 | | | | | |
| (tons/acre) | (2.28) | | | | | |
| Net farm income | $17,436 | $18,334 | $19,236 | $21,040 | $20,854 | $24,462 |

[1]Construction costs were reduced from $1.30 per lineal foot to $0.48 per lineal foot of terrace. The former cost is based on the use of a dozer, the latter on use of a terracing machine.

[2]Crop rotation: WF and B = winter wheat (25%), fallow (25%) and spring barley (50%).

The Lp runs illustrated the reduction in farm income occurring at each level of soil loss constraint in the model. Inclusion of the initial BMPs at the first constraint level caused a decrease of 2 percent in net farm income. The next soil loss constraint resulted in a further decrease of 9 percent. The final constraint level reflected the impact of the entire package of BMPs on farm income. Net farm income was lowered 27 percent with adoption of all the BMPs.

The results of the models assessing the effect of yield increases for terracing were nearly identical to the original findings. The impact on net farm income of adopting the package of BMPs was lessened slightly when terracing was accompanied by increased yields. Farm income was initially $69,997 when all BMPs were included in the solution and no yield increase was assumed for terracing. A 2 1/2 percent increase in yields on terraced acres caused net farm income to increase to $72,195. Assuming a yield increase of 5 percent increased net farm income to $74,390. An increase of 10 percent in yields resulted in a net farm income of $78,779.

Reduced construction cost for terracing in the models had no effect unless the assumption of a 10 percent yield increase was maintained. With this scenario, terracing entered the solution at the first soil loss constraint level. Terracing was substituted for the other practices as the more profitable alternative when accompanied by the 10 percent gain in yields.

Table 7 gives results of the Lp analysis for the large sized farm. Profit maximizing rotations and BMPs are identified, and accompanying net farm income and soil losses are presented.

# Conclusions

This report analyzed the effects of implementing measures to control soil erosion on three representative sized, dryland farms in the lower precipitation zone of the Snake River Basin. The practices considered were crop residue management, terracing, stripcropping and grass waterways.

**Table 7. Impact of BMPs on net farm income, soil loss and rotations on a representative 2,700-acre farm in the lower zone of the Snake River Basin.**

| | Original program | Terracing programs | | | | |
|---|---|---|---|---|---|---|
| | | | | | Reduced construction costs for terracing[1] | |
| BMP scenarios Model | No yield increase for terracing | 2½% yield increase for terracing | 5% yield increase for terracing | 10% yield increase for terracing | No yield increase | 10% yield increase |
| Unrestricted model | | | | | | |
| Rotation[2] and BMPs | WF and B<br>None | | | | | |
| Soil loss (tons/acre) | 10,665<br>(3.95) | Same | Same | Same | Same | Same |
| Net farm income | $95,998 | | | | | |
| Level one constraints | | | | | | |
| Rotation[2] and BMPs | WF and B<br>Minimum tillage<br>Stripcropping | | | | | WF and B<br>Terrace |
| Soil loss (tons/acre) | 9,500<br>(3.52) | Same | Same | Same | Same | 9,500<br>(3.52) |
| Net farm income | $94,172 | | | | | $95,499 |
| Level two constraints | | | | | | |
| Rotation[2] and BMPs | WF and B<br>Minimum tillage<br>Stripcropping<br>Terracing | | | | | WF and B<br>Min till<br>Terrace<br>Stripcrop |
| Soil loss (tons/acre) | 7,500<br>(2.78) | Same | Same | Same | Same | 7,500<br>(2.78) |
| Net farm income | $85,648 | $86,391 | $87,135 | $88,622 | $88,099 | $93,029 |
| Level three constraints | | | | | | |
| Rotation[2] and BMPs | WF and B<br>Minimum tillage<br>Stripcropping<br>Terracing<br>Grass waterways | Same | Same | Same | Same | Same |
| Soil loss (tons/acre) | 6,165<br>(2.28) | | | | | |
| Net farm income | $69,997 | $72,195 | $74,390 | $78,779 | $76,107 | $85,886 |

[1]Construction costs were reduced from $1.30 per lineal foot to $0.48 per lineal foot of terrace. The former cost is based on the use of a dozer, the latter on use of a terracing machine.

[2]Crop rotation: WF and B = winter wheat (25%), fallow (25%) and spring barley (50%).

These BMPs are all effective in reducing soil erosion. Application of the BMPs at the maximum level specified in the programs caused an average reduction in soil loss of 61 percent for the three farms studied. Soil losses averaged 6.4 tons per acre when no soil erosion control measures were practiced on the farms. Soil loss was lowered to 2.28 tons per acre on each farm with inclusion of the full package of BMPs.

Implementation of the BMPs represent a cost to the farm operator. Crop residue management had the lowest average per acre cost followed by stripcropping, terracing and grass waterways. Estimates of terracing construction costs were particularly expensive in this region compared to other parts of the state.

The linear programs present guidelines on which practices reduce income the least for a given amount of soil loss. For the small sized farm, crop residue management proved to be the most economical alternative. Stripcropping was selected as a more efficient measure on the medium sized farm, followed by minimum tillage. On the large farm, both crop residue management and stripcropping were used before the other BMPs. Terracing and grass waterways were not included in the models because of the high construction costs accompanying these practices.

The impact on net farm income of adopting the most erosion resistant package of BMPs was substantial. The average decrease in net returns to the three farm operations was 36 percent. This impact would be reduced somewhat if terracing were accompanied by an increased yield on the terraced portion of the farm.

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# Appendix A — Input Costs by Farming

**Appendix A. Table 1. Input costs per crop.**

| Farm size | Crop* | Seed lb/acre @ 11 to 12¢/lb | | Anhydrous ammonia lb/acre @ 21¢/lb | | 2-4-D qt/acre @ $3.25/qt | | Total cost |
|---|---|---|---|---|---|---|---|---|
| Small | WW-F | 60 | $6.60 | 40 | $ 8.40 | .38 | $1.23 | $16.23 |
| (500 acres) | SB | 60 | $7.20 | 50 | $10.50 | .38 | $1.23 | $18.93 |
| Medium | WW-F | 60 | $6.60 | 40 | $ 8.40 | .38 | $1.23 | $16.23 |
| (1,300 acres) | SB | 60 | $7.20 | 60 | $12.60 | .38 | $1.23 | $21.03 |
| Large | WW-F | 55 | $6.05 | 40 | $ 8.40 | .5 | $1.63 | $16.08 |
| (2,700 acres) | SB | 60 | $7.20 | 40 | $ 8.40 | .25 | $0.81 | $16.41 |

*WW-F = winter wheat-fallow, SB = spring barley.

**Appendix A. Table 2. Operating costs of terracing per crop.**

| Farm size | Crop* | Added fuel oil, lube and repair costs | Added labor costs | Added herbicide, fertilizer and seed costs | Total added operating costs |
|---|---|---|---|---|---|
| Small | WW-F | $3.63 | $1.20 | $1.62 | $6.45 |
| (500 acres) | SB | $3.08 | $1.03 | $1.89 | $6.00 |
| Medium | WW-F | $3.21 | $0.90 | $1.62 | $5.73 |
| (1,300 acres) | SB | $2.95 | $0.80 | $2.10 | $5.85 |
| Large | WW-F | $3.96 | $0.95 | $1.61 | $6.52 |
| (2,700 acres) | SB | $3.40 | $1.74 | $1.64 | $6.78 |

*WW-F = winter wheat-fallow, SB = spring barley.

**Appendix A. Table 3. Operating costs of stripcropping per crop.**

| Farm size | Crop* | Added fuel oil, lube and repair costs | Added labor costs | Added herbicide, fertilizer and seed costs | Total added operating costs |
|---|---|---|---|---|---|
| Small | WW-F | $2.52 | $1.20 | $1.62 | $5.34 |
| (500 acres) | SB | $2.14 | $1.03 | $1.89 | $5.06 |
| Medium | WW-F | $2.23 | $0.90 | $1.62 | $4.75 |
| (1,300 acres) | SB | $2.08 | $0.80 | $2.10 | $4.98 |
| Large | WW-F | $2.74 | $0.95 | $1.61 | $5.30 |
| (2,700 acres) | SB | $2.35 | $1.74 | $1.64 | $5.73 |

*WW-F = winter wheat-fallow, SB = spring barley.

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