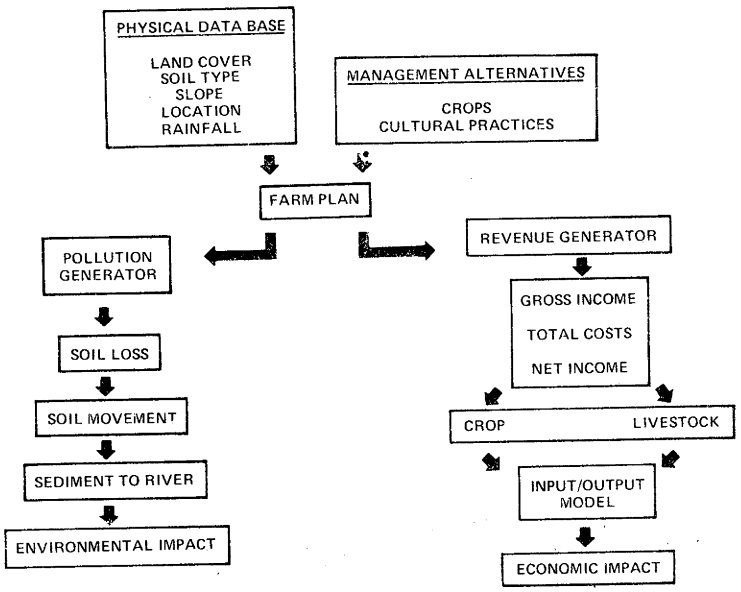

Figure 1. Simulation Model of Farm Sector.

Land Use and Nonpoint Pollution in the Sheyenne Valley

William C. Nelson and Rodney J. Ehni

Agriculture possesses the greatest potential for affecting the quality of the nation's water resources. Agriculture's potential for lowering water quality appears greater than all other industries combined (1). Erosion by surface-runoff produces four billion tons of sediment each year (2). Three-fourths of this sediment comes from agricultural land (3). Sediment carries nutrients (and pesticides) and is a primary hazard to water quality (4). Sediment is felt to be the major agricultural pollutant.

The potential damage from agricultural pollutants has generated demands to examine alternative control mechanisms. The Federal Water Pollution Control Act Amendments of 1972 contain a section (208) which states the Governor of each state must prepare a plan which shall include "a process to (i) 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 (ii) set forth procedures and methods (including land use requirements) to control, to the extent feasible, such sources" (1). The passage of the 1972 amendments prompted a group of scientists from North Dakota State University, Moorhead State University and Concordia College to develop a project to analyze the land use and water quality relationships in the lower Sheyenne River Valley (2). This is a report on the results of one part of the study.

About 90 per cent of the land in the lower Sheyenne River Valley is in agriculture. A computerized model was developed by Ehni to simulate the relationships between crop agriculture, the regional economy and sediment entering the Sheyenne river. The situation model used two data bases, one on physical characteristics and the other for various management alternatives (Figure 1). The physical data base contained the dominant soil type, rainfall, length and percent of slope, and type of land cover of each section (640 acres) of land. Several potential cropping combinations and erosion control practices were in the management alternatives base.

Environmental effects were measured by computing the amount of soil reaching the lower Sheyenne river in the form of sediment. Economic effects were measured by calculating total revenue and net revenue for crop activities, livestock activities, and total agricultural activities. The economic indicators were computed as basin totals and on a per-acre basis. The total revenue figures for crop activities and livestock activities were inputs to the North Dakota input-output model. It estimated the impact (gross receipts) from agricultural revenues in the basin.

The model synthesized all information for parcels of land which are one square-mile sections. The information by parcels was aggregated into

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several watersheds (subbasins) to measure the environmental effects. The parcels also were aggregated into basin totals to yield economic effects.

Environmental effects were estimated by the universal soil loss equation (USLE) and sediment delivery ratios to calculate the total soil eroded in the basin and the per cent of the eroded soil which would be expected to reach the lower Sheyenne river as sediment. The USLE evaluated the effects of rainfall, soil type and the generalized length of slope and gradient of a parcel, along with crop management and erosion control practices for that parcel. Sediment delivery ratios were based on the size of the drainage area (watershed). The delivery ratios gave the percentage of soil moved that was expected to reach the river as sediment from a particular watershed. The USLE computed the total soil moved by sheet and rill erosion in tons on a parcel. The amount of soil loss was added for each subbasin and multiplied by the sediment delivery ratio to measure the total sediment reaching the river from each watershed.

The economic section evaluated the effects of rainfall and soil type on the yields of crops and forages. The effect of soil type was evaluated by a North Dakota Soil Productivity Index. Rainfall effects were previously evaluated by the "ARE" interdisciplinary study team. Crop and livestock production decisions were made for each parcel, and the cost and revenue resulting from the decisions were computed. The results were summed to form basin totals and used to develop the economic indicators. Total revenue from crop production and total revenue from livestock production represented gross business volume in the agriculture-crop and agriculture-livestock sectors of the input-output model. Although the model used the square mile parcels as a basis for making calculations, it did not attempt to predict soil loss or cost and revenue from any individual parcel. All information was applied to the basin and reflected the average conditions throughout the basin.

Cropping patterns and cultural practices currently existing in the basin yielded annual soil loss estimates of 0.62 tons per acre (Table 1). Approximately 0.13 tons of sediment per acre were estimated to reach the river each year under average rainfall conditions. This translated into 43,225 tons of sediment annually entering the Sheyenne river between Bald Hill Dam and its confluence with the Red river.

Restrictions on cropping patterns (elimination of summer fallow and limiting the acreage of row crops, such as corn and sunflowers) had very little effect on profitability and land values, but did result in a major reduction in soil loss and sediment. Both of the profit maximization alternatives (change to higher valued crops, such as wheat and barley, and limiting summer fallow) resulted in soil loss and sediment values similar to the current situation with restrictions; profitability and land values of cropland were substantially improved. Profitability of pasture decreased slightly because of high productivity land being shifted from pasture to crops.

Table 1. Preliminary Results of Farm Simulation in Lower Sheyenne River Basin.

Item	Current Situation	Current With Restrictions	Profit Maximization	Profit Maximization With Restrictions
Soil Loss in Tons/Acre	.62	.27	.33	.29
Sediment in Tons/Acre	.13	.06	.07	.06
Cropland				
Profit/Acre	$ 38.37	$ 37.14	$ 48.21	$ 44.89
Land Value	480.00	464.00	603.00	561.00
Pastureland				
Profit/Acre	9.19	9.23	8.77	8.77
Land Value	115.00	115.00	110.00	110.00
Regional Gross Receipts in Millions	153.6	155.5	191.5	184.0

The results are preliminary and will undergo additional analysis for accuracy and reliability. The current results indicate that soil loss can be reduced and, consequently, water quality in the Sheyenne river can be improved substantially by eliminating summer fallow, limiting row crops and emphasizing the production of high-value small grains. The changes not only improve water quality, but also increase profits per acre and regional gross receipts. The preliminary results suggest that procedures to control nonpoint pollution from cropland will not cause economic losses to farmers and may actually improve their economic situations.

1. U.S. Congress. 1972. **Federal Water Pollution Control Act Amendments of 1972.** Public Law 92-500, Washington, D.C.

2. Sheyenne River Basin Research Team. 1974. **Lower Sheyenne River Basin: Water-Land-People,** North Dakota Research **Report No. 55.**