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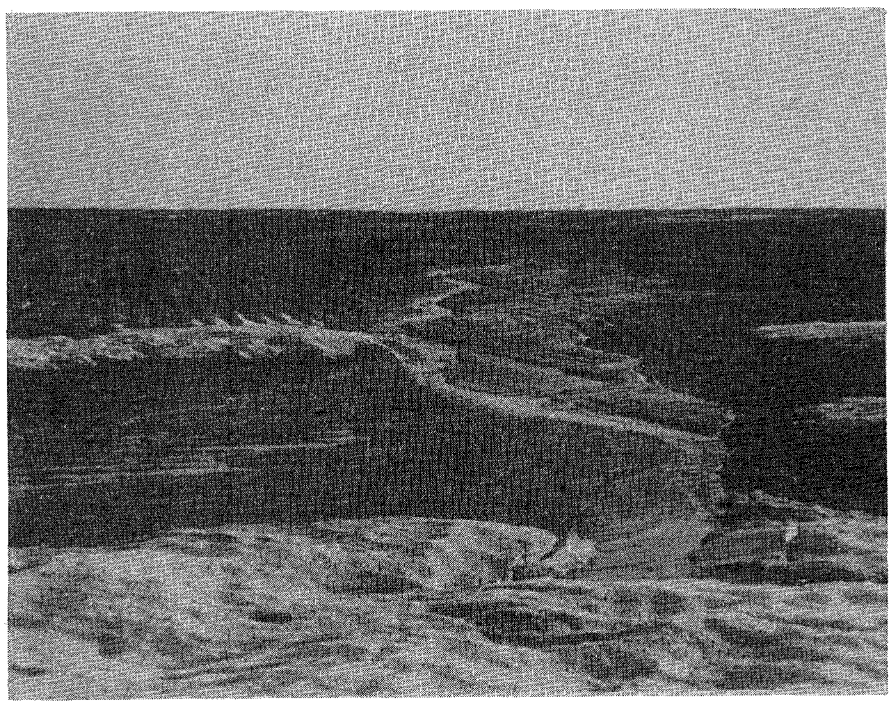
Effects of alternative cropping patterns and management decisions on soil erosion and revenue, region VII, North Dakota



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FOREWORD

The implementation of Public Law 92-500, Section 208 has created a need for methods to evaluate the cost of desired water quality levels. This report focuses on the economic impact of selected agricultural management policies and the corresponding effect upon soil erosion.

We would like to extend a special thanks to:

Karen Santoyo for her efforts in converting the raw data into a useable form; and

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Highlights

The effects of land use alternatives on the economy and the environment of State Region VII are examined in this study. The results are based on the RIMAS-AGSIM Model, which estimates the soil erosion, sediment delivery, average net return, and the economic impact of regional management alternatives.

The RIMAS study area is a subregion of State Region VII consisting of parts of Burleigh, McLean, Mercer, Morton, and Oliver counties. Approximately one-fourth of the land area in State Region VII drainage systems has been defined as critical or highly erosive areas.

Current practices allow over 6 tons/acre of soil erosion (2.4 tons/acre on all land) on cropland in the RIMAS area. This is over the 5 ton/acre maximum tolerable limit. The elimination of summer fallow would decrease this level to under 4 tons/acre (1.7 tons/acre on all land) and would increase the economic impact of agriculture on the region to over 300 million dollars. The cropland erosion could be further reduced to approximately 1.75 ton/acre by using contour strip cropping. The critical areas show negative net returns and high levels of erosion when used as cropland. If these areas were summer fallowed, estimated soil erosion would exceed 19 tons/acre.

Cropland erosion per acre on critical areas was estimated to be 10.8 tons for the drainage systems in State Region VII. Fifteen percent of the critical areas in the region was cropland. Total sediment loads for the region could be lowered by 16 percent by using these critical areas as pasture or for the production of hay. Replacing nutrients lost in the erosion process costs the region 2.7 million dollars each year.

EFFECTS OF ALTERNATIVE CROPPING PATTERNS AND MANAGEMENT DECISIONS ON EROSION AND FARM REVENUE, REGION VII, NORTH DAKOTA

Rodney J. Ehni, Louis A. Ogaard, and William C. Nelson*

Relationship Between Agriculture and Water Quality

Ninety-two percent of the land in State Planning Region VII is used for agricultural production. Soil loss from agricultural land, even though low on a per acre basis, is the dominant force affecting water quality in the region. Other sources of water pollutants, such as urban areas and mining operations, may have major effects in specific areas, but the total land area devoted to these uses is less than 2 percent of the region (12).

Agricultural activity affects water quality primarily due to soil eroded and moved into streams. Nitrogen in the form of NH_3 and NO_3 and phosphate (PO_4) are carried with the sediment. The quantity of soil loss depends on the type of land use, its soil association, degree and length of slope, rainfall, and conservation practices.

The analysis of soil loss in State Planning Region VII is based on the RIMAS-AGSIM model. RIMAS--Resource Inventory, Monitoring, and Analysis System--is a research project in the Department of Agricultural Economics, North Dakota State University.

Scope of RIMAS

The resource inventory, monitoring, and analysis system (RIMAS) is a set of computer programs designed to represent the region and to project impacts of coal development. RIMAS is composed of six modules: 1) Agricultural and Land Use Simulation (AGSIM); 2) Environmental Quality (ENVIR); 3) Base Economic System (ECON); 4) Coal Mining-Conversion System (COAL); 5) Demographic System (DEMO); and 6) Governmental System (GOVT) (Figure 1). Each module is partially independent, it can operate separately, but also generates output needed by other modules and/or requires data generated by one or more other modules in RIMAS.

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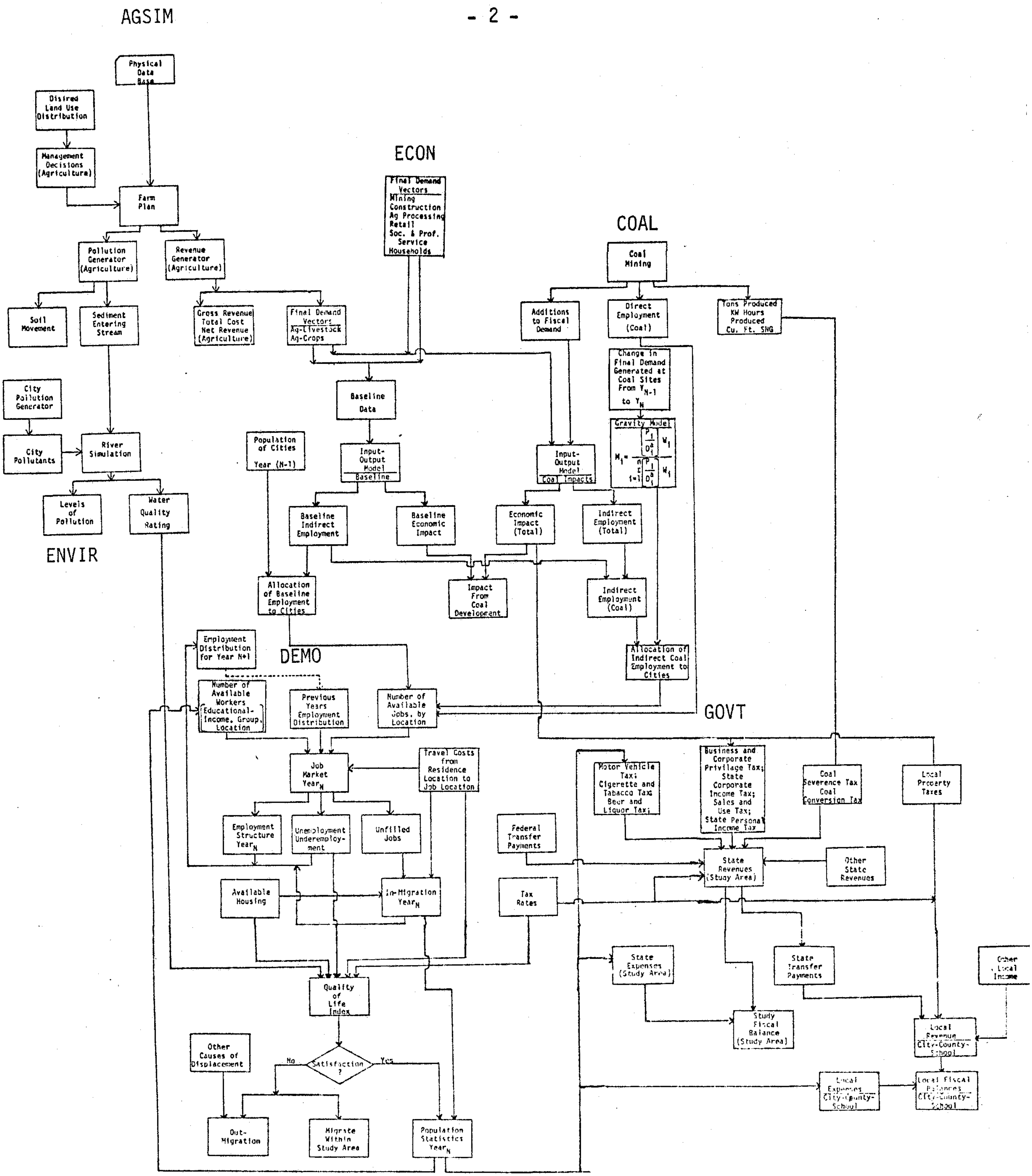

Figure 1. Resource Inventory, Monitoring and Analysis System

Description of the RIMAS Area

The RIMAS study area consists of 3,295 square miles in Region VII. All of Oliver County and portions of Burleigh, McLean, Mercer, and Morton counties are included (Figure 2).

Climate

The study area is semiarid with an average annual precipitation of 16 to 17 inches which occurs mainly in the form of rain from April to September. The annual average snowfall is about 38 inches. The north central location of North Dakota precludes any moderating effects from such sources as large bodies of water or ocean currents. Consequently, the climate is best described as continental with great fluctuation in the daily and annual air temperatures. An average of 45 to 55 days have below zero readings and 190 to 200 days have temperatures of 32^{o} Fahrenheit or below. There are between 16 and 28 days with temperature readings of 90^{o} Fahrenheit or above. The average wind speed is about 11 miles per hour. Winds are strongest in April, averaging 14 mph and weakest in July, averaging 10 mph (20).

Soils

Soil is defined as the group of natural bodies occupying the unconsolidated portion of the earth's crust, capable of supporting plant life and having characteristics and properties resulting from the combined effect of climate and living organisms--as modified by time and topography--upon parent material. A soil association is a group of defined and named soils which occur in a predictable proportion and pattern on a characteristic landscape (19). The predominant soil associations in the RIMAS study area are summarized in Table 1.

The pedology of these soils dates back over a long time frame. The study area was covered by ice at various times from 10,000 to one million years ago. This "Glaciated Missouri Plateau" of the Great Plains Province may be subdivided into categories based on topography (Figure 3). The Coteau Slope and Central Zone lie immediately east and north of the Missouri River encompassing the western portions of Burleigh and all of McLean counties. This area is characterized by relatively level ground and large areas of outwash plains.

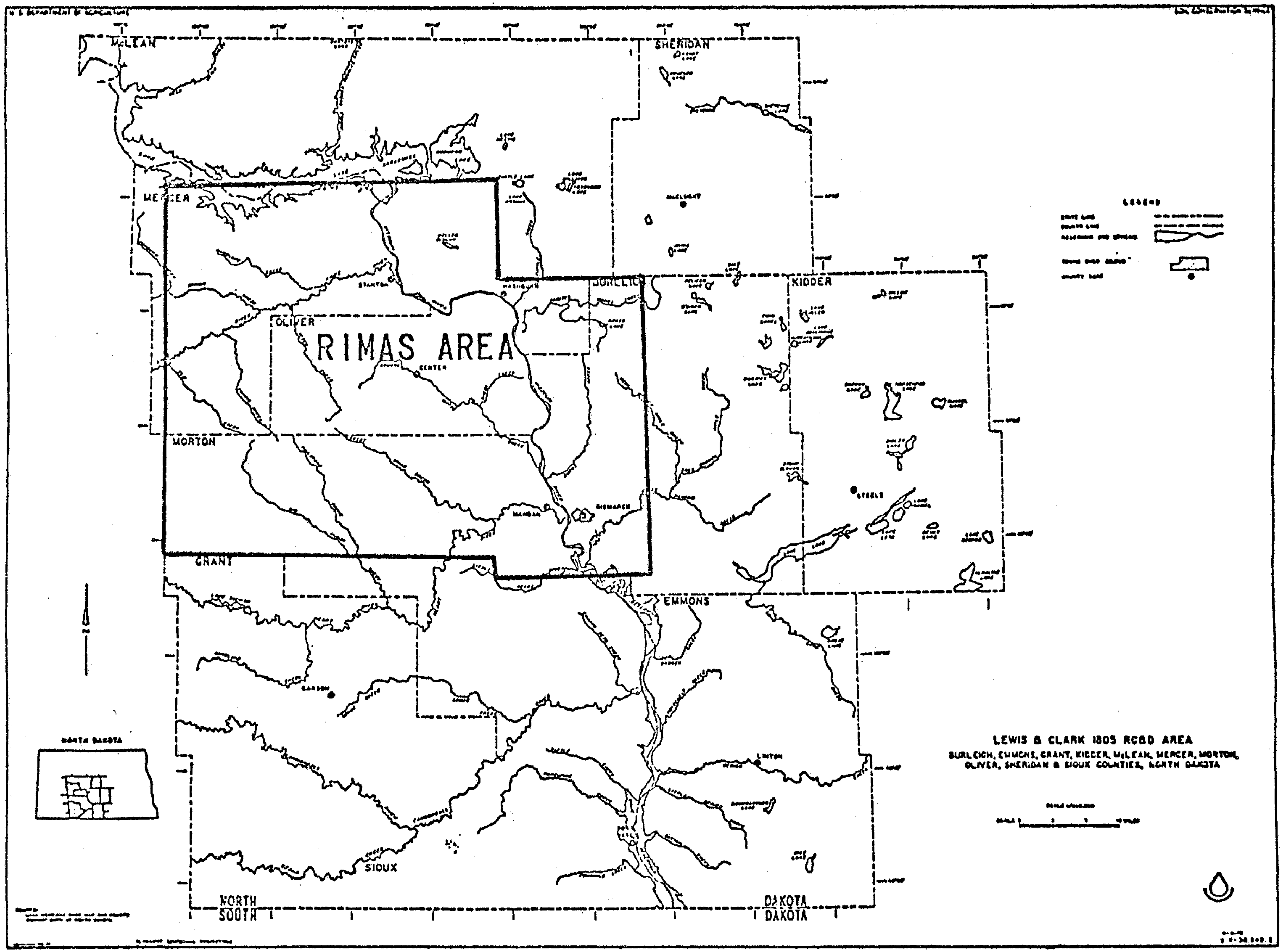

Figure 2. Study Area of the Resource Inventory, Monitoring and Analysis System, West Central North Dakota, (RIMAS) Project

TABLE 1. GENERAL SOIL DESCRIPTIONS AND MAJOR SOIL ASSOCIATIONS FOR RIMAS STUDY AREA

DARK BROWN SOILS OF SEMIARID GRASSLAND

Nearly level to gently rolling soils with thick dark brown surface layer (Chestnut) and associated soils with claypan subsoil (Solonetz) or steeply sloping soils with thin surface layer (Regosol and Lithosol).

Loams and Clay Loams
- Agar-Williams-Zahl
- Morton
- Morton-Rhoades
- Morton-Williams
- Savage-Wade-Farland
- Williams

Sandy Loams and Loams
- Parshall-Lihen

Rolling soils with thick dark brown surface layer (Chestnut) and associated steeply sloping soils with thin surface layer (Regosol).

Loams
- Williams-Zahl

SOILS OF STREAM VALLEYS

Nearly level soils on bottomlands (Alluvial), gently sloping soils on alluvial fans (Alluvial and Chernozem), and steeply sloping soils (Regosols).

Loams and Sandy Loams
- Havre-Banks

SOILS ON STEEP SLOPES

Hilly and steeply sloping soils with thin surface layer (Regosol and Lithosol) with associated soils with thick surface layer (Chernozem and Chestnut) or with claypan subsoil (Solonetz).

Hilly and Steep Land
- Bainville-Flasher-Agar
- Bainville-Morton
- Bainville-Rhoades
- Bainville-Zahl

SOURCE: Omodt, H. W., D. D. Patterson, and O. P. Olson, General Soil Map of North Dakota, North Dakota Agricultural Experiment Station, Fargo, ND, 1961.

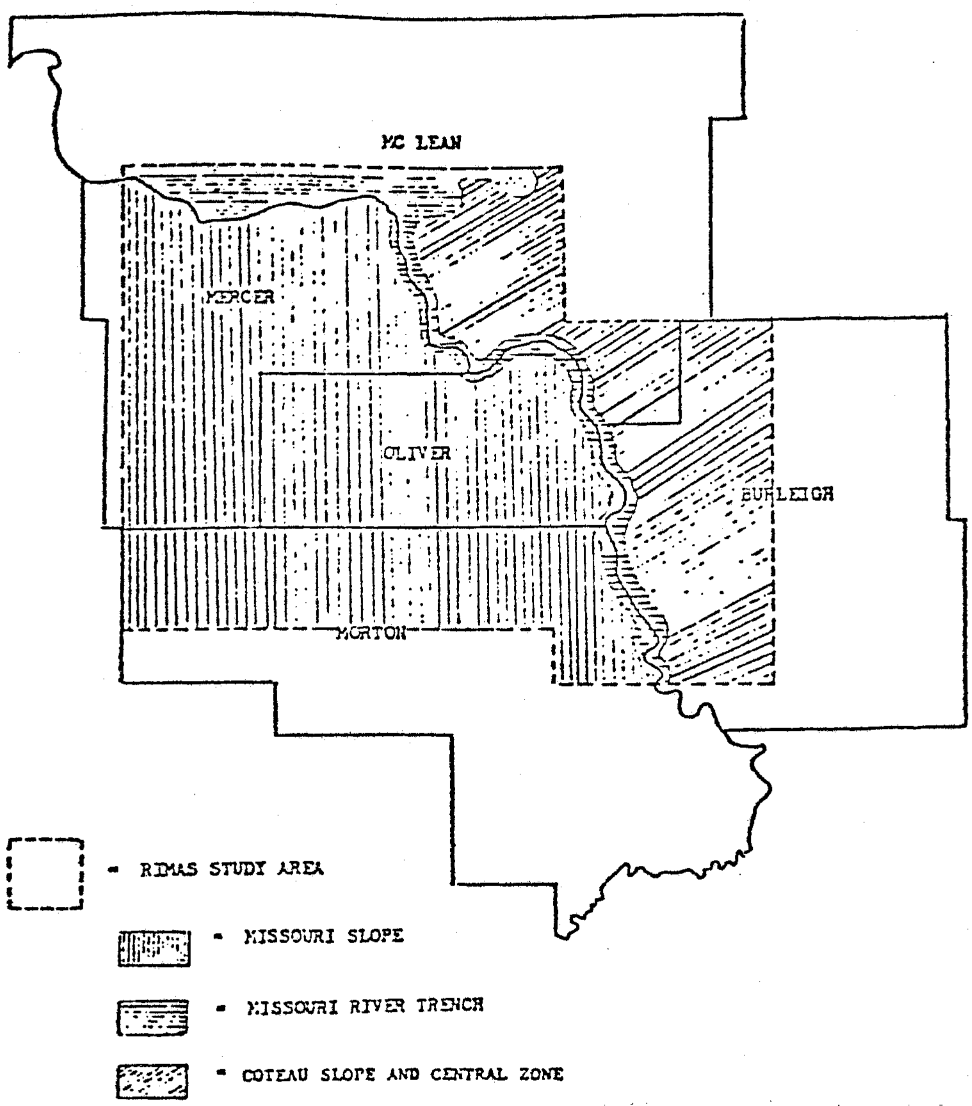

Figure 3. Geologic and Vegetation Zones Within the RIMAS Study Area

SOURCE: Soil Conservation Service, Vegetation Zones of North Dakota for Use in Range Site and Condition Classification, Lincoln, Nebraska, 1974.

The Missouri River Trench involves the channel of the Missouri River, its floodplain, and Lake Sakakawea. The present course of the river was caused by the blockage of its former route north by a glacier.

The last subdivision is the Glaciated Missouri Slope. This covers the area west of the Missouri River. Here most of the area has been mantled with glacial till. Some of this till has been worn away in places through erosion to reveal the boulders moved in glaciation (29).

Land Use

Nine categories of land use are defined in the physical data base of the simulation model. These include cropland, rangeland, river, lake, woods, mines, farmsites, cities, and wetland. Cropland and rangeland are the current major land uses within the study area. Table 2 lists the acres for each land use category in each county, which was developed from analysis of black and white quad photography (Scale 1:24000).

The major crops constituting cropland include hard red spring wheat, oats, barley, rye, flax, and alfalfa (Table 3).

Rangeland is predominantly a mixed grass prairie dominated by blue grama, needle-and-thread, and western wheatgrass (26). It is used extensively by ranchers for grazing cattle and as a source of hay. Range may be further subdivided based on the soil association and vegetation zone present. Examples of these "range site" types include saline lowland, sandy, shallow to gravel, and thin claypan.

Three rivers with their respective subbasins are simulated in the RIMAS model. These include the Knife, Heart, and Missouri rivers. All small creeks and streams in the study area eventually empty into these three drainage systems.

The lake category includes part of Lake Sakakawea and a few other smaller lakes defined on topographic maps of the area. Smaller bodies of water are classified as wetland. Wetlands, as used in the RIMAS model, are actually pothole lakes which are bodies of water with winter depths of two to three meters and which support hydrophytes.

Woodland is a small category of land use which includes hardwood draws, shelterbelts, and riparian forest. Other minor categories include strip mines, farms, and cities. The strip mining process necessitates the conversion of approximately 64 acres/million tons of mined coal from its present land use, usually cropland or rangeland, to stripped land (11).

Farms and towns are two of the smallest land use categories comprising about 1 percent of the total study area.

Agricultural Simulation (AGSIM)

The agricultural sector simulation model (AGSIM) calculates economic and environmental information based on alternate crop and livestock management

TABLE 2. ACREAGE FOR LAND USE CATEGORIES WITHIN THE RIMAS STUDY AREA

Land Use	Burleigh	McLean	Mercer	Morton	Oliver	Total RIMAS
	- - - - -	- - - - -	- - - *acres*	- - - - -	- - - - -	- - - - -
Cropland	204,515	155,841	225,002	195,957	177,714	959,029
Rangeland	185,042	70,044	261,416	236,240	271,275	1,024,017
River	2,802	4,684	3,773	4,242	5,818	21,319
Lake	0	1,534	10,428	49	412	12,423
Woodland	6,966	8,339	5,836	6,087	8,415	35,643
Mines	277	754	8,730	253	2,765	12,779
Farmstead	3,466	2,030	3,736	4,006	3,165	16,403
Urban	10,463	1,317	1,694	6,998	389	20,861
Wetlands	1,829	3,137	350	568	447	6,331
Total	415,360	247,680	520,965	454,400	470,400	2,108,805

SOURCE: Interpreted by technical staff of RIMAS study team from Bureau of Land Management aerial photos taken in 1975.

TABLE 3. AGRICULTURAL ACTIVITY IN THE RIMAS AREA, 1971-1976 COUNTY AVERAGES

Activity	County					
	Burleigh	McLean	Mercer	Morton	Oliver	Total
Crop	- - - - -	- - - - -	- - - *acres planted*	- - - - -	- - - - -	- - - - -
Spring Wheat-Fallow	67,820	165,020	71,800	88,560	28,820	422,020
Spring Wheat-CC[a]	54,560	33,960	14,600	29,400	15,080	147,600
Durum-Fallow	10,520	139,720	2,640	2,900	400	156,180
Durum-CC[a]	9,740	16,720	340	1,500	400	28,700
Barley-Fallow	8,040	14,380	4,300	16,120	3,200	46,040
Barley-CC[a]	12,040	8,480	3,060	10,780	3,460	37,820
Oats	57,820	60,080	34,260	69,080	23,220	244,460
Flax	22,100	31,880	3,240	2,060	4,600	63,880
Summer Fallow	92,600	335,600	82,400	113,800	38,800	663,200
Alfalfa	63,240	28,100	34,780	78,400	31,800	236,320
Other Tame Hay	20,120	20,700	15,560	31,180	9,520	97,080
Corn Silage	15,100	6,020	11,040	17,960	8,400	58,520
Total Acreage	434,500	865,240	278,480	463,080	168,080	2,210,000
Livestock	- - - - -	- - - - -	- - - *number*	- - - - -	- - - - -	- - - - -
All Cattle[b]	84,000	64,000	67,000	114,000	38,000	367,000
Milk Cows[b]	3,100	3,000	3,600	8,200	2,600	21,500
All Hogs	11,100	4,800	4,600	14,600	6,500	41,600

[a]Continuous Cropped
[b]1972 to 1976 five-year average

SOURCE: North Dakota Crop and Livestock Statistics, Agricultural Statistics Statistical Reporting Service, United States Department of Agriculture, in cooperation with the Department of Agricultural Economics, North Dakota State University, Fargo, ND, 1973-1977.

decisions in the RIMAS area. The simulation model consists of three main parts: the management allocator, the revenue generator, and the pollution generator. The management allocator controls the agricultural land use for each section in the study region. Agricultural land use is based on the desired cropping patterns and pasture usage interacting with the physical characteristics by county. The revenue and pollution models compute the soil movement and revenue information for each section (640-acre unit) in the study area. This information is aggregated to watershed, county, and area totals to estimate total sediment entering the rivers from the watersheds and total economic impact.

The revenue and pollution generators both use the same physical data base in estimating the effects of land use alternatives. The physical data base consists of the present distribution of cropland, pasture, range, woodland, wetlands, and mined or other land uses; the soil association; the generalized degree of slope; length of slope; and the legal and geographic descriptor of each section. A flowchart of the AGSIM model is shown in Figure 4.

Management Allocator. The management allocator is used as a proxy for the management decisions made by farmers and ranchers in the study region. These proxy decisions may be developed for any distribution of cropland and rangeland.

The cropland from each section of land in the study area was divided into fields of 100 acres or less.* Each field was assigned to one of the 12 crop activities used in the study by a random number generator (Appendix A). Acreage was aggregated by crop and county to obtain the predetermined distribution of cropland and rangeland.

The random number generator was also used in the assignment of one of three types of livestock grazed on pasture acreage. The number of livestock that theoretically could be supported on this acreage was estimated by dividing the available Animal Unit Months (AUM's) by the required AUM's per animal. Available animal unit months were estimated by multiplying the rangeland productivity index (in AUM's/acre, Appendix A) of each section's soil association by the number of acres of pasture and range on the section.

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*All cropland on a section was divided into fields of 100 acres. Any residual crop acreage was left as a separate field.

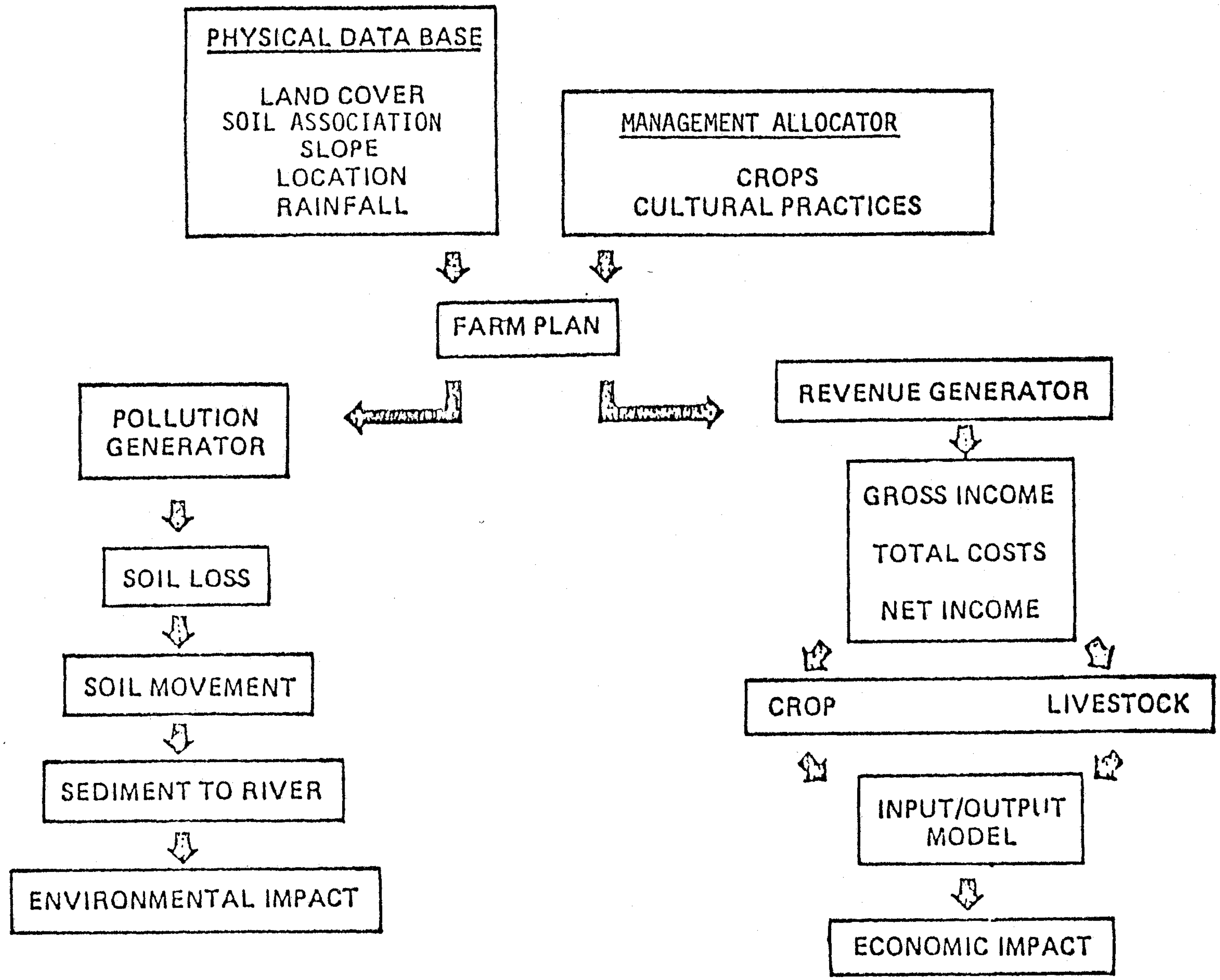

Figure 4. General Flowchart of the Agricultural Sector Simulation Model

Required animal unit months per animal were estimated by multiplying the monthly AUM requirements per animal times the number of months of grazing.

A multiplier was developed to bring the recommended grazing practices in line with the actual grazing practices. The multiplier was estimated by dividing the actual number of each type of livestock per county by the number that theoretically could be supported in that county. These multipliers were applied to each type of livestock to reflect actual conditions.

Erosion control codes were assigned to each parcel. They were based on the generalized slope of the section and the intensity of erosion control desired for the study region.

Revenue Generator. The revenue generator develops cost and revenue information based on the relative productivity of each section and aggregates this information to county and region totals. Total revenue is the sum of total revenue from crop activities and total revenue from livestock activities. Total crop revenue from a section of land is found by multiplying the expected yield for each crop activity in the section times the expected per unit price for the commodity. The expected crop yield on a given section reflects the average county yield adjusted for rainfall and the relative productivity of that section. (Prices, average yields, the effects of rainfall, and productivity indices are found in Appendix A.)

Total livestock revenue is found by multiplying the revenue from one animal unit (sales from young and culls) times the number of animal units supported on the section (Appendix A).

Costs are assumed to remain constant throughout the area. Total cost is found by multiplying the number of acres or animals times the average cost per acre or animal (Appendix A). Subtracting the total cost from total revenue gives the net revenue for the section. Total revenue, total cost, and net revenue are aggregated to an area total for crop activities, livestock activities, and agricultural activities. The total for the area is divided by the number of crop acres, pasture acres, and total agricultural acres, respectively, to find average total revenue, average total cost, and average net revenue for cropland, pasture and range, and agricultural land for the RIMAS area. Total revenue from crops and total revenue from livestock are two of the eight final demand vectors in the North Dakota Input-Output Model (Appendix B). The input-output model is used to estimate gross business volume changes in Region VII due to changes in agricultural management practices.

Pollution Generator. The pollution generator estimates soil movement on each section of land, aggregates this soil loss to watershed totals, and estimates sediment entering streams. The total amount of soil movement on a parcel of land is found by using the Universal Soil Loss Equation (31):

$$A = R \cdot K \cdot L \cdot S \cdot C \cdot P$$

Where A = Annual soil loss in tons per acre per year
R = Rainfall factor
K = Soil erodibility factor
L = Length of slope factor
S = Slope factor
C = Crop management factor
P = Erosion control practice factor

These factors relate physical aspects of the section with management decisions concerning a given section.

The soil loss from each field is estimated along with the soil loss from pasture and woodlands. The total soil movement (the sum of soil losses from cropland, pasture and range, and woodland) is aggregated to watershed and area totals. The average soil movement from all land and the average soil movement from cropland are then computed. The total amount of sediment (suspended solids) contributed from each watershed is estimated by multiplying a delivery ratio, based on the size of the drainage area, times the total soil movement in the watershed.

Analysis of Agriculture and Soil Loss Relationships

The RIMAS area includes about 2.2 million acres of the 9.3 million acres in Region VII. Results based on the RIMAS model will be generalized to the entire region as the agricultural land in the RIMAS area is assumed to be representative of the larger region. The soil loss effects of changed cropping patterns and conservation practices in the RIMAS area would have similar effects on the region.

Areas of highly erodible soil were identified for the RIMAS area and for the region (32). Analysis of agricultural activities and resulting soil losses on highly erodible soils in the RIMAS area also will be generalized to the region.

In each of the uses of the RIMAS model, only land contributing sediment to a river or stream is considered in the soil loss and sediment estimates. Land which is not a part of a drainage region of a river or stream was not considered as a contributing section (Table 4).

TABLE 4. COMPARISON OF TOTAL RIMAS AREA TO SEDIMENT CONTRIBUTING AREAS

Land Use	Total RIMAS Area		Sediment Contributing Area Only	
	Acres	Percent	Acres	Percent
Cropland	959,029	45.48	261,986	35.26
Rangeland	1,024,017	48.56	415,032	55.86
River	21,319	1.01	20,129	2.71
Lake	12,423	0.59	366	0.05
Woodland	35,643	1.69	27,617	3.72
Mines	12,779	0.60	5,653	0.76
Farmstead	16,403	0.78	4,457	0.60
Urban	20,861	0.99	7,029	0.94
Wetlands	6,331	0.30	771	0.10
Total	2,108,805	100.00	743,040	100.00

The area contributing sediment comprises 35 percent of the total RIMAS area. Net revenue estimates are based on the total RIMAS area.

RIMAS Area

All Agricultural Land. Cropland in contributing sections generates an annual average of 6.06 tons per acre of soil loss under current cropping patterns, tillage practices, and normal rainfall distribution (Table 5). This is an average of 2.41 tons per acre per year for all agricultural land. Agricultural land includes cropland, pasture, and woodland. The distribution of land use under current cropping patterns is given in Appendix A, Table A-14.

Elimination of summer fallow from the cropping pattern (Appendix A, Table A-15), resulted in major changes in soil loss and net revenues. Soil losses were reduced by 35 percent. Revenues from cropland nearly doubled.

An average of 25 to 30 percent of cropland was summer fallowed from 1971 to 1976. Summer fallow has been a normal practice in this area for a number of reasons. During the period when farm programs restricted acreage,

TABLE 5. NET REVENUE, SOIL LOSS, AND SEDIMENT BY CROPPING PATTERN AND EROSION CONTROL PRACTICE FOR RIMAS AREA

Management Alternatives	Net Revenue Per Acre			Soil Loss Per Acre		Sediment Per Acre
	Cropland	Pasture	Total	Cropland	All Land	
	---------dollars--------			-------tons-------		--------
Normal						
No Conservation Practice	6.78	2.82	4.73	6.06	2.41	0.31
Contour or Strip Cropping	6.78	2.82	4.73	5.43	2.16	0.28
Contour and Strip Cropping	6.78	2.82	4.73	2.68	1.07	0.14
Normal-No Summer Fallow						
No Conservation Practice	12.22	2.82	7.36	3.96	1.67	0.22
Contour or Strip Cropping	12.22	2.82	7.36	3.51	1.49	0.19
Contour and Strip Cropping	12.22	2.82	7.36	1.77	0.75	0.10
Small Grains and Hay						
No Conservation Practice	12.56	2.82	7.53	3.78	1.61	0.21
Contour or Strip Cropping	12.56	2.82	7.53	3.37	1.44	0.19
Contour and Strip Cropping	12.56	2.82	7.53	1.71	0.73	0.10
All Small Grains						
No Conservation Practice	5.88	2.82	4.30	4.51	1.87	0.24
Contour or Strip Cropping	5.88	2.82	4.30	4.03	1.67	0.22
Contour and Strip Cropping	5.88	2.82	4.30	2.01	0.84	0.11
All Hay						
No Conservation Practice	30.03	2.82	16.00	1.49	0.80	0.10
All Summer Fallow						
No Conservation Practice	-25.93	2.82	-11.09	9.78	3.72	0.48
All Pasture						
No Conservation Practice	2.82[a]	2.82	2.82	0.38	0.38	0.05

[a]Value of cropland when used as pasture.

a percentage of cropland was required to be summer fallowed. This practice has continued partially through inertia, and partially to conserve moisture supplies and reduce weed problems. Water conservation by summer fallow is not necessarily an economic practice during normal precipitation patterns. Herbicides are usually a more economical method to control weeds than summer fallow and farm programs no longer require summer fallow.

Two other rotations, small grains and hay, and all small grains yield soil losses similar to the normal cropping pattern excluding summer fallow. Hay and pasture yield minimum soil losses while all summer fallow yields an average soil loss of nearly 10 tons per acre. (Distributions are given in Appendix A, Tables 16-18.)

Soil loss and sediment reductions can be obtained with strip-cropping and contouring, separately or jointly. Only a minor reduction in soil loss is achieved by each conservation practice separately; however, over a 50 percent reduction can be achieved by a combination of both practices. Contour strip-cropping of the normal cropping pattern and excluding summer fallow reduces soil loss from 6.06 tons per acre to 1.77 tons per acre of cropland.

Accurate data on annual cost and revenue effects of contour and strip-cropping are not available for this area. Contour and strip-cropping are normally assumed to increase yields and operating costs by a small amount. Quantitative estimates of these effects were unavailable, so the effects were assumed to balance and net revenues were assumed to be constant. The Soil Conservation Service does have estimates of the first year costs of establishing conservation practices. Contouring is estimated to be $7.50 per acre; strip cropping, $4.97 per acre; and a combination of contour strip-cropping, $9.94 per acre. Amortization of these costs at 8 percent over 20 years results in annual costs from $0.50 to $1 per acre.

Each of the alternative cropping patterns and conservation practices which exclude summer fallow result in similar economic impacts, $299.8 million to $306.6 million (Table 6). Inclusion of summer fallow in the rotation reduces the total economic impact by $36.2 million to $43.0 million. All summer fallow and pasture result in major reductions in economic activity in the region.

TABLE 6. ECONOMIC IMPACT OF AGRICULTURE IN THE RIMAS AREA ON REGION VII

Cropland Use	Gross Business Volume Crop Sector	Livestock Sector	Total Impact
Normal	$174,820,000	$88,841,000	$263,661,000
Normal-No Fallow	217,781,000	88,832,000	306,613,000
Small Grains & Hay	217,276,000	88,832,000	306,108,000
All Small Grains	216,645,000	88,805,000	305,450,000
All Hay	210,932,000	88,823,000	299,755,000
All Summer Fallow	a	88,841,000	88,841,000
All Pasture	82,793,000	88,404,000	171,197,000

[a]Summer fallowing does not produce an economic return.

High Erosion Areas

Sections (640 acre units) in the RIMAS area with 95 percent or more of high erosion soil associations were isolated (32) and a special set of crops were evaluated on these sections (Table 7). Agricultural land use on highly erodible soil associations was 15 percent crops and 85 percent rangeland.

Negative returns were estimated for each of the grain crops. This is due to the low productivity rating of the highly erodible soil associations. Each of the grain crops was assumed to be continuously cropped. Positive net revenues were achieved with alfalfa, tame hay, and converting cropland to permanent pasture.

Soil losses from grain production were 8.64 tons per acre annually from highly erodible cropland and averaged 1.61 tons per acre per year for all agricultural land.* A fifty percent reduction in soil losses was estimated with contour strip-cropping. An annual average of nearly 19 tons per acre of soil loss can be expected under conditions of continuous summer fallow from the areas with highly erodible soil associations. There are approximately 680 sections (435,200 acres) in the RIMAS area with 50 percent or more of their area designated as highly erodible.

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*The relatively low soil loss of 1.61 tons per acre was due to the distribution of land use on highly erodible soil associations, 85 percent rangeland and 15 percent cropland.

TABLE 7. NET REVENUES AND SOIL LOSS, BY CROP AND EROSION CONTROL PRACTICE FOR HIGH EROSION AREAS IN THE RIMAS AREA

Management Alternatives[a]	Net Revenue Per Acre			Soil Loss Per Acre	
	Cropland	Pasture	Total	Cropland	All Land
	------------dollars-----------			--------tons---------	
HRSW - 1	-1.50	2.82	2.22	8.64	1.61
HRSW - 2	-1.50	2.82	2.22	7.73	1.53
HRSW - 3	-1.50	2.82	2.22	3.87	1.17
Durum - 1	-7.52	2.82	1.30	8.64	1.61
Durum - 2	-7.52	2.82	1.30	7.73	1.53
Durum - 3	-7.52	2.82	1.30	3.87	1.17
Barley - 1	-10.24	2.82	0.85	8.64	1.61
Barley - 2	-10.24	2.82	0.85	7.73	1.53
Barley - 3	-10.24	2.82	0.85	3.87	1.17
Oats - 1	-12.55	2.82	0.49	8.64	1.61
Oats - 2	-12.55	2.82	0.49	7.73	1.53
Oats - 3	-12.55	2.82	0.49	3.87	1.17
Flax - 1	-2.39	2.82	2.07	10.56	1.79
Flax - 2	-2.39	2.82	2.07	9.45	1.69
Flax - 3	-2.39	2.82	2.07	4.72	1.25
Alfalfa - 1	23.76	2.82	5.94	2.88	1.08
Tame Hay - 1	12.99	2.82	4.33	2.88	1.08
S. Fallow - 1	-25.90	2.82	-1.51	18.88	2.55
Pasture[b] - 1	2.82	2.82	2.82	0.885	0.885

[a]Alternatives designated 1 have no erosion control practice; alternatives designated 2 have contour or strip-cropping, and alternatives designated 3 have contour with strip-cropping.
[b]The pasture alternative does not calculate average soil loss per acre (for cropland).

River Basins in State Planning Region VII

Estimates of sediment loads were developed for the major drainage areas within Region VII. These estimates were based on results from the RIMAS Agricultural Simulation Model (AGSIM). The base AGSIM model assumed a normal rainfall, a normal distribution of crop activities on cropland, and that erosion control and soil management practices were not utilized. Further assumptions which were required to extrapolate the RIMAS information to Region VII include a similar distribution of cropping activities, a similar land use distribution between the RIMAS area and Region VII. AGSIM results were also used in developing estimates of the effectiveness of selected management practices on the highly erosive areas.

The number of sections with high, medium, and low soil erosion potential were estimated for each of the major drainage systems (watersheds) in Region VII (Table 8). Only 4,362,880 acres of the 8,581,162 acres of agricultural land were identified as contributing sediment to surface waters in Region VII.

Soil Loss and Sediment

Sections of land in each watershed which received an erosion classification of low or medium were estimated to yield 2.41 tons of soil loss per acre. This is the per acre soil loss estimated by RIMAS/AGSIM for normal cropping patterns without conservation practices on all agricultural land (Table 5, Normal, No Conservation Practice). Soil loss from low and medium erosion acres was estimated by multiplying the number of acres times 2.41 tons. Sediment from each watershed was estimated by multiplying the total soil loss by its sediment delivery coefficient (based upon the size of the watershed). This procedure yielded an estimated sediment load of 571,559 tons annually in the region (Table 9).

Estimated soil loss from high erosion potential sections was 10.80 tons per acre from cropland under normal cropping patterns and 0.88 tons per acre from pasture (Appendix C). Approximately 85 percent of the highly erosive sections are currently in pasture with the remainder of the agricultural land in crops. A weighted average, .15 (10.80 tons) + .85 (.88 tons), of crop and pasture yielded an estimated 2.34 tons per acre of soil loss under normal cropping patterns (Appendix C). Soil losses from high erosion potential sections are presented in Table 10. The soil loss per acre coefficients used to compute soil losses under small grain, hay and alfalfa, pasture, and summer fallow alternatives were obtained from the RIMAS/AGSIM estimates (Table 7, Soil Loss Per Acre, All Land).

Total sediment from low and medium erosion potential areas and highly erosive areas is presented in Table 11. The major portion of sediment moved to streams and rivers is from the low and medium erosive sections under normal cropping patterns. This is because: (1) nearly three-quarters of the sections

TABLE 8. NUMBER OF LOW, MEDIUM, AND HIGHLY EROSIVE SECTIONS BY DRAINAGE SYSTEM IN STATE REGION VII

Code	Drainage System	Erosion Rating Low	Medium	High	Total	Percent Highly Erosive
		- - - *number of sections*			- - -	
A	Painted Woods Creek	69	154	18	241	7.5
B	Turtle Creek	42	13	15	70	21.4
C	Douglas Creek	46	47	25	118	21.2
D	Lake Sakakawea	17	65	80	162	49.4
E	Knife River	224	385	300	909	33.0
F	Square Butte Creek	41	115	95	251	37.8
G	Heart River	276	841	445	1,562	28.5
H	Little Heart River	54	43	102	199	51.2
I	Apple Creek	365	574	92	1,031	8.9
J	Beaver Creek	52	304	36	392	9.2
K	Cannonball River	396	556	428	1,380	31.0
L	Burnt Creek	4	88	19	111	17.1
M	Porcupine Creek	30	75	53	158	33.5
N	Missouri River (west side-Oliver County)	54	95	84	233	36.0
	Total	1,670	3,355	1,792	6,817	26.3
	Percent of Total	24.5	49.2	28.3	100.0	

SOURCE: Louis Ogaard, unpublished data, RIMAS project, Department of Agricultural Economics, North Dakota State University, Fargo, ND, 1978.

were designated as low and medium erosion potential; and (2) cropland comprises 48.7 percent of all agricultural land in the low and medium erosion sections and only 14.7 percent in the highly erosive sections. The remainder of the agricultural land is pasture.

TABLE 9. SOIL LOSS AND SEDIMENT FROM LOW AND MEDIUM EROSION POTENTIAL SECTIONS UNDER NORMAL CROPPING PATTERNS IN STATE REGION VII

Watershed	Number of Low & Medium Erosion Sections	Number of Low & Medium Erosion Acres	Delivery Ratio[a]	Estimated Soil Loss[b]	Estimated Sediment
A. Painted Woods Creek	223	142,720	.092	343,955	31,644
B. Turtle Creek	55	35,200	.117	84,832	9,925
C. Douglas Creek	93	59,520	.106	143,443	15,205
D. Lake Sakakawea	82	52,480	.099	126,476	12,521
E. Knife River	609	389,760	.070	939,321	65,752
F. Square Butte Creek	156	99,840	.091	240,614	21,896
G. Heart River	1,117	714,880	.063	1,722,860	108,540
H. Little Heart River	97	62,080	.095	149,613	14,213
I. Apple Creek	939	600,960	.068	1,448,313	98,485
J. Beaver Creek	356	227,840	.083	549,094	45,575
K. Cannonball River	952	609,280	.065	1,468,364	95,444
L. Burnt Creek	92	58,880	.107	141,900	15,183
M. Porcupine Creek	105	67,200	.099	161,952	16,033
N. Missouri River (west)	149	95,360	.092	229,818	21,143
Total	5,025	3,216,000		7,750,560	571,559

[a] Sediment delivery ratio is based on size of drainage area.
[b] Soil loss per acre is estimated at 2.4 tons per acre under normal cropping patterns.

TABLE 10. SOIL LOSS FROM HIGHLY EROSIVE SECTIONS BY CROPPING PATTERN AND CONSERVATION PRACTICE IN STATE REGION VII

Watershed	Number of High Erosion Sections	Number of High Erosion Acres	Soil Loss					
				Small Grains				
			Normal Crops[a]	Strip or Contour[b]	Strip & Contour[c]	Hay & Alfalfa[d]	Pasture[e]	Summer Fallow[f]
			tons					
A. Painted Woods Creek	18	11,520	26,957	21,888	15,322	12,442	10,138	29,376
B. Turtle Creek	15	9,600	22,464	18,240	12,768	10,368	8,448	24,480
C. Douglas Creek	25	16,000	37,440	30,400	21,280	17,280	14,080	40,800
D. Lake Sakakawea	80	51,200	119,808	97,280	68,096	55,296	45,056	130,560
E. Knife River	300	192,000	449,280	364,800	255,360	207,360	168,960	489,600
F. Square Butte Creek	95	60,800	142,272	115,520	80,864	65,664	53,504	155,040
G. Heart River	445	284,800	666,432	541,120	378,784	307,584	250,624	726,240
H. Little Heart River	102	65,280	152,755	124,032	86,822	70,502	57,446	166,464
I. Apple Creek	92	58,880	137,779	111,872	78,310	63,590	51,814	150,144
J. Beaver Creek	36	23,040	59,914	43,776	30,643	24,883	20,275	58,752
K. Cannonball River	428	273,920	640,973	520,448	364,314	295,834	241,050	698,496
L. Burnt Creek	19	12,160	28,454	23,104	16,173	13,133	10,701	31,008
M. Porcupine Creek	53	33,920	79,373	64,448	45,114	36,634	29,850	86,496
N. Missouri River (west)	84	53,760	125,798	102,144	71,501	58,061	47,309	137,088
Total	1,792	1,146,880	2,683,699	2,179,072	1,525,350	1,238,630	1,238,630	2,924,544

[a] Soil loss per acre is estimated at 2.34 tons/acre.
[b] Soil loss per acre is estimated at 1.90 tons/acre.
[c] Soil loss per acre is estimated at 1.33 tons/acre.
[d] Soil loss per acre is estimated at 1.08 tons/acre.
[e] Soil loss per acre is estimated at 0.88 tons/acre.
[f] Soil loss per acre is estimated at 2.55 tons/acre.

TABLE 11. SEDIMENT FROM HIGHLY EROSIVE SECTIONS BY CROPPING PATTERN AND CONSERVATION PRACTICE IN STATE REGION VII[a]

Watershed	Sediment From Low & Medium Erosion Acres	Sediment From High Erosion Acres					
			Small Grains				
		Normal Crops	Strip or Contour	Strip & Contour	Hay & Alfalfa	Pasture	Summer Fallow
		tons					
A. Painted Woods Creek	31,644	2,480	2,014	1,410	1,145	933	2,703
B. Turtle Creek	9,925	2,628	2,134	1,494	1,213	988	2,864
C. Douglas Creek	15,205	3,969	3,222	2,256	1,832	1,492	4,325
D. Lake Sakakawea	12,521	11,861	9,631	6,741	5,474	4,461	12,925
E. Knife River	65,752	31,450	25,536	17,875	14,515	11,827	34,272
F. Square Butte Creek	21,896	12,947	10,512	7,359	5,975	4,869	14,109
G. Heart River	108,540	41,985	34,090	23,863	19,378	15,789	45,753
H. Little Heart River	14,213	14,512	11,783	8,248	6,698	5,457	15,814
I. Apple Creek	98,485	9,369	7,607	5,325	4,324	3,523	10,210
J. Beaver Creek	45,575	4,973	3,633	2,543	2,065	1,683	4,876
K. Cannonball River	95,444	41,663	33,829	23,680	19,229	15,668	45,402
L. Burnt Creek	15,183	3,045	2,472	1,730	1,405	1,145	3,318
M. Porcupine Creek	16,033	7,858	6,380	4,466	3,627	2,955	8,563
N. Missouri River (west)	21,143	11,573	9,397	6,578	5,342	4,352	12,612
Total	571,559	200,313	162,240	113,568	92,222	75,142	217,746

[a]The sediment delivery ratio for each watershed times soil loss yields sediment.

Conservation measures, such as returning all highly erosive sections to pasture, could reduce the sediment by 125,171 tons in Region VII, a 62.5 percent reduction from highly erosive sections. This would reduce the overall level of sediment in the region by 16 percent, i.e., from 771,872 tons to 646,701 tons.

Sediment from each watershed varies from a low of 0.1244 tons to a high of 0.2855 tons per acre (Table 12). Low and medium erosive sections were assumed to remain in normal cropping patterns while the land use of the cropland portion of the highly erosive sections varied from all pasture to all summer fallow.

Value of Nutrients Lost

Sediment is not only a pollutant itself, but it also carries nutrients. In addition to the environmental effects resulting from nutrients, there is a cost of replacing these nutrients to retain productivity. This cost may be estimated for Region VII by estimating the total sediment load in Region VII.

The average sediment load for Region VII under normal conditions was estimated to equal .177 tons per contributing acre. There are 4,362,880 acres in the drainage systems of the region. This would yield a total sediment load of 771,872 tons. Estimates of the average nutrient content per ton of sediment have been developed for the drainage systems in the United States (Table 13). Nutrient loss can be estimated when these estimates are applied to the total sediment load.

TABLE 12. SEDIMENT PER ACRE FROM AGRICULTURAL LAND BY CROPPING PATTERN AND CONSERVATION PRACTICE IN STATE REGION VII

Watershed	Total Acres	Normal Crops	Small Grains: Strip or Contour	Small Grains: Strip & Contour	Hay & Alfalfa	Pasture	Summer Fallow
		-----	-----	----- tons -----	-----	-----	-----
A. Painted Woods Creek	154,240	.2212	.2182	.2143	.2126	.2112	.2227
B. Turtle Creek	44,800	.2802	.2692	.2549	.2486	.2436	.2855
C. Douglas Creek	75,520	.2539	.2440	.2312	.2256	.2211	.2586
D. Lake Sakakawea	103,680	.2352	.2136	.1858	.1736	.1638	.2454
E. Knife River	581,760	.1671	.1569	.1437	.1380	.1334	.1719
F. Square Butte Creek	160,640	.2169	.2017	.1821	.1735	.1666	.2241
G. Heart River	999,680	.1506	.1427	.1324	.1279	.1244	.1543
H. Little Heart River	127,360	.2255	.2041	.1763	.1642	.1544	.2358
I. Apple Creek	659,840	.1634	.1608	.1573	.1552	.1546	.1647
J. Beaver Creek	250,880	.2015	.1961	.1918	.1899	.1886	.2011
K. Cannonball River	883,200	.1552	.1464	.1349	.1298	.1258	.1595
L. Burnt Creek	71,040	.2566	.2485	.2380	.2335	.2298	.2604
M. Porcupine Creek	101,120	.2363	.2216	.2027	.1944	.1878	.2432
N. Missouri River (west)	149,120	.2194	.2048	.1829	.2194	.1776	.2264
Study Area	4,362,880	.1769	.1682	.1570	.1521	.1482	.1809

[a] Sum of total sediment from low, medium, and high erosion areas divided by total acres in watershed.

TABLE 13. NUTRIENT ANALYSIS OF SEDIMENT IN THE UNITED STATES

Nutrient	Nutrient Content of Sediment	Nutrient Content Per Ton
	(Percent)	(Pounds)
Nitrogen[a]	.10	2
Phosphate	.15	3
Potassium	1.50	30

[a]Includes only Nitrogen attached to soil particles.

SOURCE: Wadleigh, C. H., Wastes in Relation to Agriculture and Forestry, Miscellaneous Publication No. 1065, United States Department of Agriculture Agricultural Research Service, 1968.

The value of nutrients lost is estimated when the prices of replacing lost nutrients are known (Table 14).

TABLE 14. AVERAGE VALUE OF NUTRIENTS

Nutrient	Price (Per Pound)
Nitrogen[a] (Ammonium Nitrate, 33.5%)	$.186
Phosphorus[a] (Superphosphate, 46%)	.163
Potassium[b]	.090

[a]North Dakota Crop and Livestock Statistics, 1976, Agricultural Statistics No. 40, North Dakota Agricultural Experiment Station, May, 1977.
[b]D. Hofstrand, Unpublished data, Department of Agricultural Economics, North Dakota State University, Fargo.

The sediment entering the river systems in Region VII carries over 13,500 tons of nutrients.* The annual replacement cost for the nutrients carried with the sediment is over 2.7 million dollars (Table 15). The average value of replacing the lost nutrients was $0.63 for each contributing acre in Region VII.

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*This does not include nitrogen losses through leaching or nutrients carried in the runoff (unattached to soil particles).

TABLE 15. VALUE OF NUTRIENTS LOST IN STATE PLANNING REGION VII

Nutrient	Total Pounds Lost	Price Per Pound	Value of Nutrients Lost
Nitrogen	1,543,744	$.186	$ 287,136
Phosphate	2,315,616	.163	377,445
Potassium	23,156,160	.090	2,084,054
Total	27,015,520		2,748,635

Recommendations for Soil Loss Reductions

All Agricultural Land

A 30-35 percent reduction in soil loss and sediment can be achieved by eliminating summer fallow from the crop rotation. Elimination of summer fallow also increases net revenues per acre under normal climatic conditions.

The number of acres summer fallowed declined by one-third from 1972 to 1976 (Table 16). Continued reduction in summer fallow acres can be expected barring the advent of dry conditions. The new farm program which discourages summer fallow on "set-aside" acres will encourage additional reduction. Educational programs on the economic and environmental consequences of summer fallowing large acreages should lead to a more rapid decrease in acres being left idle. It may be impossible, however, to completely eliminate summer fallow since under certain conditions it can be profitable practice.

Contour and strip-cropping can reduce soil loss by an additional 50 percent. The absence of immediate economic benefits from these practices will make their adoption much more difficult. Additional public cost sharing of the initial costs of establishing these practices would accelerate the process.

TABLE 16. NUMBER OF ACRES SUMMER FALLOWED IN REGION VII, 1970-1976

County	1970	1972	1974	1976
	-----------------	thousands of acres	-----------------	
McLean	340	371	325	317
Mercer	90	94	76	77
Oliver	46	50	32	33
Kidder	67	69	48	37
Sheridan	125	137	105	103
Burleigh	87	116	84	55
Emmons	105	150	43	51
Grant	153	161	116	111
Morton	122	144	110	95
Sioux	45	45	22	20
Total	1,180	1,337	961	899

SOURCE: North Dakota Crop and Livestock Statistics, Annual Summaries 1971-1977, Agricultural Statistics Statistical Reporting Service, United States Department of Agriculture, in cooperation with the Department of Agricultural Economics, North Dakota State University, Fargo.

Other "best management practices" such as, minimum tillage, spring plowing, grassed waterways, terracing, etc., would assist in reducing soil loss and sedimentation. There is little quantitative data on the effectiveness of these practices under conditions of western North Dakota. Many of these practices also have substantial investment and/or operating costs associated with their adoption. Additional research is needed on their effectiveness in reducing soil loss and sedimentation to determine the benefits and costs to landowners and to society. Expanded cost-sharing by federal and/or state governments may be required to obtain voluntary adoption if and when these practices are found to be a desirable means to improve water quality.

High Erosion Areas

Land identified as highly erodible was estimated to yield negative economic returns in grain production and high soil losses. Cropland on highly erosive sections can yield soil losses of over 10 tons per acre if summer fallowed as compared to four tons under normal cropping patterns and 0.02 tons in well-managed permanent pasture. Economic returns to landowners were also higher if land use were changed to forage production or permanent pasture. Educational programs which emphasize the increased economic returns and reduced soil loss by using this land for forage or pasture production may be effective in obtaining voluntary cooperation of private landowners.

Priorities

The most critical area for reducing sediment from agriculture is the highly erosive land used for crops (less than 4 percent of the agricultural land). Transfer of these areas from crop to rangeland can reduce the total quantity of sediment in the region by 16 percent. The Little Heart River basin contains the highest percentage of highly erosive sections (51.2 percent). The Heart River basin contains the largest number of highly erosive sections (445).

A second effective strategy to improve water quality is to discourage the use of summer fallow as a regular part of the crop rotation. Elimination of summer fallow from cropland can reduce sediment levels by 30 percent.

The final strategy would be to encourage the use of strip-cropping and contouring, particularly on medium erosion potential areas.

Each 100,000 tons of sediment contains approximately $356,000 of nitrogen, phosphate, and potassium. The change from crop to pasture on highly erosive acres would prevent the loss of about $356,000 in nutrients. Elimination of summer fallow from low and medium erosive sections would result in the prevention of an additional $600,000 of nutrient losses.

Appendix A

Agricultural Simulation Model:

Data Base

TABLE A-1. CROP MANAGEMENT FACTORS, NORTH DAKOTA

Management Activity	C Factor	Conditions
Sheep on Pasture		Canopy of tall weeds or short brush
Beef on Pasture	.013[a]	(0.5 m. fall height) 60 percent ground cover
Dairy on Pasture		50 percent canopy cover[b], grass-like plant cover[c]
Spring Wheat-Fal.	.34	SG-SF 200 number residue at seeding
Spring Wheat-CC	.27	Continuous SG, plow plant
Durum-Fal.	.34	SG-SF 200 number residue at seeding
Durum-CC	.27	Continuous SG, plow plant
Barley-Fal.	.34	SG-SF 200 number residue at seeding
Barley-CC	.27	Continuous SG, plow plant
Oats	.27	Continuous SG, plow plant
Flax	.33	SG-Flax-SF, spring plow for flax
Summer Fallow	.59	SE up and down slope
Alfalfa	.09	SG (one year)-Alfalfa (five year)-SF
Other Tame Hay	.09	SG (one year)-Hay (three years)-SF
Corn Silage	.45	SG-RC-SG-SF spring plow for RC; disk second SG 200 number residue

[a]Values assume 1) random distribution of mulch or vegetation, and 2) mulch of appreciable depth where it exists.

[b]Portion of total area surface that would be hidden from view by canopy in a vertical projection (birds-eye view).

[c]Cover at surface is grass, grass-like plants, decaying compacted duff, or litter at least two inches deep.

SOURCE: United State Department of Agriculture-Soil Conservation Service, "Estimating Soil Loss Resulting from Water and Wind Erosion in North Dakota," Bismarck, ND, 1975, adapted by James Knuteson, RIMAS Project, Department of Soils, North Dakota State University, Fargo.

TABLE A-2. FIVE-YEAR COUNTY AVERAGE CROP YIELDS, RIMAS STUDY AREA, 1971-1976

Crop	County: Burleigh	McLean	Mercer	Morton	Oliver
	- - - - -	- - - - -	*bushels*	- - - - -	- - - - -
Spring Wheat-Fallow	23.6	26.8	24.5	23.7	24.7
Spring Wheat-CC*	16.8	19.6	18.1	18.2	20.7
Durum-Fallow	21.7	26.9	27.1	22.3	28.6
Durum-CC*	17.8	20.5	21.1	15.8	18.3
Barley-Fallow	36.5	38.4	33.4	33.3	39.1
Barley-CC*	26.1	29.0	25.6	28.8	32.3
Oats	36.5	42.5	41.4	40.1	40.4
Flax	7.5	9.5	9.7	8.7	10.3
Summer Fallow	--	--	--	--	--
	- - - - -	- - - - -	*tons*	- - - - -	- - - - -
Alfalfa	1.6	1.6	1.7	1.8	1.9
Other Tame Hay	1.1	1.3	1.4	1.2	1.4
Corn Silage	5.8	5.1	6.1	5.2	6.3

*Continuous Cropped

SOURCE: North Dakota Crop and Livestock Statistics, Annual Summaries 1972-1977, Agricultural Statistics, Statistical Reporting Service, United States Department of Agriculture in cooperation with the Department of Agricultural Economics, North Dakota State University, Fargo.

TABLE A-3. SOIL ASSOCIATIONS, SLOPE PARAMETERS, WATER ERODIBILITY FACTORS, AND PRODUCTIVITY RATINGS IN THE RIMAS STUDY AREA

State Code	Soil Association	Dominant Slope Range[a]	Typical Slope Length[b]	Water Erodibility Factor[c]	Productivity Ratings[d]	
					Cropland	Native Pasture[e]
		%	ft.			
4	Temvik, Gently Sloping	3-6	500	.31	83	.55
5	Temvik, Nearly Level	0-3	600	.32	92	.55
6	Temvik, Sloping	6-9	400	.30	63	.55
11	Temvik-Williams, Gently Sloping	3-6	400	.30	80	.55
12	Temvik-Williams, Nearly Level	0-3	500	.30	91	.55
16	Cabba, Hilly and Steep	15-30	300	.29	--	.40
17	Cabba-Badland, Steep	15-30	300	.32	--	.25
19	Cabba-Flasher, Hilly and Steep	15-30	400	.28	--	.40
20	Cabba-Morton, Strongly Sloping	9-15	400	.32	32[f]	.45
21	Cabba-Morton-Rhoades, Strongly Sloping	9-15	400	.32	24[f]	.35
23	Cabba-Rhoades, Brandenburg, Hilly & Steep	15-30	400	.31	--	.30
121	Farland, Nearly Level	0-3	600	.31	92[g]	.55
123	Farland-Lehr, Nearly Level	0-3	600	.31	79[g]	.40
125	Farland-Rhoades, Nearly Level	0-3	600	.32	66[g]	.40
129	Flasher-Vebar, Hilly and Steep	15-30	400	.18	--	.40
130	Flasher-Vebar, Strongly Sloping	9-15	400	.19	25[f]	.45
131	Flasher-Williams, Strongly Sloping	9-15	400	.23	25[f]	.45
135	Fresh Water Marsh			--	--	--
155	Grail-Arnegard, Nearly Level	0-3	400	.31	96	.70
167	Havrelon-Banks, Nearly Level	0-3	600	.31	76[g]	.70
202	Lake, Reservoir, or Pond	--			--	--
210	Lihen, Nearly Level	0-3	200	.18	42	.55
211	Lihen, Rolling	6-9	150	.17	23[f]	.55
212	Lihen, Strongly Rolling	9-15	100	.17	--	.50
213	Lihen, Undulating	3-6	150	.17	31[f]	.55
232	Mine Pits and Dumps			.50	--	--
233	Morton, Gently Sloping	3-6	400	.31	76	.55
234	Morton, Nearly Level	0-3	500	.32	91	.55
235	Morton-Temvik, Sloping	6-9	400	.32	59	.55
236	Morton-Cabba, Sloping	6-9	400	.32	56	.50

-continued-

TABLE A-3. SOIL ASSOCIATIONS, SLOPE PARAMETERS, WATER ERODIBILITY FACTORS, AND PRODUCTIVITY RATINGS IN THE RIMAS STUDY AREA (CONTINUED)

State Code	Soil Association	Dominant Slope Range[a]	Typical Slope Length[b]	Water Erodibility Factor[c]	Productivity Ratings[d]	
					Cropland	Native Pasture[e]
		%	ft.			
240	Morton-Rhoades, Gently Sloping	3-6	400	.32	54	.40
241	Morton-Rhoades, Nearly Level	0-3	500	.32	65	.40
242	Morton-Rhoades, Sloping	6-9	400	.32	46	.40
243	Morton-Vebar, Gently Sloping	3-6	400	.29	72	.55
244	Morton-Vebar, Sloping	6-9	400	.28	55	.55
245	Morton-Williams, Gently Sloping	3-6	400	.31	76	.55
246	Morton-Williams, Sloping	6-9	300	.31	57	.55
251	Lehr, Nearly Level	0-3	400	.28	53	.30
252	Manning, Nearly Level	0-3	400	.21	44	.30
253	Lehr-Wabek, Undulating	3-6	200	.28	45	.25
254	Manning-Wabek, Undulating	3-6	200	.22	38	.25
255	Lehr-Rhoades, Nearly Level	0-3	400	.30	42	.25
266	Parshall, Nearly Level	0-3	400	.20	66	.55
267	Parshall, Rolling	6-9	300	.20	48	.55
268	Parshall, Undulating	3-6	300	.20	59	.55
269	Parshall (Till Substratum), Nearly Level	0-3	500	.21	74	.55
270	Parshall (Till Substratum), Rolling	6-9	300	.23	54	.55
271	Parshall (Till Substratum) Undulating	3-6	300	.22	69	.55
272	Parshall-Temvik, Undulating	3-6	400	.25	71	.55
282	Regent-Rhoades, Gently Sloping	3-6	400	.32	50	.40
296	Rhoades, Gently Sloping	3-6	400	.32	32[f]	.30
299	Roseglen, Nearly Level	0-3	600	.31	92	.55
305	Savage, Nearly Level	0-3	600	.32	90[g]	.55
306	Savage-Rhoades, Nearly Level	0-3	600	.32	66[g]	.40
308	Wabek, Strongly Rolling	9-15	150	.28	--	.20
311	Wabek-Lehr, Rolling	6-9	200	.28	31[f]	.20
312	Wabek-Manning, Rolling	6-9	200	.24	28[f]	.20
318	Straw-Havrelon, Nearly Level	0-3	600	.30	88[g]	.60
337	Seroco-Lihen, Rolling	6-9	100	.16	--	.45
340	Vebar, Gently Sloping	3-6	400	.21	65	.55
342	Vebar, Sloping	6-9	400	.20	50	.55

-continued-

TABLE A-3. SOIL ASSOCIATIONS, SLOPE PARAMETERS, WATER ERODIBILITY FACTORS, AND PRODUCTIVITY RATINGS IN THE RIMAS STUDY AREA (CONTINUED)

State Code	Soil Association	Dominant Slope Range[a]	Typical Slope Length[b]	Water Erodibility Factor[c]	Productivity Ratings[d] Cropland	Native Pasture[e]
		%	ft.			
351	Rhoades, Nearly Level	0-3	600	.32	32[f]	.30
354	Williams, Gently Undulating	0-3	250	.28	85	.55
355	Williams, Nearly Level	0-3	200	.28	85	.55
356	Williams, Undulating	3-6	200	.28	77	.55
357	Williams-Temvik, Rolling	6-9	200	.33	59	.55
358	Williams-Temvik, Undulating	3-6	250	.29	80	.55
359	Williams-Cavour, Nearly Level	0-3	200	.30	59	.40
363	Williams-Morton, Rolling	6-9	400	.30	57	.55
364	Williams-Morton, Undulating	3-6	300	.29	77	.55
365	Williams-Lehr, Gently Undulating	0-3	250	.28	75	.45
367	Williams-Lehr, Undulating	3-6	200	.28	65	.45
369	Williams-Parshall, Undulating	3-6	250	.26	72	.55
371	Williams-Vebar, Rolling	6-9	400	.25	55	.55
372	Williams-Vebar, Undulating	3-6	400	.25	73	.55
373	Williams-Zahl, Rolling	6-9	200	.28	57	.50
374	Zahl, Hilly and Steep	15-30	200	.28	--	.40
375	Zahl-Temvik, Strongly Rolling	9-15	300	.29	26[f]	.45
376	Zahl-Cabba, Hilly and Steep	15-30	300	.32	--	.40
377	Zahl-Cabba, Strongly Rolling	9-15	300	.30	24[f]	.40
378	Zahl-Flasher, Hilly and Steep	15-30	300	.28	--	.40
381	Zahl, Wabek, Hilly and Steep	15-30	200	.28	--	.35
383	Zahl-Williams, Strongly Rolling	9-15	200	.28	35[f]	.45

[a] Omodt, H. W., et al., The Major Soils of North Dakota, Department of Soils, Bulletin No. 472, North Dakota Agricultural Experiment Station, Fargo, ND, 1968.

[b] James Knuteson, Unpublished Data, RIMAS Project, Department of Soils, North Dakota Agricultural Experiment Station, Fargo, ND, 1978.

[c] "List of Soil Erodibility Factors (K), Soil-Loss Tolerances (T), and Hydrological Groups for Soils of North Dakota." USDA-SCS, Bismarck, ND, January, 1977.

[d] Patterson, D. D., Unpublished Data, Department of Soils, North Dakota State University, Fargo, ND.

[e] The productivity ratings reflect native pasture production capabilities in A.U.M.'s.

[f] This soil association is not normally used for cropland; however, when the price-cost relationship is favorable, some areas of the association may be used for crop production.

[g] This rating applies only to unchanneled areas of sufficient size to permit use of modern farm equipment.

TABLE A-4. AVERAGE SOIL PRODUCTIVITY BY COUNTY

County	Soil Productivity Indices
Burleigh	56
McLean	61
Mercer	49
Morton	43
Oliver	50

SOURCE: Patterson, D. D., unpublished data, Department of Soils, North Dakota State University, Fargo.

TABLE A-5. YIELD RESPONSE OF CROPS TO RAINFALL DEVIATION DURING THE CRITICAL GROWING SEASON, BURLEIGH AND MCLEAN COUNTIES

Crop	Deviation from Normal Rainfall in Inches						
	+3	+2	+1	0	-1	-2	-3
	bushels/acre						
Hard Red Spring Wheat-Fallow	7.8	5.4	2.8	0	-2.9	- 5.9	- 9.0
Hard Red Spring Wheat-CC	9.6	6.6	3.4	0	-3.6	- 7.5	-11.6
Durum-Fallow[a]	1.4	0.9	0.5	0	-0.5	- 0.9	- 1.4
Durum-CC[a]	0.5	0.4	0.2	0	-0.2	- 0.4	- 0.5
Barley-Fallow	18.4	12.8	6.6	0	-7.1	-14.8	-22.9
Barley-CC	14.1	9.8	5.1	0	-5.4	-11.2	-17.4
Oats	14.7	10.1	5.2	0	-5.5	-11.3	-17.4
Flax	5.8	4.0	2.1	0	-2.2	-4.5	- 7.0
	tons/acre						
Corn Silage	1.7	1.1	0.6	0	-0.6	- 1.3	- 2.0
Alfalfa	.38	.26	.13	0	- .14	- .28	- .43
Other Tame Hay	.28	.19	.10	0	- .10	- .21	- .32

[a]Only available for east central region.

SOURCE: The Effects of Added Rainfall During the Growing Season in North Dakota, Final Report, Interdiciplinary "ARE" Research Team, North Dakota Research Report No. 52, Agricultural Experiment Station, North Dakota State University, Fargo, August, 1974.

TABLE A-6. YIELD RESPONSE OF CROPS TO RAINFALL DEVIATION DURING THE CRITICAL GROWING SEASON, MERCER, MORTON, AND OLIVER COUNTIES

Crop	Deviation						
	+3	+2	+1	0	-1	-2	-3
	bushels						
Hard Red Spring Wheat-Fallow	1.9	1.2	0.6	0	-0.6	-1.2	- 1.9
Hard Red Spring Wheat-CC	2.4	1.6	0.8	0	-0.8	-1.6	- 2.4
Durum-Fallow[a]	1.4	0.9	0.5	0	-0.5	-0.9	- 1.4
Durum-CC[a]	0.5	0.4	0.2	0	-0.2	-0.4	- 0.5
Barley-Fallow	8.7	6.0	3.1	0	-3.3	-6.7	-10.4
Barley-CC	8.3	5.7	2.9	0	-3.1	-6.3	- 9.6
Oats	9.3	6.3	3.2	0	-3.3	-6.8	-10.3
Flax	1.7	1.1	0.6	0	-0.6	-1.1	- 1.7
Corn Silage	0.4	0.3	0.1	0	-0.1	-0.3	- 0.4
Alfalfa	.17	.11	.06	0	- .06	- .11	- .17
Other Tame Hay	.16	.10	.05	0	- .05	- .10	- .16

[a]Only available for east central region.

SOURCE: The Effects of Added Rainfall During the Growing Season in North Dakota Final Report, Interdisciplinary "ARE" research team, North Dakota Research Report No. 52, Agricultural Experiment Station, North Dakota State University, Fargo, August, 1974.

TABLE A-7. CROP PRICES AND LIVESTOCK REVENUES-SOUTHWEST NORTH DAKOTA[a]

Spring Wheat	$ 2.70/Bushel
Durum	2.70/Bushel
Barley	1.50/Bushel
Oats	.95/Bushel
Flax	4.70/Bushel
Alfalfa	30.00/Ton
Other Tame Hay	25.00/Ton
Corn Silage	22.00/Ton
Sheep	47.14[b]
Range Cattle	162.77[b]
Dairy Cattle	763.45[b]

[a]1963-1972, long-term average price.
[b]Les Gullickson, North Dakota Vocational Agriculture Farm Business Management Education, Annual Report, 1975, Bismarck Junior College, 1975.

SOURCE: First Annual Report on Marketing, Irrigation Production, Report of the "MIP" Interdisciplinary Research Team, North Dakota Agricultural Experiment Station, 1973.

TABLE A-8. ESTIMATED 1975 PRODUCTION COST FOR SOUTHWESTERN NORTH DAKOTA

Activity	Cost/Unit (Animal, Acre)
Sheep	$ 40.30[a]
Range Cattle	140.89[bc]
Dairy Cattle	617.50[b]
Spring Wheat-Fallow	55.57[d]
Spring Wheat-CC	55.57[d]
Durum-Fallow	59.06[d]
Durum-CC	59.06[d]
Barley-Fallow	56.40[d]
Barley-CC	56.40[d]
Oats	54.22[d]
Flax	44.38[d]
Summer Fallow	25.90[b]
Alfalfa	33.19[b]
Other Tame Hay	21.04[b]
Corn Silage	60.06[d]

[a]Brignone, J. L., Economics of Sheep Production in North Dakota, Unpublished M.S. Thesis, Department of Agricultural Economics, North Dakota State University, 1977.
[b]Gullickson, Les, "North Dakota Vocational Agriculture Farm Business Management Education," Annual Report 1975 for Area 2, Bismarck Junior College.
[c]Used averages for high percentage of farms (above average management).
[d]Unpublished Data, LeRoy Schaffner, Department of Agricultural Economics, North Dakota State University.

TABLE A-9. VALUE OF THE EROSION CONTROL PRACTICE FACTOR, NORTH DAKOTA

Degree of Slope	P Factor: No Practice[a]	Contour or Strip-cropping[a]	Contour and Strip-cropping
1.1-2.0	1.0	.6	.30
2.1-7.0	1.0	.5	.25
7.1-12.0	1.0	.6	.30
12.1-18.0	1.0	.8	.40
18.1-24.0	1.0	.9	.45

[a]"Estimating Soil Loss Resulting From Water and Wind Erosion in North Dakota," USDA-Soil Conservation Service, Bismarck, North Dakota, March, 1975.
[b]A Universal Equation for Predicting Rainfall-Erosion Losses: An Aid to Conservation Farming in Humid Regions, ARS Report 22-66, Agricultural Research Service, United States Department of Agriculture, 1961.

TABLE A-10. FIVE-YEAR COUNTY AVERAGE ACRES PLANTED, RIMAS STUDY AREA, 1971-1976

Crop	Burleigh	McLean	Mercer	Morton	Oliver	Total
	- - - - - - - -	- - - - - - - -	- - - - - - - -	*acres* - - - - - -	- - - - - - - -	- - - - - - - -
Spring Wheat-Fallow	67,820	165,020	71,800	88,560	28,820	422,020
Spring Wheat-CC[a]	54,560	33,960	14,600	29,400	15,080	147,600
Durum-Fallow	10,520	139,720	2,640	2,900	400	156,180
Durum-CC[a]	9,740	16,720	340	1,500	400	28,700
Barley-Fallow	8,040	14,380	4,300	16,120	3,200	46,040
Barley-CC[a]	12,040	8,480	3,060	10,780	3,460	37,820
Oats	57,820	60,080	34,260	69,080	23,220	244,460
Flax	22,100	31,880	3,240	2,060	4,600	63,880
Summer Fallow	92,600	335,600	82,400	113,800	38,800	663,200
Alfalfa	63,240	28,100	34,780	78,400	31,800	236,320
Other Tame Hay	20,120	20,700	15,560	31,180	9,520	97,080
Corn Silage	15,100	6,020	11,040	17,960	8,400	58,520
Total Acreage	434,500	865,240	278,480	463,080	168,080	2,210,000
Total Excluding Winter Wheat and Rye	433,700	860,760	278,020	461,760	167,700	2,201,940
Acres of Cropland in County[b]	536,181	847,675	294,038	502,546	192,271	2,372,711

[a]Continuous Cropped
[b]North Dakota Soil Conservation Service, Conservation Needs Inventory, Bismarck, ND, 1970.

SOURCE: North Dakota Crop and Livestock Statistics, Agricultural Statistics Statistical Reporting Service, United States Department of Agriculture in cooperation with Department of Agricultural Economics, North Dakota State University, Fargo, 1972-1977.

TABLE A-11. FIVE-YEAR COUNTY AVERAGES: PERCENT OF CROPLAND USED BY SELECTED CROPS, 1971-1976

Crop	Burleigh	McLean	Mercer	Morton	Oliver
Spring Wheat-Fallow	15.64	19.17	25.82	19.18	17.19
Spring Wheat-CC	12.58	3.95	5.25	6.37	8.99
Durum-Fallow	2.43	16.23	.95	.63	.24
Durum-CC	2.25	1.94	.12	.33	.24
Barley-Fallow	1.85	1.67	1.55	3.49	1.90
Barley-CC	2.77	1.00	1.10	2.33	2.06
Oats	13.33	6.98	12.32	14.96	13.85
Flax	5.10	3.71	1.17	.45	2.74
Summer Fallow	21.35	38.99	29.64	24.64	23.14
Alfalfa	14.58	3.26	12.51	16.98	18.96
Other Tame Hay	4.64	2.40	5.60	6.75	5.68
Corn Silage	3.48	.70	3.97	3.89	5.01
Total	100.00	100.00	100.00	100.00	100.00

SOURCE: Derived from Appendix Table A-10.

TABLE A-12. NUMBER OF LIVESTOCK PER ACRE OF PASTURE AND RANGE, RIMAS STUDY REGION

	Burleigh	McLean	Mercer	Morton	Oliver
	Number/acre				
Sheep	.0142	.0123	.0073	.0082	.0105
Range Cattle	.1876	.1643	.2108	.1572	.1530
Dairy Cattle	.0075	.0082	.0128	.0128	.0105
Sum of Factors	.2093	.1848	.2309	.1782	.1740
	Percent				
Sheep	6.78	6.67	3.16	4.60	6.03
Range Cattle	89.63	88.90	91.29	88.22	87.94
Dairy Cattle	3.59	4.43	5.55	7.18	6.03
Total	100.00	100.00	100.00	100.00	100.00

SOURCE: RIMAS Project, unpublished data, Department of Agricultural Economics, North Dakota State University, Fargo, 1977.

TABLE A-13. FIVE-YEAR COUNTY AVERAGES: CROPLAND USE IN THE NO-SUMMERFALLOW ALTERNATIVE, 1971-1976

Crop	Burleigh	McLean	Mercer	Morton	Oliver
	percent				
HRSW-Fallow	0.00	0.00	0.00	0.00	0.00
HRSW-CC[a]	35.88	37.89	44.17	33.90	34.06
Durum-Fallow	0.00	0.00	0.00	0.00	0.00
Durum-CC[a]	5.94	29.79	1.52	1.27	.62
Barley-Fallow	0.00	0.00	0.00	0.00	0.00
Barley-CC[a]	5.89	4.36	3.76	7.74	5.17
Oats	16.95	11.44	17.51	19.85	18.01
Flax	6.47	6.08	1.67	.59	3.57
Summer Fallow	0.00	0.00	0.00	0.00	0.00
Alfalfa	18.54	5.35	17.78	22.53	24.66
Other Tame Hay	5.90	3.94	7.95	8.96	7.39
Corn Silage	4.43	1.15	5.64	5.16	6.52
Total	100.00	100.00	100.00	100.00	100.00

[a]Continuous Cropped

SOURCE: Based on Appendix Table A-10.

TABLE A-14. FIVE-YEAR COUNTY AVERAGE: CROPLAND USE IN THE SMALL GRAINS AND HAY ALTERNATIVE, 1971-1976

Crop	Burleigh	McLean	Mercer	Morton	Oliver
	- - - - - -	- - - - - -	*percent*	- - - - - -	- - - - - -
HRSW-Fallow	0.0	0.0	0.0	0.0	0.0
HRSW-CC[a]	37.5	38.3	46.8	35.7	36.4
Durum-Fallow	0.0	0.0	0.0	0.0	0.0
Durum-CC[a]	6.2	30.1	1.6	1.3	.7
Barley-Fallow	0.0	0.0	0.0	0.0	0.0
Barley-CC[a]	6.2	4.4	4.0	8.2	5.5
Oats	17.7	11.6	18.6	20.9	19.3
Flax	6.8	6.2	1.7	.6	3.8
Summer Fallow	0.0	0.0	0.0	0.0	0.0
Alfalfa	19.4	5.4	18.9	23.8	26.4
Other Tame Hay	6.2	4.0	8.4	9.5	7.9
Corn Silage	0.0	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0

[a]Continuous Cropped

SOURCE: Based on Appendix Table A-10.

TABLE A-15. FIVE-YEAR COUNTY AVERAGE: CROPLAND USE IN THE ALL SMALL GRAINS ALTERNATIVE, 1971-1976

Crop	Burleigh	McLean	Mercer	Morton	Oliver
	- - - - - -	- - - - - -	*percent*	- - - - - -	- - - - - -
HRSW-Fallow	0.0	0.0	0.0	0.0	0.0
HRSW-CC[a]	50.4	42.3	64.4	53.6	55.4
Durum-Fallow	0.0	0.0	0.0	0.0	0.0
Durum-CC[a]	8.3	33.3	2.2	2.0	1.0
Barley-Fallow	0.0	0.0	0.0	0.0	0.0
Barley-CC[a]	8.3	4.9	5.5	12.2	8.4
Oats	23.8	12.8	25.5	31.3	29.4
Flax	9.2	6.7	2.4	0.9	5.8
Summer Fallow	0.0	0.0	0.0	0.0	0.0
Alfalfa	0.0	0.0	0.0	0.0	0.0
Other Tame Hay	0.0	0.0	0.0	0.0	0.0
Corn Silage	0.0	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0

[a]Continuous Cropped

SOURCE: Based on Appendix Table A-10.

TABLE A-16. FIVE-YEAR COUNTY AVERAGE: CROPLAND USE IN THE HAY AND GRASS ALTERNATIVE, 1971-1976

Crop	Burleigh	McLean	Mercer	Morton	Oliver
	percent				
HRSW-Fallow	0.0	0.0	0.0	0.0	0.0
HRSW-CC[a]	0.0	0.0	0.0	0.0	0.0
Durum-Fallow	0.0	0.0	0.0	0.0	0.0
Durum-CC[a]	0.0	0.0	0.0	0.0	0.0
Barley-Fallow	0.0	0.0	0.0	0.0	0.0
Barley-CC[a]	0.0	0.0	0.0	0.0	0.0
Oats	0.0	0.0	0.0	0.0	0.0
Flax	0.0	0.0	0.0	0.0	0.0
Summer Fallow	0.0	0.0	0.0	0.0	0.0
Alfalfa	75.9	57.6	69.1	71.5	77.0
Other Tame Hay	24.1	42.4	30.9	28.5	23.0
Corn Silage	0.0	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0

[a]Continuous Cropped

SOURCE: Based on Appendix Table A-10.

Appendix B

Economic Model

Economic Model

The economic model is based on the North Dakota Input/Output Model developed by Hertsgaard and others.* The input/output model is derived from a transactions table which indicates the volume of dollar transactions that firms in each sector conduct with other firms (Table B-1). Values in the columns are purchased inputs for production by firms in the column sector that are obtained from firms in the row sector. These same values are outputs of firms in the row sector that are sold as inputs to firms in the column sectors. Goods and services are also sold to satisfy final demands. Sales for final demand are to households for personal consumption, to business firms for capital investment, to units of government, or to firms outside the study region (exports).

Imports from outside the region, wages and profits paid to households, tax payments, and depreciation allowances for capital investments comprise a special input row similar to the special column sales for final demand. The sum of each column is the total expenditures by firms in that economic sector and the sum of a row is the gross receipts from sales by firms in that economic sector.

The data to develop the transactions table were obtained from records of business firms in North Dakota.

The elements of each column of the transactions table (matrix) are converted to percentages which sum to one. This new table is referred to

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*Development of the input/output model has been supervised by Thor Hertsgaard, Department of Agricultural Economics, North Dakota State University and reported in:

1. Sand, Larry D., "Analysis of Effects of Income Changes on Intersectoral and Intercommunity Economic Structure," unpublished M.S. Thesis, North Dakota State University, 1966.
2. Bartch, Bruce L., "Analysis of Intersectoral and Intercommunity Structure in South Western North Dakota," unpublished M.S. Thesis, North Dakota State University, 1966.
3. Senechal, Donald M., "Analysis of Validity of North Dakota Input/Output Models," unpublished M.S. Thesis, North Dakota State University, 1971.
4. Dalsted, N. D., *et al.*, "Economic Impacts of a Proposed Coal Gasification Plant in Dunn County, North Dakota," An Interim Report to Natural Gas Pipeline Company of America, Chicago, Illinois, Department of Agricultural Economics, North Dakota State University, January, 1976.
5. Hertsgaard, Thor, *et al.*, *REAP Economic Demographic Model: Technical Description*, Regional Environmental Assessment Program Bismarck, North Dakota, 1977.

TABLE B-1. ECONOMIC SECTORS OF INPUT-OUTPUT MODEL AND SIC CODE NUMBER OF EACH

Economic Sector	SIC Code[a]
1. Agr., Livestock	Group 013-Livestock
2. Agr., Crops	All of Major Group 01-Agricultural Production, Except Group 013-Livestock
3. Coal Mining	Major Group 12-Bituminous Coal and Lignite Mining
4. Contract Construction	Division C-Contract Construction (Major Groups 15, 16, and 17)
5. Transportation	All Division E-Transportation, Communications, Electric, Gas, and Sanitary Services Except Major Groups 48 and 49
6. Communication and Utilities	Major Group 48-Communication and Major Group 49-Electric, Gas, and Sanitary Services (Except Industry No. 4911)
7. Processing and Misc. Manufacturing[b]	Major Group 50-Wholesale Trade and Major Group 20-Food and Kindred Products Manufacturing
8. Retail Trade	All of Division F-Wholesale and Retail Trade, Except Major Group 50-Wholesale Trade
9. Finance, Insurance, and Real Estate	Division G-Finance, Insurance, and Real Estate
10. Business and Personal Services	All Division H-Services, Except Major Groups 80, 81, 82, 86, and 89
11. Professional and Social Services	Major Group 80-Medical and Other Health Services, Major Group 81-Legal Services, Major Group 82-Educational Services, Major Group 86-Nonprofit Membership Organizations, Major Group 89-Miscellaneous Services
12. Households	Not Applicable
13. Government	Division 1-Government

[a]Executive Office of the President/Bureau of the Budget, <u>Standard Industrial Classification Manual, 1967</u>, U.S. Government Printing Office, Washington, D.C., 1967.

[b]Wholesale trade, although relatively insignificant, is included in Sector 7.

as the table of technical input/output coefficients or direct requirements table because it indicates the input requirements per dollar of output of the producing sector (Table B-2). The direct requirements table is inverted via matrix algebra to yield the interdependence coefficients table (Table B-3). This is the final input/output matrix which is used to estimate the effects of a change in final demand on the regional economy.

The interpretation of the coefficients in Table B-3 follows using column 1 (Ag-Livestock) as an example: the total input requirements, direct and indirect, of each $1 of output produced for final demand by sector 1 are $1.2082 from other firms in sector 1, $0.3973 from firms in sector 2, $0.0083 from mining, $0.0714 from contract construction, etc. The sum of the coefficients in column 1 is 4.5134. This represents the total input required by a $1 increase in production for final demand by the agriculture livestock sector. Similarly, knowledge of the final demands of each sector allows calculation of the gross business volume of a sector. For example, if the final demand for output from each sector were $1, the gross business volume of agriculture livestock would be $1.9557, the sum of the row coefficients.

Input/output analysis assumes constant prices, technology, and that each input increases or decreases proportionately to changes in outputs. Caution must be taken when using the input/output model to project economic impacts into the future. Explicit adjustments need to be made when it is known that one or more of the assumptions will be violated. The North Dakota input/output model has been tested over the 1958 to 1975 period and has been found to be accurate within a 5 to 10 percent error range.

Use of the North Dakota input/output model in RIMAS is primarily focused on five sectors: livestock, crops, contract construction, retail trade, and households. The agricultural simulation model generates final demand values for crop and livestock sectors. Special schedules representing construction and operation of electrical plants, synthetic natural gas plants, and export mines are used for coal development activities. Coal development activities interact with the local economy via contracts for construction, purchases from retail trade, and wages to households. A flowchart of the Economic Model is presented in Figure B-1.

TABLE B-2. INPUT-OUTPUT TECHNICAL COEFFICIENTS, NORTH DAKOTA ECONOMY

	(1) Ag, Lvst.	(2) Ag, Crops	(3) Mining	(4) Contract Const.	(5) Trans.	(6) Util.	(7) Ag Proc. & Misc. Mfg.	(8) Retail Trade	(9) Fin., Ins., & Real Estate	(10) Bus. & Pers. Serv.	(11) Prof. & Soc. Serv.	(12) House-holds	(13) Government[a]
(1) Ag, Livestock	.0937	.0019	.0000	.0000	.0000	.0000	.0742	.0575	.0000	.0000	.0005	.0097	0
(2) Ag, Crops	.1535	.0210	.0000	.0000	.0000	.0000	.3476	.0013	.0011	.0000	.0000	.0000	0
(3) Mining	.0025	.0021	.0030	.0276	.0061	.0008	.0006	.0003	.0002	.0012	.0006	.0016	0
(4) Contract Construction	.0013	.0174	.0127	.0125	.0013	.0174	.0010	.0093	.0016	.0102	.0147	.0488	0
(5) Transportation	.0043	.0019	.0034	.0056	.0015	.0078	.0024	.0067	.0033	.0059	.0019	.0009	0
(6) Utilities	.0069	.0036	.0219	.0136	.0228	.0414	.0059	.0207	.0435	.0537	.0394	.0444	0
(7) Ag Processing and Misc. Mfg.	.2736	.0692	.0236	.0006	.0001	.0000	.3761	.0002	.0201	.0000	.0010	.0015	0
(8) Retail Trade	.0602	.2921	.0646	.1025	.1507	.0384	.0090	.0582	.0808	.0911	.1420	.4129	0
(9) Fin., Ins., & Real Estate	.0115	.0525	.0017	.0151	.0315	.0240	.0044	.0097	.0077	.0267	.0223	.0961	0
(10) Bus. & Pers. Service	.0028	.0253	.0018	.0037	.0134	.0050	.0010	.0019	.0278	.0209	.0030	.0328	0
(11) Prof. & Soc. Service	.0026	.0019	.0066	.0011	.0014	.0019	.0005	.0015	.0049	.0037	.0347	.0593	0
(12) Households	.3417	.4317	.3775	.3252	.4212	.4477	.0430	.1779	.6956	.3698	.5654	.0683	0
(13) Government[a]	.0101	.0202	.0014	.0059	.1993	.0398	.0029	.0064	.0184	.0216	.0104	.0579	1

[a]Main diagonal element was set equal to 1.0 and other elements to zero to reflect the fact that expenditures of local units of government are determined by the budgeting process of those units, rather than endogenously within the economic system.

TABLE B-3. INTERDEPENDENCE COEFFICIENTS OF INPUT-OUTPUT MODEL, NORTH DAKOTA

	(1) Ag, Lvst.	(2) Ag, Crops	(3) Mining	(4) Con-tract Const.	(5) Trans.	(6) Util.	(7) Ag Proc. & Misc. Mfg.[a]	(8) Retail Trade	(9) Fin., Ins., & Real Estate	(10) Bus. & Pers. Serv.	(11) Prof. & Soc. Serv.	(12) House-holds	(13) Government[b]
(1) Ag, Livestock	1.2082	0.0777	0.0445	0.0343	0.0455	0.0379	0.1941	0.0889	0.0617	0.0384	0.0571	0.0674	0
(2) Ag, Crops	0.3973	1.0931	0.0176	0.0135	0.0180	0.0152	0.6591	0.0320	0.3720	0.0153	0.0231	0.0268	0
(3) Mining	0.0083	0.0067	1.0395	0.0302	0.0092	0.0043	0.0063	0.0024	0.0049	0.0043	0.0050	0.0056	0
(4) Contract Construction	0.0714	0.0784	0.0512	1.0494	0.0488	0.0645	0.0620	0.0343	0.0728	0.0538	0.0776	0.0886	0
(5) Trans-portation	0.0152	0.0113	0.0284	0.0105	1.0079	0.0135	0.0131	0.0104	0.0120	0.0118	0.0100	0.0093	0
(6) Utilities	0.0923	0.0835	0.1556	0.0603	0.0839	1.1005	0.0777	0.0528	0.1321	0.1103	0.1191	0.1054	0
(7) Ag Processing and Misc. Mfg.[a]	0.5821	0.1637	0.0276	0.0210	0.0281	0.0242	1.7678	0.0459	0.0714	0.0241	0.0368	0.0423	0
(8) Retail Trade	0.7098	0.8134	0.5229	0.4098	0.5472	0.4313	0.6206	1.2733	0.6761	0.4522	0.6665	0.7442	0
(9) Fin., Ins., & Real Estate	0.1531	0.1677	0.1138	0.0837	0.1204	0.1128	0.1341	0.0577	1.1423	0.1084	0.1400	0.1680	0
(10) Bus. & Pers. Service	0.0564	0.0684	0.0430	0.0287	0.0461	0.0374	0.0521	0.0194	0.0766	1.0509	0.0455	0.0605	0
(11) Prof. & Soc. Service	0.0712	0.0644	0.0559	0.0402	0.0519	0.0526	0.0539	0.0276	0.0816	0.0497	1.1026	0.0982	0
(12) House-holds	1.0490	0.9646	0.8419	0.6086	0.7872	0.7946	0.7977	0.4032	1.2013	0.7157	1.0432	1.5516	0
(13) Government[b]	0.0991	0.0957	0.0852	0.0519	0.2583	0.0999	0.0808	0.0393	0.1071	0.0774	0.0881	0.1080	1

[a] Wholesale trade, although relatively insignificant, is included in Sector 7.
[b] Direct and indirect requirements of the local government sector are assumed to be exogenous to the model.

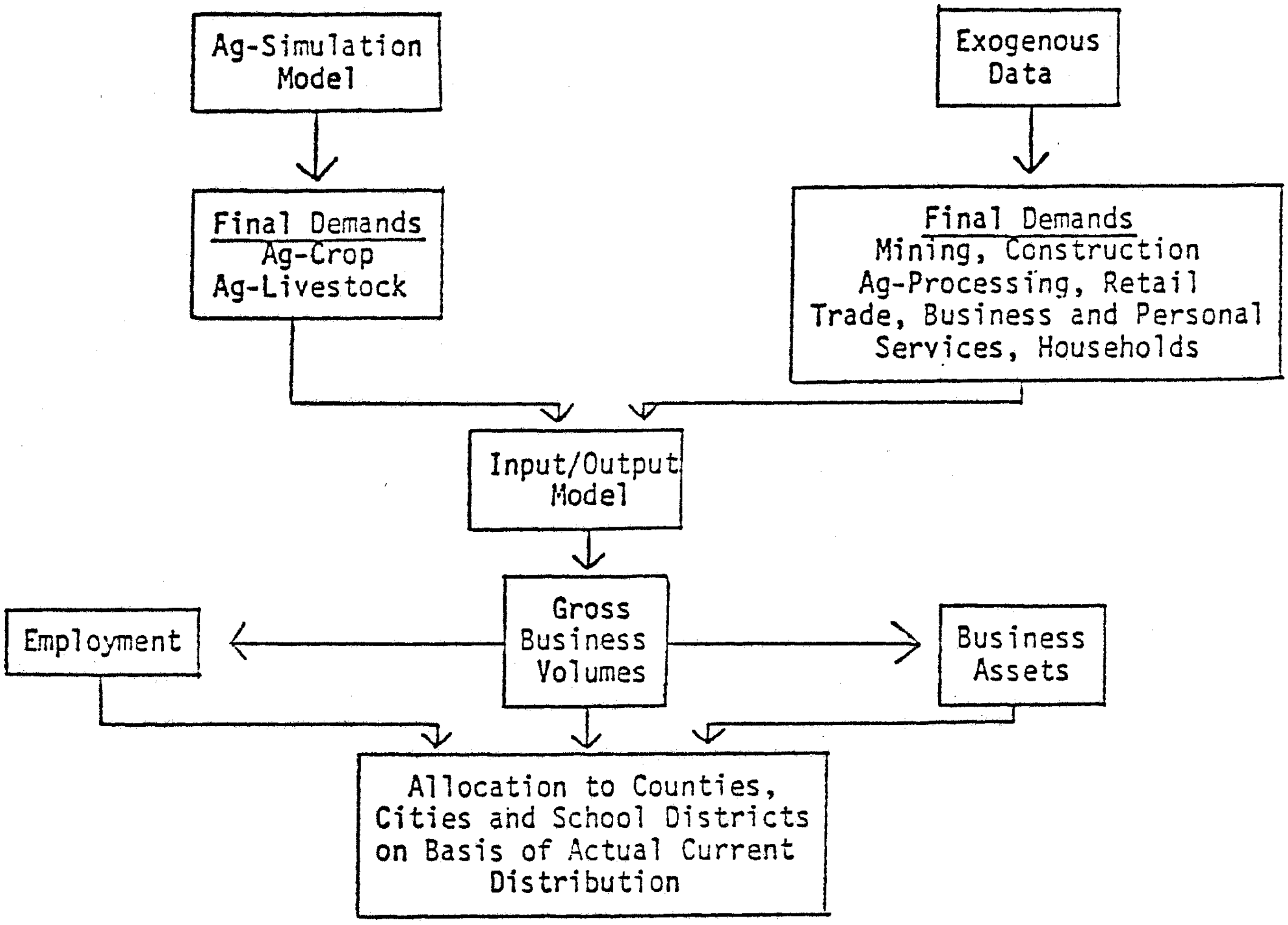

Figure B-1. Flow Chart of Economic Model

Appendix C

Estimation of Average Soil Loss and Sediment Under Normal Conditions for Region VII

Average soil loss from parcels with high erosion potential is a composite of soil loss from cropland and from pasture and range on highly erosive land in the RIMAS area. The estimates of soil loss from cropland by crop activity and from pasture and range were developed for highly erosive land in the RIMAS area. This procedure assumes the percent of highly erosive land to total land area in Region VII is similar to the RIMAS area; the distribution of crop activities is similar for both areas; and there is no difference between the crop activities on cropland with low, medium, or high erosion potential.

The average soil loss for pasture and range on highly erosive areas for the RIMAS area was estimated to equal 0.88 tons per acre. The estimate of average soil loss for highly erosive cropland was the summation of the products of the percent distribution of cropland use under normal conditions for each crop activity divided by 100 and the estimated soil loss for that crop activity on highly erosive land in the RIMAS area (Table C-1). The average soil loss (in tons per acre) from agricultural land is the sum of the product of average soil loss from pasture and range and the proportion of pasture and range to total agricultural land in the RIMAS area and the product of average soil loss from cropland and the proportion of cropland to total agricultural land in the RIMAS area.

Estimation of Soil Loss on Highly Erosive Land - Equations

SL_p = 0.88 tons per acre

$$SL_c = \sum_{i=1}^{n} \left[(NCDi) \cdot (SLCi) \right]$$

$$SL_H = (P_p)\ (SL_p) + (P_c)\ (SL_c)$$

WHERE: NCDi - Normal Proportion of Crop to total crop production.

Pc - Proportion of cropland to total agricultural land.

Pp - Proportion of pasture and range to total agricultural land.

SLc - Cropland soil loss on areas with high erosion potential.

SLp - Soil loss from pasture and range on areas with high erosion potential.

SL_H - Soil loss on critical areas (in tons per acre)

TABLE C-1. ESTIMATION OF AVERAGE SOIL LOSS FROM HIGHLY EROSIVE CROP LAND WITH NORMAL CROPPING PATTERNS

$Crop_i$	Normal Proportion[a]	Soil Loss From Each Crop[a]	Cropland Soil Loss
	percent	tons/acre	weighted average
Spring Wheat	25.8	8.64	2.23
Durum	8.4	8.64	0.73
Barley	3.8	8.64	0.33
Oats	11.2	8.64	0.97
Flax	2.9	10.56	0.31
Fallow	30.1	18.88	5.68
Alfalfa	10.7	1.08	0.11
Hay	4.4	1.08	0.05
Silage	2.7	14.40	0.39
Summation	100.0		10.80 Tons/Acre

[a]RIMAS Project, unpublished data, Department of Agricultural Economics, North Dakota State University, 1977.

TABLE C-2. ESTIMATION OF AVERAGE SOIL LOSS FROM HIGHLY EROSIVE LAND WITH NORMAL CROPPING PATTERNS

Land Use	Proportion Land Use to Total Ag Land[a]	Soil Loss	Soil Loss on Critical Areas
	percent	tons/acre	weighted average
Cropland	14.68	10.80[b]	1.585
Pasture	85.32	0.88[c]	0.751
Summation			2.34 Tons/Acre

[a]Louis Ogaard, unpublished data, RIMAS Project, Department of Agricultural Economics, North Dakota State University, 1977.
[b]Appendix Table C-1.
[c]RIMAS Project, unpublished data, Department of Agricultural Economics, North Dakota State University, 1977.

<u>Estimation of Sediment Loads Under Normal Conditions</u>

$$TSEDAj = (ALj + AMj) \cdot (DRj) \cdot (SL_R)$$

$$TSEDHj = (TSLHj) \cdot (DR_j)$$

$$TSLHj = (AHj) \cdot (SLHj)$$

$$TSEDj = (TSEDAj + TSEDHj)$$

$$SEDNj = (TSEDj/Aj)$$

TABLE C-3. ESTIMATION OF AVERAGE SOIL LOSS FROM HIGHLY EROSIVE CROP LAND UNDER THE ALL SMALL GRAINS ALTERNATIVE

$Crop_i$	Normal Proportion[a]	Soil Loss from $Crop_i$[a] ECP = 2	Soil Loss from $Crop_i$[a] ECP = 3	Cropland Soil Loss ECP = 2	Cropland Soil Loss ECP = 3
	percent	tons/acre		weighted average	
Spring Wheat	49.6	7.73	3.87	3.83	1.92
Durum	16.1	7.73	3.87	1.24	0.62
Barley	7.4	7.73	3.87	0.57	0.29
Oats	21.3	7.73	3.87	1.65	0.82
Flax	5.6	9.45	4.72	0.53	0.26
Summation				7.82 Tons/ Acre	3.91 Tons/ Acre

[a]RIMAS Project, unpublished data, Department of Agricultural Economics, North Dakota State University, 1977.

TABLE C-4. ESTIMATION OF AVERAGE SOIL LOSS FROM HIGHLY EROSIVE LAND UNDER THE ALL SMALL GRAINS ALTERNATIVE

Land Use	Proportion Land Use to Total Ag Land[a]	Soil Loss EPC = 1	Soil Loss EPC = 2	Soil Loss on Critical Areas EPC = 1	Soil Loss on Critical Areas EPC = 2
	percent				
Cropland	14.68	7.83[b]	3.92[b]	1.149	0.575
Pasture	85.32	0.88[c]	0.88[c]	0.751	0.751
				1.90 Tons/ Acre	1.33 Tons/ Acre

[a]Louis Ogaard, unpublished data, RIMAS Project, Department of Agricultural Economics, North Dakota State University, 1977.
[b]Appendix Table C-3.
[c]RIMAS Project, unpublished data, Department of Agricultural Economics, North Dakota State University, 1977.

<u>Estimation of Sediment Loads Using Special Management in Critical Areas</u>

$$TSEDAij = (ALj + AMj) \cdot (SLAi) \cdot (DRj)$$

$$SEDHij = (Rp/n) \cdot (SEDNj)$$

$$Rp/n = (SLAi/SL_R)$$

$$TSEDHij = (SEDHij) \cdot (AHj)$$

$$TSEDij = (TSEDAij + TSEDHij)$$

$$SEDij = (TSEDij/Aj)$$

DESCRIPTION OF VARIABLES:

- Aj - Total number of acres in watershed j
- AHj - Total number of acres with high erosion potential in watershed j
- ALj - Total number of acres with low erosion potential in watershed j
- AMj - Total number of acres with medium erosion potential in watershed j
- DR_j - Delivery Rate for the watershed
- Rp/n - Ratio of Average Soil Loss from management alternative_i on critical acres in the RIMAS area to the average soil loss under normal conditions in the RIMAS area
- SEDij - Average Sediment Load under Management Alternative_i in watershed j
- SEDj - Average Sediment Load in Watershed j under normal conditions
- SEDHij - Average Sediment load from critical areas in watershed j under normal conditions
- SEDNj - Average sediment load in watershed j under normal conditions
- SL_R - Soil loss in the RIMAS area under normal conditions (constant = 2.41 ton/acre)
- SLAi - Soil loss in the RIMAS area for management alternative i
- SLH_R - Soil loss in the RIMAS area for highly erosive land (constant = 2.34 ton/acre j)
- TSEDij - Total sediment load in watershed j under management alternative i
- TSEDj - Total sediment load in watershed j under normal conditions
- TSEDAij - Total sediment load from noncritical areas in watershed j under management alternative i
- $TSEDA_j$ - Total sediment load from noncritical areas in watershed, under normal conditions
- TSEDHj - Total sediment load from critical areas in watershed j under normal conditions
- TSLHj - Total soil movement from critical areas in watershed j under normal conditions

SUBSCRIPTS:

i - signifies the management alternative used in estimation.
i = 1 to 4

Alternative 1 represents small grain production with contour farming or strip-cropping on the critical areas.

Alternative 2 represents small grain production with contour strip-cropping on the critical areas.

Alternative 3 represents alfalfa or hay production with no other management practice on the critical areas.

Alternative 4 represents summer fallow on the critical areas.

j - signifies a watershed or is representative of Region VII.

j = 1 to n where

n - 1 = the number of watersheds in the region and watershed j = n is representative of Region VII

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