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Establishing Agricultural Use Values Based on Soil Survey Information and Enterprise Budgets

by
Glenn D. Pederson, Donald D. Patterson, Harvey G. Vreugdenhil, and Mark F. Weber

Department of Agricultural Economics
North Dakota Agricultural Experiment Station
North Dakota State University
Fargo, North Dakota 58105-5636

Preface

This report summarizes a case study which established agricultural land use values for Richland County, North Dakota, based on detailed soil maps of the county. The authors conducted the study under North Dakota State University Agricultural Experiment Station Project ND-3306. This study summarizes the major findings of the project and demonstrates a method by which other counties in North Dakota can automate the process of assessment at the ownership tract level.

The authors wish to thank Mr. Henry Luther, Director of Tax Equalization and his staff in Richland County for assistance in providing the acreage tabulations. Dr. Roger Johnson, Dr. Jerome Johnson, and Dr. Norbert Dorow provided useful comments on prior drafts of this report, their assistance is appreciated. Mr. Harvey Vreugdenhil provided computer programming assistance throughout the study, and deserves special recognition for maintaining the integrity of the data base and resulting estimates.

TABLE OF CONTENTS

Highlights

The North Dakota Legislature adopted a preferential form of assessment in 1981 by which agricultural land was to be valued according to its agricultural use. The method of determining value in the 1981 law has two major limitations which prohibit its direct use at the local assessment level. First, variations in production costs among crops are not considered directly. Second, soil productivity information is not used in establishing agricultural use value.

This study describes a case study of agricultural use values in Richland County, North Dakota. A computer model was developed for 126 soil units identified in the 1975 detailed soil survey. This study is unique for North Dakota, since it provides an economic interpretation of productivity (using enterprise budgets) on these soil units for six major crops (wheat, barley, sunflower, corn, hay, and soybeans) and rangeland. Results indicate that the method provides 1) estimates of the net returns for soil units, which can be used directly in the assessment process, 2) estimates of the acreage-weighted net return on an ownership tract, which can be used for assessment and equalization, and 3) estimates of the acreage-weighted net return at the township and county level.

The computational procedure can be adapted to other counties where detailed soil map acreage tabulations have been completed.

ESTABLISHING AGRICULTURAL USE VALUES BASED ON SOIL SURVEY INFORMATION AND ENTERPRISE BUDGETS

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The North Dakota Legislature adopted a preferential form of assessment in 1981, which required that all real property (excluding buildings) be assessed at "true and full" market value with the exception of farmland. True and full value of agricultural land (farmland and ranchland) is to reflect earning capacity, market value, farm rental price, soil capability, soil productivity, and soils analysis as defined under section 57-02-02 of the North Dakota Century Code (13). Farmland, as a category, is to be assessed according to its agricultural use value, rather than its market value. That law also provided a specific method for use in estimating the county-average agricultural value.

The 1981 law requires that county-average gross return for 22 major crops be computed. The gross return is multiplied by 30 percent if return is from cropland or 50 percent if return is from rangeland to determine the landowners' share of returns. A 1983 amendment lowered the return to grassland to 25 percent and return from land in sugarbeets or potatoes to 20 percent (13). The share obtained represents what landowners would receive from cash or crop-share rent minus taxes and other landowner expenses, and represents the net return to land.

A capitalization of income approach is used in establishing a county average agricultural land value under the new law. The approach converts an estimate of the annual net return to the land per acre for each county into an estimate of its present use value. Capitalization of the share of gross return for landowners, including government payments, is used as a proxy for estimating the county-average true and full value of agricultural land. The capitalized value is the county average agricultural use value which serves as a benchmark for local district assessment. The County Director of Tax Equalization uses the best information available from soil surveys and past assessment data to determine relative average agricultural values among assessment districts. The average of all assessment districts within the county should equal the county-average agricultural value. The local assessor establishes the relative value on each property tract in his assessment district so that average value meets the assessed value established for the district by the County Director of Tax Equalization (15).

The procedure has many limitations. Cash or crop-share rental arrangements vary across the state. Although 86 percent of the crop-share leases for wheat reported for 1980 were on the two-thirds tenant to one-third landowner sharing ratio, some state areas reported a significantly lower percentage of leases on this type of arrangement. Johnson (11) reported that about 36 percent of the crop-share arrangements for wheat were on a 50-50 sharing agreement in the South Red River Valley area. The 30 percent return for cropland and 25 percent for grassland specified in the 1983 law does not fit all parts of the state and, therefore, may not be an accurate indication of the owners' return to land.

The county-aggregate method does not account for variations in production costs among crops and regions. Different crops may have similar gross returns but may vary in production costs. Similarly, a crop may have similar gross returns for several regions but have different production costs. Gross return does not reflect the net return to land for each state area.

Soil productivity is a major factor which determines crop yields and net income after other determinants such as weather are considered. Higher net incomes are realized from more productive soils (holding other factors constant). Soil productivity is an important determinant value and should be incorporated in the assessment process.

Agricultural economists and soil scientists at North Dakota State University have proposed a more comprehensive approach to estimating agricultural value than the system currently in use. The proposed method incorporates soil information as presented in county detailed soil survey reports, and explicitly accounts for current costs of production. Net return per acre is based on soil productivity in two major steps. First, gross return is estimated for each mapping unit (soil unit) in the county. Second, an estimated cost of production per acre (excluding the land charge) is calculated and subtracted from the gross return estimate. This yields a net return per acre which more accurately reflects the owner's expected return than the share rental method currently in use in North Dakota.

The objective of this study is to develop a method for improving the quality of farmland assessments in North Dakota by use of a true productivity approach. The approach is based on:

1. estimated yield potential of soil units, and
2. estimated production costs for major crop and livestock enterprises.

The study applies this approach to farmland in Richland County, North Dakota to demonstrate that an internally consistent set of net returns for different soils can be estimated using detailed soil survey information and enterprise (crop and livestock) budgets.

Study Area

Richland County contains 927,424 acres of land and water in the southeastern corner of North Dakota. The area has a subhumid continental climate characterized by warm summers and cold winters. Average annual precipitation is 19.5 to 21 inches. The main physiographic areas in the county are the eastern Lake Agassiz Plain, the Sheyenne Delta, which includes the Sandhills, and the glacial till plain (21).

The county has a diversity of soils, topography, and crop and livestock enterprises. The Lake Agassiz Plain contains some of the most fertile cropland in North Dakota. This area is intensely cultivated to crops which include corn, soybeans, wheat, barley, sunflower, and sugarbeets. The lake plain is nearly level and surface drainage is a problem in many areas. The Sheyenne Delta contains a large acreage of coarse-textured soils. In the Sandhills area slopes are too steep and irregular for cultivation and beef cattle production is the major enterprise. Corn, oats, and hay are grown in the delta area. The soils of the glacial till plain are nearly level to hilly. Most runoff collects in closed depressions, marshes, and small lakes. A combination of crops and livestock is produced in that area (21).

Richland County was selected as the study area for two reasons. First, a detailed soil survey for the county was completed in 1970. It is one of 23 counties which have published, modern, detailed soil surveys (21). Second, the Director of Tax Equalization has tabulated the acreage of each soil unit by ownership tract. Acreage tabulation is a major effort and its completion was a necessary prerequisite to implementing this study.

Detailed Soil Maps

Detailed soil maps were used to estimate farmland productivity. Soil maps show the location and extent of areas of similar soil and slope for each tract of land. Drainage-ways and selected cultural features are recorded, along with soil boundaries and symbols, on aerial photographs. Some soil units consist mainly of one kind of soil but others are complexes of two or more soils which cannot be separated at the selected scale of mapping. One hundred twenty-six soil units and land types were recognized in the soil survey of Richland County (21). The survey was the cooperative work of the USDA-Soil Conservation Service, Forest Service, and the North Dakota Agricultural Experiment Station.

Crop Yield Data Base

Yields for the principal crops and rangeland were estimated for each soil unit in the county assuming improved management. The predicted yields were based on the results of field research by soil scientists and agronomists at North Dakota State University (NDSU), information furnished by farmers, and field observations of USDA-SCS and NDSU soil scientists. Long-term moisture and temperature variations during the growing season were reflected in the yield estimates. Loss from hail and extraordinary damage caused by insects, blackbirds, and disease were not included. Table 1 lists estimated yields per acre of crops and rangeland by soil unit assuming improved management.

Cultural practices under improved management include the following (21):

- Regular application of fertilizer in the kinds and amounts indicated by soil tests that will maintain the supply of plant nutrients at the level suggested by the NDSU Soil Testing Laboratory
- Use of the latest recommended varieties of crops
- Regulation of seeding rates to produce the greatest number of plants that the available moisture supply can support
- Tilling, seeding, cultivating, and harvesting at the proper time

TABLE 1. ESTIMATED YIELDS PER ACRE OF CROPS AND RANGELAND IN RICHLAND COUNTY BY SOIL UNIT

Soil Unit	Wheat	Barley	Soybeans	Corn	Hay	Sunflower	Rangeland
	- - - - - - -	bu. - - - - - - -			tons	- lbs. -	- AUMs[a] -
Aastad-Forman loams	39	62	29	87	3.2	1,700	1.3
Aberdeen fine sandy loam	29	46	19	70	3.0	1,400	1.0
Aberdeen silt loam	38	61	24	75	3.2	1,600	1.0
Aberdeen-Galchutt silty clay loams	40	64	24	75	3.2	1,700	1.0
Aberdeen-Ryan silty clay loams	32	51	16	50	2.7	1,400	.9
Antler silty clay loam	35	56	25	75	3.9	1,800	1.5
Antler-Tonka silty clay loams	33	53	23	70	3.3	1,700	1.6
Arveson-Fossum fine sandy loams	24	38	16	45	3.1	1,350	1.7
Arveson and Fossum loams	24	38	16	45	3.1	1,350	1.7
Arvilla fine sandy loam	18	29	14	35	1.2	800	.7
Barnes-Svea loams, undulating	35	56	26	78	2.8	1,550	1.2
Bearden silty clay loam	43	69	26	80	4.0	1,900	1.5
Bearden and Glyndon silt loams, moderately deep over clay	43	69	26	80	4.0	1,900	1.5
Borup loam	30	48	19	55	3.6	1,700	1.8
Cashel silty clay	38	61	26	75	3.4	1,700	1.4
Colvin silty clay loam	30	48	18	50	3.6	1,700	1.8
Dickey-Towner fine sandy loams, undulating	23	36	19	60	2.2	1,300	1.1
Doran clay loam	41	65	32	80	3.9	1,900	1.0
Doran-Perella clay loams	38	61	30	75	3.4	1,800	1.5
Doran-Tonka silty clay loams	38	61	30	75	3.4	1,800	1.5
Dovray silty clay	33	53	19	60	2.8	1,500	1.8
Eckman-Zell silt loams, rolling	27	43	16	50	2.0	1,100	1.0
Egeland and Maddock fine sandy loams, undulating	21	34	16	47	2.0	1,000	1.1
Embden-Tiffany fine sandy loams	35	56	30	90	3.4	1,800	1.2
Embden-Tiffany loams	35	56	32	95	3.4	2,000	1.2
Fairdale silt loam	40	64	29	90	3.4	1,900	1.4
Fairdale silt loam, channeled	38	61	27	85	3.4	1,700	1.4
Fairdale silty clay loam	40	64	29	90	3.4	1,900	1.4
Fargo silty clay loam	44	70	35	85	4.0	2,000	1.0
Fargo silty clay	41	66	32	80	3.6	1,900	1.0
Fargo silty clay, depressional	38	61	26	65	3.0	1,600	1.4
Fargo silty clay, gently sloping	40	64	32	75	3.5	1,750	1.0
Fargo silty clay, till substratum	40	64	32	80	3.6	1,900	1.0
Fargo-Enloe silty clay loams	40	64	30	75	3.1	1,700	1.5
Fargo-Enloe complex, till substratum	40	64	30	75	3.1	1,700	1.5
Fargo-Hegne silty clays	40	64	31	80	3.6	1,900	1.0
Fargo-Hegne silty clays, till substratum	40	64	31	75	3.6	1,900	1.0
Fargo-Ryan silty clay loams	33	53	16	45	2.7	1,400	.8
Fargo-Ryan silty clay	33	53	16	45	2.7	1,400	.9
Fordville-Renshaw loams	23	36	16	45	1.8	1,100	1.0
Forman-Aastad loams, undulating	35	56	26	78	2.8	1,500	1.2
Forman-Aastad loams, undulating, eroded	35	56	26	78	2.8	1,500	1.2
Forman-Buse loams, rolling	26	42	19	58	2.0	1,200	1.0
Forman-Buse loams, rolling, eroded	26	42	19	58	2.0	1,200	1.0
Forman-Peever clay loams, undulating	37	58	26	78	3.0	1,500	1.1
Fossum fine sandy loam	24	38	16	45	3.0	1,300	1.7
Galchutt silt loam	43	69	30	85	3.4	1,900	1.1
Galchutt-Enloe-Fargo complex	40	64	28	75	3.1	1,800	1.3
Galchutt-Overly silt loams	43	69	33	90	3.4	1,900	1.1
Gardena silt loam	45	72	35	100	3.4	2,000	1.1
Gardena-Eckman silt loams, undulating	41	66	29	90	3.2	1,800	1.1
Gardena and Embden loams	38	61	32	95	3.2	2,000	1.1
Gilby silt loam	38	61	26	75	4.0	1,800	1.5
Gilby silt loam, moderately saline	22	36	14	40	2.6	1,300	1.0
Gilby and Hamerly loams	38	61	26	75	4.0	1,800	1.5
Glyndon silt loam	43	69	29	90	4.0	1,900	1.5
Glyndon-Tiffany very fine sandy loams	36	58	26	80	3.8	1,700	1.6
Glyndon-Tiffany loams, moderately deep over clay	40	64	29	90	3.8	1,800	1.6
Glyndon and Wyndmere loams	33	53	29	90	3.8	1,800	1.5
Grano clay	29	46	15	40	2.8	1,300	1.8

- continued -

TABLE 1. ESTIMATED YIELDS PER ACRE OF CROPS AND RANGELAND IN RICHLAND COUNTY BY SOIL UNIT (CONTINUED)

Soil Unit	Wheat	Barley	Soybeans	Corn	Hay	Sunflower	Rangeland
	- - - - - - -	bu.	- - - - - -		ton	- lbs. -	AUMs[a]
Hamar loamy fine sand	24	38	24	75	3.6	1,500	1.7
Hamar loamy fine sand, moderately deep over clay	24	38	24	75	3.6	1,500	1.7
Hamar fine sandy loam	29	46	29	85	3.6	1,700	1.7
Hamar fine sandy loam, moderately deep over clay	29	46	29	80	3.6	1,700	1.7
Hamar-Ulen loamy fine sands	24	38	22	70	3.5	1,500	1.6
Hamar-Ulen fine sandy loams	29	46	27	85	3.5	1,700	1.6
Hamerly loam	35	56	25	75	3.4	1,700	1.5
Hecla loamy fine sand, loamy substratum	24	38	22	70	3.2	1,500	1.1
Hecla-Hamar loamy fine sands	24	38	22	75	3.2	1,500	1.3
Hecla-Hamar fine sandy loams	29	46	29	85	3.2	1,700	1.3
Hecla-Maddock loamy sands	19	32	16	55	2.6	1,200	1.1
Kratka fine sandy loam	29	46	26	80	3.6	1,600	1.7
LaDelle silty clay loam	45	72	32	90	3.4	2,000	1.4
LaPrairie silt loam	45	72	35	100	3.4	2,000	1.4
Maddock-Hecla loamy fine sands, undulating	17	27	18	55	2.0	1,100	1.1
Nutley silty clay, rolling	29	46	21	60	2.4	1,300	1.0
Overly silty clay loam	45	72	35	100	3.4	2,000	1.1
Overly-Bearden silt loams, moderately saline	22	36	14	40	2.6	1,300	1.0
Overly-Bearden silty clay loams, moderately saline	22	36	14	40	2.6	1,300	1.0
Overly-Beotia silty clay loams, undulating	43	69	29	85	3.2	1,800	1.1
Parnell and Tonka silty clay loams	31	50	18	55	1.5	1,100	1.8
Peever-Forman clay loams	38	61	27	85	3.0	1,700	1.1
Perella loam, moderately deep over clay	35	56	21	65	2.8	1,500	1.8
Perella silty clay loam, moderately deep over clay	35	56	21	65	2.8	1,500	1.8
Roliss clay loam	32	51	18	50	2.8	1,500	1.8
Ryan-Fargo complex	28	44	15	40	2.5	1,200	.8
Stirum-Arveson loams	18	32	11	30	2.0	1,000	1.7
Svea loam	43	69	33	95	3.6	1,850	1.4
Svea-Buse loams, undulating	36	58	26	75	2.8	1,500	1.2
Svea-Buse loams, rolling	32	51	21	65	2.6	1,400	1.2
Svea-Gardena loams	43	69	33	95	3.6	1,850	1.3
Swenoda-Wyndmere fine sandy loams	33	53	29	90	3.2	1,800	1.3
Tiffany fine sandy loam	24	38	19	60	3.6	1,700	1.7
Tiffany loam	33	53	30	85	3.6	1,700	1.7
Tiffany loam, moderately deep over clay	33	53	30	85	3.6	1,700	1.7
Tonka silt loam	35	56	21	65	2.0	1,500	1.8
Towner loamy fine sand	24	38	20	60	2.4	1,300	1.1
Towner and Swenoda fine sandy loams	33	53	28	80	2.6	1,600	1.1
Ulen fine sandy loam	29	46	26	75	3.2	1,700	1.5
Vallers clay loam	30	48	17	50	3.6	1,600	1.8
Wahpeton silty clay	43	69	32	90	3.6	2,000	1.0
Wyndmere fine sandy loam	33	53	26	80	3.6	1,800	1.5

[a]Grazing units are in animal-unit months (AUMs).

SOURCE: Yields of wheat, barley, soybeans, and corn adapted from Thompson, Donald G. and Lloyd L. Joos, Soil Survey of Richland County and Sheyenne National Grassland Area, Ransom County, North Dakota, U.S. Department of Agriculture, Soil Conservation Service and Forest Service in cooperation with North Dakota Agricultural Experiment Station, December 1975, by D. D. Patterson, Department of Soil Science, North Dakota State University. Yields of hay and sunflower developed by D. D. Patterson. AUM estimates developed by D. D. Patterson from preliminary data provided by Leonard J. Jurgens, Range Conservationist, USDA-SCS.

- Effective control of erosion
- Drainage of wet soils by surface drains and controlling flooding where needed
- Controlling weeds, insects, and plant diseases by chemicals and cultural practices

Certain soil units were considered unsuitable for crop production due to low (or negative) net return per acre for the major crops grown in the county. Table 2 contains a list of soil units which are best suited to rangeland production.

Generation of Agricultural Use Values

The procedures used in generating agricultural use values are illustrated in Figure 1. The Oklahoma Enterprise Budget Generator (10) was used to combine crop yields for soil units, average price and cost information, and production input information. The computerized budget system creates crop budgets for crops on each soil unit.

Crop pattern (rotation) information for soil units and additional cost adjustments for storage, drying, hail insurance, management fees, stone removal and drainage maintenance are entered in the crop budgets to develop weighted net returns per acre for soil units.

The soil acreage data base contains the number of acres of each soil unit in each ownership tract. This information is used to compute a net return per acre for each ownership tract in the county. Net return per acre for each tract is divided by a capitalization rate to estimate the agricultural use value.

The basic steps used in estimating agricultural values are listed and an explanation of each step follows:

TABLE 2. SOIL AND LAND TYPE UNITS UNSUITABLE FOR CROPLAND IN RICHLAND COUNTY

Soil Unit or Land Type	Rangeland[a]
Arveson and Fossum loams, very wet	1.8
Barnes-Buse loams, hilly	1.0
Barnes-Buse loams, hilly, eroded	1.0
Barnes-Buse-Langhei loams, hilly	1.0
Borup silt loam, very wet	1.8
Exline and Ryan soils	0.4
Hecla-Hamar loamy fine sands, severely eroded	1.0
Hecla-Hamar-Arveson complex	1.3
LaDelle and Wahpeton soils, channeled	1.0
LaMoure silty clay loam	1.7
Maddock loamy fine sand, rolling	1.0
Maddock-Hecla-Hamar, loamy fine sands, undulating	1.2
Marsh	Waste
Parnell silty clay loam	0.3
Serden loamy fine sand	0.8
Serden-Stabilized Dune land complex	0.6
Sioux-Renshaw complex, undulating	0.5
Sioux-Renshaw complex, hilly	0.5
Strongly saline land	Waste
Venlo fine sandy loam	1.8
Water	Waste
Wet alluvial land	1.8
Zell-Eckman silt loams, hilly	1.0
Zell-Eckman silt loams, steep	1.0

[a]Units are in animal-unit months.

SOURCE: Developed by D. D. Patterson from preliminary data provided by Leonard J. Jurgens, Range Conservationist, USDA-SCS, Bismarck.

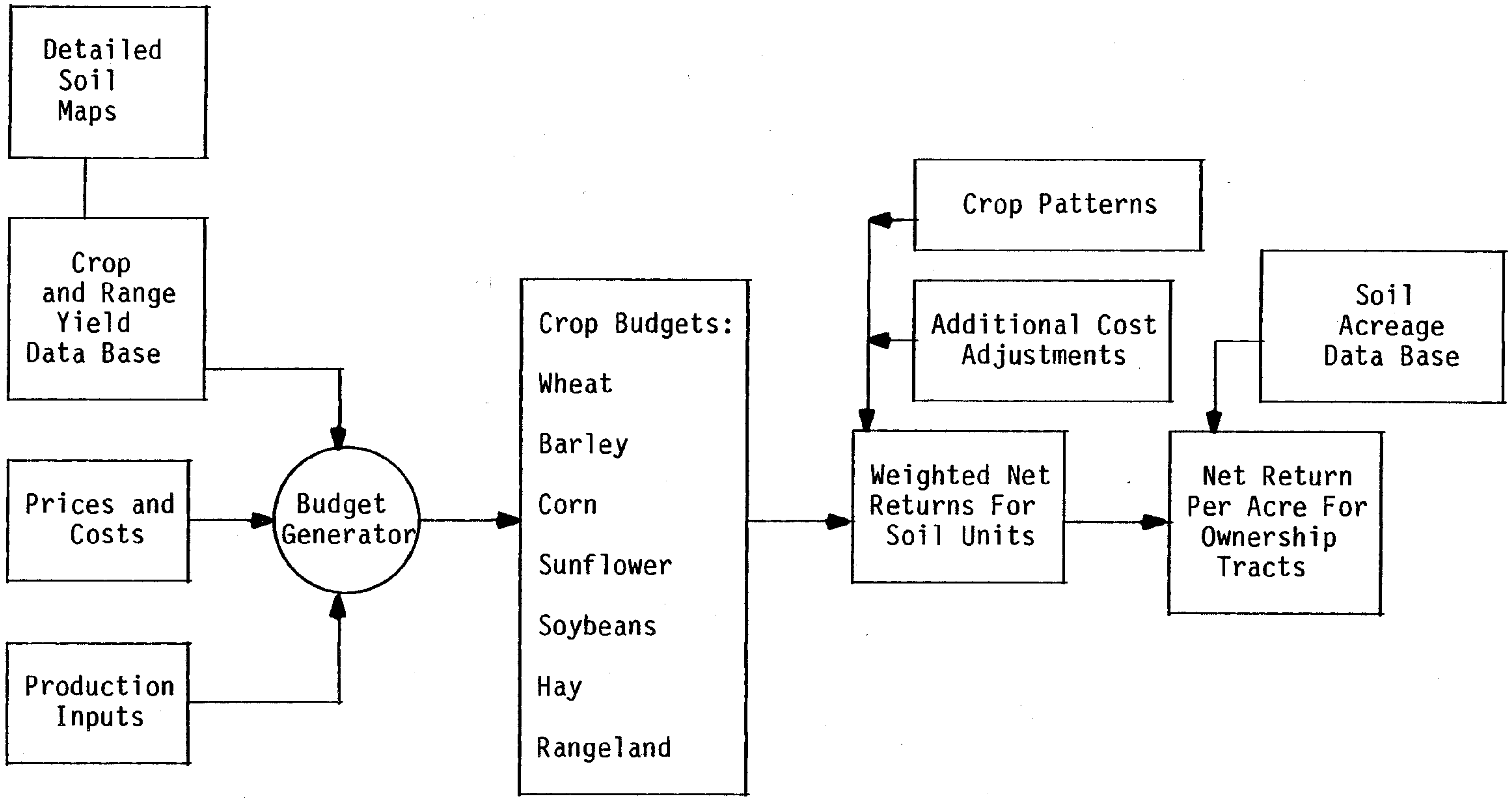

Figure 1. Procedures Used in Generating Agricultural Values

- Combine soil units into groups with similar tillage requirements and productive capacities
- Identify major crops grown in the county
- Estimate crop patterns for each soil unit identified in the county
- Develop enterprise budgets for cropland and rangeland for each soil group
- Establish a net economic return for each soil group and ownership tract
- Calculate agricultural values for each tract by capitalizing the economic return
- Generate comparable agricultural use values for sections and township-level aggregates

Grouping Soil Units

Soil units were combined into groups with similar surface textures to facilitate calculation of tillage costs (Table 3). The three textural groups used were fine, medium (includes moderately fine), and coarse (includes moderately coarse). Textural groups were used in estimating fuel requirements and machine repair costs. Power needs for fine-textured soils were higher than those for coarse-textured soils and resulted in higher production costs for fine-textured soils.

The soil units were grouped according to productive capacity to facilitate computation of production costs for the various crops. To estimate production costs for wheat, the soil units were grouped by five bushel increments over a range of 15 to 45 bushels per acre.

Because of the range in tillage requirements and yields, the number of groups varied for each crop. For example, wheat required 14 groups. The number of groups required to evaluate other crops was: 14 groups for barley; 20 groups for corn; 10 groups for soybeans; 15 groups for sunflower; and 8 groups for hay.

TABLE 3. TEXTURAL AND CROP PATTERN GROUP FOR SOIL UNITS, AND SOIL UNITS THAT REQUIRE ADJUSTMENTS FOR STONE REMOVAL AND DRAINAGE MAINTENANCE

Soil	Textural Group[a]	Crop Pattern Group[b]	Stone Removal[c]	Drainage Maintenance[d]
Aastad-Forman loams	2	3	2	
Aberdeen fine sandy loam	3	1		
Aberdeen silt loam	2	1		
Aberdeen-Galchutt silty clay loams	2	1		1
Aberdeen-Ryan silty clay loams	2	1		1
Antler silty clay loam	2	1	2	2
Antler-Tonka silty clay loams	2	1	2	3
Arveson-Fossum fine sandy loams	3	2		1
Arveson and Fossum loams	2	2		1
Arvilla fine sandy loam	3	4		
Barnes-Svea loams, undulating	2	3	3	
Bearden silty clay loam	2	1		1
Bearden and Glyndon silt loams, moderately deep over clay	2	1		1
Borup loam	2	2		1
Cashel silty clay	1	1		
Colvin silty clay loam	2	1		1
Dickey-Towner fine sandy loams, undulating	3	4		
Doran clay loam	2	1	2	2
Doran-Perella clay loams	2	1	2	3
Doran-Tonka silty clay loams	2	1	2	3
Dovray silty clay	1	1		2
Eckman-Zell silt loams, rolling	2	2		
Egeland and Maddock fine sandy loams, undulating	3	2		
Embden-Tiffany fine sandy loams	3	2		
Embden-Tiffany loams	2	2		
Fairdale silt loam	2	2		
Fairdale silt loam, channeled	2	2		
Fairdale silty clay loam	2	2		
Fargo silty clay loam	2	1		1
Fargo silty clay	1	1		2
Fargo silty clay, depressional	1	1		2
Fargo silty clay, gently sloping	1	1		
Fargo silty clay, till substratum	1	1	1	2
Fargo-Enloe silty clay loams	2	1		2
Fargo-Enloe complex, till substratum	1	1	1	3
Fargo-Hegne silty clays	1	1		2
Fargo-Hegne silty clays, till substratum	1	1	1	2
Fargo-Ryan silty clay loams	2	1		2
Fargo-Ryan silty clay	1	1		2
Fordville-Renshaw loams	2	2		
Forman-Aastad loams, undulating	2	3	3	
Forman-Aastad loams, undulating, eroded	2	3	3	
Forman-Buse loams, rolling	2	3	3	
Forman-Buse loams, rolling, eroded	2	3	3	
Forman-Peever clay loams, undulating	2	3	3	
Fossum fine sandy loam	3	4		
Galchutt silt loam	2	1		1
Galchutt-Enloe-Fargo complex	2	1		2
Galchutt-Overly silt loams	2	1		1
Gardena silt loam	2	2		
Gardena-Eckman silt loams, undulating	2	2		
Gardena and Embden loams	2	2		
Gilby silt loam	2	3	2	1
Gilby silt loam, moderately saline	2	3	2	1
Gilby and Hamerly loams	2	3	2	1
Glyndon silt loam	2	2		1
Glyndon-Tiffany very fine sandy loams	2	2		1
Glyndon-Tiffany loams, moderately deep over clay	2	2		1
Glyndon and Wyndmere loams	2	2		1
Grano clay	1	1		2
Hamar loamy fine sand	3	4		
Hamar loamy fine sand, moderately deep over clay	3	4		
Hamar fine sandy loam	3	4		
Hamar fine sandy loam, moderately deep over clay	3	4		
Hamar-Ulen loamy fine sands	3	4		
Hamar-Ulen fine sandy loams	3	4		

- continued -

TABLE 3. TEXTURAL AND CROP PATTERN GROUP FOR SOIL UNITS, AND SOIL UNITS THAT REQUIRE ADJUSTMENTS FOR STONE REMOVAL AND DRAINAGE MAINTENANCE (CONTINUED)

Soil	Textural Group[a]	Crop Pattern Group[b]	Stone Removal[c]	Drainage Maintenance[d]
Hamerly loam	2	3	3	2
Hecla loamy fine sand, loamy substratum	3	4		
Hecla-Hamar loamy fine sands	3	4		
Hecla-Hamar fine sandy loams	3	4		
Hecla-Maddock loamy sands	3	4		
Kratka fine sandy loam	3	4		1
LaDelle silty clay loam	2	2		
LaPrairie silt loam	2	2		
Maddock-Hecla loamy fine sands, undulating	3	4		
Nutley silty clay, rolling	1	1		
Overly silty clay loam	2	1		
Overly-Bearden silt loams, moderately saline	2	1		
Overly-Bearden silty clay loams, moderately saline	2	1		
Overly-Beotia silty clay loams, undulating	2	1		
Parnell and Tonka silty clay loams	2	3		2
Peever-Forman clay loams	2	3	3	
Perella loam, moderately deep over clay	2	1		2
Perella silty clay loam, moderately deep over clay	2	1		2
Roliss clay loam	2	1	2	2
Ryan-Fargo complex	1	1		2
Stirum-Arveson loams	2	2		1
Svea loam	2	3	1	
Svea-Buse loams, undulating	2	3	2	
Svea-Buse loams, rolling	2	3	2	
Svea-Gardena loams	2	2	1	
Swenoda-Wyndmere fine sandy loams	3	2		
Tiffany fine sandy loam	3	2		1
Tiffany loam	2	2		1
Tiffany loam, moderately deep over clay	2	2		1
Tonka silt loam	2	3		2
Towner loamy fine sand	3	4		
Towner and Swenoda fine sandy loams	3	4		
Ulen fine sandy loam	3	4		
Vallers clay loam	2	3	1	2
Wahpeton silty clay	1	1		
Wyndmere fine sandy loam	3	2		1

[a]
1-refers to fine-textured soils.
2-refers to medium and moderately fine-textured soils.
3-refers to coarse and moderately coarse-textured soils.

[b]Refer to following table for crop patterns.

Group	Wheat	Barley	Soybeans	Hay	Corn	Sunflower	Rangeland
1	40	15	25	0	5	15	0
2	25	5	15	5	40	10	0
3	35	20	10	10	10	15	0
4	10	10	5	10	40	10	15

Above figures show average percentages of crops raised by soil group.

[c]
1-Stone adjustment of -$ .50/acre
2- -$ .75/acre
3- -$1.00/acre

[d]
1-Drainage adjustment of -$ .45/acre
2- -$ .90/acre
3- -$3.40/acre

SOURCE: Developed by D. D. Patterson, Department of Soil Science, North Dakota State University, Fargo.

Identification of Major Crops

Crops were selected on the basis of a five-year summary by the North Dakota Crop and Livestock Reporting Service (12). The data include the average number of acres of each crop raised in Richland County. The crops selected were: wheat, barley, sunflower, corn, soybeans, hay, and rangeland. Sugarbeets, edible beans, oats, and millet are grown in some areas, and account for only a small percent of total crop acreage, so they were not included.

Estimation of Crop Patterns for Soil Units

Proportions of the various crops grown in the county vary by soil and physiographic area. Wheat and soybeans are the major crops grown on the fine and moderately fine-textured soils of the Lake Agassiz Plain. Corn is the dominant crop on the coarse-textured soils of the Sheyenne Delta. Agricultural Stabilization and Conservation Service (ASCS) township crop acreage statistics for 1981 and 1982 were used to develop "crop pattern groups" for all soil units (Table 3). The four major crop pattern groups represent multi-township areas within the county. Group 1 represents the fine and moderately fine-textured soils on the lake plain. Group 2 consists of medium and moderately coarse-textured soils which mainly border the delta. Group 3 represents the medium-textured soils on the glacial till plain. Group 4 consists of the coarse-textured soils which occur mainly on the delta.

Enterprise Budgets for Cropland

The Oklahoma Enterprise Budget Generator was used to construct the crop budgets. The computerized budget system is a means of inputing budget data, performing the necessary computations, and printing the information in standard budget form (10).

A model farm was developed to construct the crop budgets. The model farm represents a size of 775 total tillable acres and no summerfallow (2). The model farm was endowed with resources that were characteristic of an average county farm. Cultural practices employed were representative of the area. The model farm was used to develop specific crop enterprise budgets.

A wage rate of $4.50 per hour was assigned to part-time labor hours required to operate field implements. The operator's labor time and management were paid a total management charge of 10 percent of operating costs.

A machinery complement was developed for the model farm. The following data were specified for each machine: machine size, speed of travel, field efficiency, purchase price of machine, hours of annual use, number of years owned, and hours of life.[1] The variables were used to estimate depreciation, required operating labor, repair costs, and interest on machine investment.

Information used to develop machinery complements was obtained from published results of a 1977 survey of farm machinery characteristics in North Dakota (20). Machine sizes and field speeds for tillage, seeding, and harvesting equipment for the model farm were estimated by agricultural engineers of the NDSU Cooperative Extension Service. Production costs varied by soil group. Differences in crops and estimated yields were captured in the cost budgets.

Table 4 contains estimated production costs for wheat raised on the most productive soil units, which had an estimated yield of 45 bushels per acre. Soil units in this group were fine textured and yield capabilities range from 41 to 45 bushels.

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[1]Hours of life refers to the theoretical hours of service the machine was built to provide.

TABLE 4. ESTIMATED PRODUCTION COSTS PER ACRE FOR WHEAT ON SOIL GROUP 1[a]

Inputs	Units	Quantity	Price	Value	
			- - dollars - -		
Operating Inputs					
Wheat Seed	Bushel	1.25	$4.80	$ 6.00	
MCP Herbicide	Pounds	0.375	3.32	1.24	
Fargo Herbicide	Pounds	1.5	6.64	9.96	
Nitrogen and Phosphorus (18-46-0)	Pounds	54	0.10	5.40	
Anhydrous (82-0-0)	Pounds	84	0.12	10.08	
Overhead	Acre	1	5.14	5.14	
Tractor Fuel and Lubrication	Acre			4.89	
Tractor Repairs	Acre			1.19	
Equipment Fuel and Lubrication	Acre			5.61	
Equipment Repairs	Acre			4.24	
Total Operating Costs					$53.76
Capital Cost					
Annual Operating Capital		5.21	15.6[b]	0.81	
Tractor Investment		20.71	5.0[b]	1.04	
Equipment Investment		86.24	5.0[b]	4.31	
Total Capital Costs					$ 6.16
Ownership Cost (depreciation, taxes, insurance)					
Tractor				2.09	
Equipment				12.68	
Total Ownership Cost					$14.77
Labor Cost					
Machinery Labor	Hour	1.53	$4.50	6.89	
Total Labor Costs					$ 6.89
Total Costs[c]					$81.59

[a]Yield is 41 to 45 bushels per acre on fine-textured soils.

[b]Interest rate in percent.

[c]Total production costs per acre is the sum of operating costs, capital costs, ownership, and labor costs. Costs exclude adjustments for stone removal, drainage maintenance, management fees, hail insurance, drying, and storage.

TABLE 5. ESTIMATED PRODUCTION COSTS PER ACRE FOR WHEAT ON SOIL GROUP 14[a]

Inputs	Units	Quantity	Price	Value	
			- - dollars - -		
Operating Inputs					
Wheat Seed	Bushel	1.25	$4.80	$ 6.00	
MCP Herbicide	Pounds	0.375	3.32	1.24	
Fargo Herbicide	Pounds	1.50	6.64	9.96	
Nitrogen and Phosphorus (18-46-0)	Pounds	33	0.10	3.30	
Nitrogen (46-0-0)	Pounds	5	0.11	0.55	
Overhead	Acre	1	5.14	5.14	
Tractor Fuel and Lubrication	Acre			4.21	
Tractor Repairs	Acre			1.02	
Equipment Fuel and Lubrication	Acre			5.26	
Equipment Repairs	Acre			3.65	
Total Operating Costs					$40.34
Capital Cost					
Annual Operating Capital		4.75	15.6[b]	0.74	
Tractor Investment		17.77	5.0[b]	0.89	
Equipment Investment		75.98	5.0[b]	3.80	
Total Capital Costs					$ 5.43
Ownership Cost (depreciation, taxes, insurance)					
Tractor				1.80	
Equipment				11.24	
Total Ownership Cost					$13.04
Labor Cost					
Machinery Labor	Hour	1.38	$4.50	6.22	
Total Labor Cost					$ 6.22
Total Costs[c]					$65.03

[a]Yield is 15 to 20 bushels per acre on coarse-textured soils.

[b]Interest rate in percent.

[c]Total production costs per acre is the sum of operating costs, capital costs, ownership, and labor costs. Costs exclude adjustments for stone removal, drainage maintenance, management fees, hail insurance, drying, and storage.

Table 5 lists production costs for wheat on the least productive soils. Soil units in Table 4 were coarse-textured with yields of 15 to 20 bushels per acre.

Seeding and herbicide application rates per acre were assumed to be constant regardless of estimated yield or soil texture and, therefore, remained constant across all soil groups. Costs which varied by soil groups included: fertilizer, fuel, lubrication and repair costs, labor costs, and ownership costs. Fine-textured soils required more power for tillage operations than coarse-textured soils, so fuel, lubrication, and repair costs were slightly higher for these soil groups.[2]

Production cost estimates shown in Tables 4 and 5 do not include cost adjustments for stone removal, drainage maintenance, management fees, hail insurance, storage, and drying. Calculation of these cost is explained in a later section.

Wheat and barley had similar production costs. Production cost estimates for wheat ranged from $65.03 to $81.59 per acre. Production costs for barley ranged from $65.25 to $83.33 per acre. Sunflower and soybeans had slightly higher costs. Sunflower costs ranged from $86.79 to $94.92 per acre. Soybean costs ranged from $83.16 to $90.65 per acre. Corn costs ranged from $102.01 to $128.95 per acre.

Corn was the most expensive crop to raise. Corn production costs varied more than other crops, except hay. The most productive soil units for corn had production costs of $130.11 per acre. The least productive soil units had costs of $102.01 per acre. Fertilizer and drying costs varied the most for corn. Some soil units used extensively for corn production

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[2]Size of machinery remained constant among soil units but the speed of travel was adjusted to reflect the power requirements of different soil textured groups.

generated a negative net return per acre, so the model was programmed to replace cropland income estimates with rangeland income estimates.

Hay had the greatest variation in production costs, ranging from $68.62 to $119.58 per acre. Harvesting and hauling costs contributed to this wide range in production costs. Harvesting and hauling costs were considerably higher on those soil units with yields of three to four tons per acre than for soil units with yields of less than two tons per acre.

Gross receipts were calculated by multiplying an average price received times the crop yield for each soil unit. Total production costs for each soil group were subtracted from gross receipts. Additional cost adjustments which were subtracted from gross receipts, included stone removal, drainage maintenance, hail insurance, management fees, storage, and drying. The resulting economic return is an estimate of the net return to the land resource. It represents an economic estimate of the productive capacity of each soil unit for production of each crop.

Production Cost Estimates

Production costs for each crop vary among soil groups. The cost estimates calculated were those anticipated under improved management practices. All production costs were included except land charges and real estate taxes. Certain costs such as fertilizer, machinery, fuel and oil, stone removal, and drainage maintenance vary with soil groups and/or yield. Other costs were assumed to be constant regardless of soil group or crop yield (e.g., seeding, spraying, overhead, and interest). Cost information was based on survey prices gathered annually by the NDSU Cooperative Extension Service and the North Dakota Crop and Livestock Reporting Service. Table 6 lists input prices used. All input prices were a three-year average for 1980, 1981, and 1982.

TABLE 6. INPUT PRICES USED IN ENTERPRISE COST ESTIMATES

Inputs	Cost
Wheat seed	$ 4.80/bu.
Barley seed	$ 3.45/bu.
Alfalfa seed	$ 1.69/lb.
Corn seed	$42.00/bu.
Sunflower seed	$ 1.45/lb.
Soybean seed	$ 8.85/bu.
Fargo herbicide	6.64/lb.
Carbyne herbicide	19.20/lb.
MCP amine herbicide	3.32/lb.
Lasso herbicide	4.60/lb.
Bladex herbicide	3.97/lb.
Banvel herbicide	10.21/lb.
Furdan fungicide	0.90/lb.
Treflan herbicide	8.07/lb.
Amiben herbicide	7.60/lb.
Anhydrous ammonia 82-0-0	0.12/lb.
Nitrogen and Phosphorus 18-46-0	0.10/lb.
Phosphorus 0-44-0	0.09/lb.
Nitrogen 46-0-0	0.11/lb.
Potash	0.14/lb.
Seed treatment	4.60/lb.
Sencor herbicide	10.20/lb.
Wage rate	$ 4.50/hour
Silage feed	22.23/ton
Alfalfa feed	51.01/ton
Barley feed	1.53/bu.
Salt and minerals	0.04/lb.
Vet service and medicine	$ 6.50/cow-calf unit
Hauling and marketing	8.18/cow-calf unit
Short-term interest rate	15.6 percent
Medium-term interest rate on machinery	5 percent
Gasoline	$ 1.24/gal.
Diesel	$ 1.12/gal.

Input Costs

The following sections detail how various costs were estimated.

Seed. Seeding rates were assumed to be constant for all soil groups. The North Dakota Crop Production Guide (12) provided suggested seeding rates.

Fertilizer. Recommended fertilizer application rates depend on yield goal and current fertility level of the soil. Yield goals were established by multiplying the estimated yields by a factor of 1.3. Fertilizer needs for various crops were estimated from fertilizer recommendations made by the NDSU Extension Service (4,5,6,7,8,9). A certain level of fertility was assumed to be in the soil depending on textural group. Sixty-five pounds of available nitrogen were assumed to be in the fine- and medium-textured soils. Fifty pounds of available nitrogen were assumed to be in the coarse-textured soils. Low-to-medium levels of phosphorous and high levels of potassium were assumed for all soil units.

Spray. Recommended herbicide application rates were taken from the 1983 Farm Management Planning Guide (19). Herbicide, insecticide, and fungicides used and their application rates were assumed to be constant regardless of soil group.

Drying and Storage. Drying costs vary with yield levels, and apply mainly to corn and sunflower. Custom rates provided annually by the North Dakota Crop and Livestock Reporting Service and yield data were used to calculate drying costs (12). The crop was assumed to be harvested at 14.8 percent moisture for sunflower and 18.9 percent for corn.

Wheat and soybeans were assumed to be stored on the farm for six months while barley, corn, and sunflower were stored for five months (5). The cost of storage used was $.03 per bushel per month. The storage charge reflected what local elevators would charge.

Overhead and Management. Overhead and management fees were based on data provided by the NDSU Agricultural Experiment Station and North Dakota Vocational Agriculture farm record summaries. Overhead costs included the farm share for utilities and auto, insurance, farm magazine subscriptions, the farm shop, accounting fees, bank charges, etc., and were estimated at \$5.14 per acre for all crops, regardless of soil group (14). A management fee of 10 percent of total operating costs was assumed (3). Management fees were a constant percentage for all soil units.

Stones. Crop budgets for some soil units were adjusted to reflect the cost of stone removal (Table 2). Costs of \$0.50, \$0.75, or \$1.00/acre/year were assigned to crops grown on those soil units depending on estimated annual stone removal requirements.

Drainage. Certain soil units in the county require annual maintenance of surface drainage systems (Table 2). Those soil units were identified and costs of \$0.45, \$0.90, or \$3.40/acre/year were assigned.

Interest on Operating Capital. The interest rate used for operating capital was 15.6 percent of all operating costs excluding land and machinery (16). The selected interest rate was an average annual contractual rate provided by the Production Credit Association. The rate was a three-year average of 1980, 1981, and 1982 rates.

Crop Insurance. The cost of hail insurance was included in the production cost estimates. Hail insurance rates within the county, vary by crop and region. The differences were reflected in the cost estimates. Hail insurance rates were taken from Richland County hail insurance data (17). Table 7 contains a list of the insurance rates used for each crop depending on location. Insurance coverages were set at levels which would cover out-of-pocket cash costs for the major crops considered in the study.

TABLE 7. HAIL COSTS FOR VARIOUS CROPS DEPENDING ON LOCATION

Township Location Group	Wheat, Barley, Corn[a]	Soybeans[a]	Sunflower[a]
1	$3.00	$ 5.00	$ 4.40
2	3.25	5.40	4.70
3	3.50	5.80	5.00
4	3.75	6.10	5.40
5	4.00	6.70	5.80
6	4.50	7.40	6.50
7	5.00	8.20	7.20
8	6.00	9.90	8.60
9	7.00	11.40	10.00

Township	Township Location Group	Township	Township Location Group
Wyndmere	1	Helendale	7
Danton		Grant	
Abercrombie		Viking	
Ibsen		Garborg	
Summit		Barney	
Homestead	2	Sheyenne	8
Nansen		Freeman	
Antelope		Barrie	9
West End		Duerr	
Mooreton			
Waldo	3		
Center			
Lamars			
Fairmount			
Brandenburg			
Devillo	4		
Liberty Grove			
Walcott			
Colfax			
Belford	5		
Brightwood			
Eagle			
Dwight			
Dexter			
Moran	6		
Elma			
Greendale			

[a]Rates are in dollars per acre, per one hundred dollars of coverage.

SOURCE: Rates and Rules for Crop Hail Insurance in North Dakota, Crop-Hail Insurance Actuarial Association, Chicago, Illinois, 1979-CHIA72, 1982.

Machinery Requirements. Machinery requirements for each crop reflects the number of times each acre is covered by a particular power unit and implement. Machinery costs per acre were calculated using the enterprise budget generator program.

Machinery costs per acre may be divided into fixed and variable costs. Fixed costs are those costs which are incurred regardless of use or output level. Fixed machinery costs included depreciation, insurance, and interest on machine investment. Variable machinery costs are those costs which vary directly with machine use. They included fuel and oil, repairs, and labor required to operate the machine. Fixed and variable costs were used to calculate total machinery costs.

Fixed Machinery Costs

All fixed costs were computed using the enterprise budget generator. Fixed costs were depreciation, interest on investment, and insurance. These costs do not vary with soil group and were held constant. A modified double-declining balance method developed by Bowers (1), calculates machinery depreciation. The modified double declining balance method incorporated purchase price, the number of years owned and hours of annual use. The purchase price of the machines used were survey prices compiled by the Minnesota Cooperative Extension Service.

Interest on investment reflects forgone earnings by having money invested in machinery less any increased in value of the machinery due to inflation. The nominal interest rate minus the inflation rate yields a real interest rate of 5 percent that was used to reflect machinery ownership costs. Insurance costs were computed using an insurance rate of 0.6 percent/year. Both interest and insurance costs were based on average machine investment.

Variable Machinery Costs

Fuel and Oil

Draft requirements for different tillage operations depend on soil moisture content, depth of penetration, soil compaction, and soil texture. Soil texture varied among soil groups while the effects of other soil conditions were assumed to be constant. Higher draft requirements (and slower tillage speeds) are needed for the fine-textured soils. Medium- and coarse-textured soils have lower draft requirements, therefore, faster tillage speeds are assumed. The study assumed that the same tractor and implement size was used regardless of soil group. Harvesting fuel costs depend on crop, yield, moisture content, and condition of crop. Harvest speeds were selected for each crop depending on yield. Fuel consumption per hour was assumed to be constant for each tractor and implement combination. Faster tillage and harvesting speeds resulted in less fuel consumption, and lower fuel costs per acre.

Oil and lubrication costs were assumed to be 15 percent of fuel costs. They were computed only for machines with engines. Lubricant cost for machines without engines was included in repair costs.

Labor. The hours of labor required to operate the machinery were based on the field operations performed, the width of machine and speed of travel. Allowances were made for time required to adjust equipment and to provide lubrication and maintenance. The required labor hours were multiplied by a wage rate to compute labor costs.

Repairs. Repair costs are influenced by a number of items including: operator's experience, soil conditions, yield and kind of crop, and age of the machine. The enterprise budget generator based repair costs on the initial list price of machine, type of machine, and age of machine. Age of machine is measured by the percent of useful life that has accumulated.

Gross Returns

Gross return per acre is directly related to yield and were calculated for various crops according to soil unit. Estimated gross return for a crop was calculated by multiplying the yield for each soil unit by an average product price. Product prices for various crops were reported Minneapolis Grain Exchange prices less freight and handling charges to Wahpeton, North Dakota. The alfalfa price was based on North Dakota Crop and Livestock Statistics. Prices were a five-year average for 1978 through 1982. The prices represented a season-average price received by farmers in the Richland County area. Data shown in Table 8 are estimated product prices received by farmers in Richland County.

Enterprise Budgets for Rangeland

Livestock carrying capacity was estimated for each soil unit in Richland County. To estimate rangeland net incomes for soil units, rangeland was assumed to be composed of native grasses in excellent condition and used primarily for grazing.

Animal-unit days per acre were used as the measure of carrying capacity. Animal-unit days refer to the number of days an acre of a given soil unit will supply a sufficient quantity of forage for one cow with calf. Thirty animal-unit days equal one animal-unit month. Table 9 presents the enterprise budget for beef used to calculate the value of an animal-unit month. The estimated value of an animal-unit month (AUM) was $38.67.

A beef enterprise budget was used to estimate the value of an animal unit month. Data from the NDSU Cooperative Extension Service was used as a guide in developing cost estimates. It was assumed that the expense of maintaining a given number of animals on pasture remained constant regardless of range quality.

TABLE 8. COMMODITY PRICES USED IN THE BUDGET GENERATOR[a]

		- dollars -
Spring Wheat[a]		$ 3.45/bu.
Barley[a]		2.30/bu.
Corn[a]		2.04/bu.
Soybeans[a]		6.02/bu.
Sunflower[a]		.0963/lb.
Alfalfa[b]		49.50/ton
Steer Calves[c]	450 lbs.	76.67/cwt.
Heifer Calves[c]	410 lbs.	68.46/cwt.
Cull Cows[c]	1,100 lbs.	42.78/cwt.
Cull Heifers[c]	750 lbs.	61.96/cwt.
Cull Bull[c]	1,800 lbs.	53.28/cwt.

[a]Freight and handling charges were subtracted to reflect local elevator price received in Wahpeton, North Dakota.

SOURCE: One-hundreth Annual Report, year ending December 31, 1982, published by Minneapolis Grain Exchange, Minneapolis, Minnesota, Thomas Hoffman, Statistician.

[b]SOURCE: North Dakota Agricultural Statistics, North Dakota Crop and Livestock Reporting Service, issued cooperatively by North Dakota State University Agricultural Experiment Station, and U.S. Department of Agriculture Economics and Statistics Service, Agriculture Statistics, No. 52, June 1983.

[c]SOURCE: U.S. Department of Agriculture, Agricultural Marketing Service, Livestock Detailed Quotations weekly, West Fargo, North Dakota, 1978-1982.

TABLE 9. BEEF COW-CALF ENTERPRISE BUDGET FOR RICHLAND COUNTY, 1981-82

Inputs	Units	Price[a]	Quantity	Value[b]		
Operating Inputs						
Barley	Bushel	1.53	6.00	$ 9.18		
Alfalfa	Ton	51.01	1.26	64.27		
Silage	Ton	22.23	1.50	33.34		
Salt and Minerals	Pounds	0.04	24.00	0.96		
Veterinary and Medicine	Dollar	1.00	6.50	6.50		
Hauling and Marketing	Dollar	1.00	8.18	8.18		
Overhead	Acre	5.14	1.00	5.14		
Tractor Fuel and Lubrication				6.68		
Tractor Repair Cost				2.35		
Machinery Fuel and Lubrication				5.31		
Machinery Repair Cost				7.08		
Equipment Repair Cost				5.58		
Total Operating Cost					$154.58	
Capital Cost						
Annual Operating Capital		15.6[c]	37.62	5.87		
Tractor Investment		5.0	40.77	2.04		
Machinery Investment		5.0	20.86	1.40		
Equipment Investment		5.0	131.10	6.56		
Livestock Investment		5.0	573.85	28.69		
Total Capital Cost					$ 44.20	
Ownership Cost: (Depreciation, taxes, insurance)						
Tractor				4.12		
Machinery				3.50		
Equipment				15.46		
Livestock				8.24		
Total Ownership Cost					$ 31.32	
Labor Cost						
Livestock Labor Costs	Hour	4.50	8.04	36.18		
Total Labor Cost					$ 36.18	
Management Costs		0.10	154.58	15.46		
Total Management Costs					$ 15.46	
Total Costs					$281.74	
	Weight[d]	Price[e]	Quantity[f]	Value		
Production						
Steer Calves	450	76.67	0.45	155.26		
Heifer Calves	410	68.46	0.27	75.79		
Cows	1,100	42.78	0.15	70.59		
Heifers	750	61.96	0.02	9.29		
Bulls	1,800	53.28	0.01	9.59		
Total Receipts						$320.51
Less Production Costs						$281.74
Returns to Rangeland						$ 38.67

[a]Price in dollars per unit.
[b]Cost in dollars.
[c]Interest rate in percent.
[d]Weight in pounds.
[e]Price in dollars per hundredweight.
[f]Percentage of total herd.

It was assumed that herd-size was 100 cows and that the grazing period for the cow-calf unit was 180 days in estimating costs and return for a beef enterprise. Other assumptions included:

1. 90 percent calf crop;
2. 16 percent replacement rate;
3. 1 percent cow death loss;
4. 1 bull per 25 cows; and
5. 45 percent steer, 27 percent heifer, and 15 percent cull cows.

Price per pound of livestock sold was based on a five-year average of prices received by livestock producers in 1978, 1979, 1980, 1981, and 1982. Costs were three-year averages of the years 1980, 1981, and 1982. Prices received by livestock producers are shown in Table 8. Costs used in developing a beef enterprise budget are shown in Table 6.

Net income for rangeland is estimated as follows:

$$\frac{\text{Value of an animal unit year}}{\text{6 AUMs}} \times \text{Carrying capacity per acre (in AUMs)} = \text{Net income per acre}$$

Net Returns for Soil Units

Net return on each soil unit was estimated for all crops using a weighting procedure shown in Table 10 for Fargo silty clay. Weighted net return reflects crop patterns associated with soil units. Percentages of crops raised on soil units were multiplied by their respective net returns (Column 13 minus Column 12 times Column 14). The sum of the products in Column 15 equals the weighted net return for a soil unit. Thus, the net return to Fargo silty clay in the example was $59.68 (excluding costs for stone removal and drainage maintenance).

Cost adjustments for stone removal, drainage maintenance, hail insurance, management fees, storage, and drying were reflected in final cost estimates. Storage and drying costs were estimated by crop yield.

TABLE 10. CALCULATION OF WEIGHTED NET RETURN PER ACRE FOR FARGO SILTY CLAY BY CROP ENTERPRISE

Column 1 Crop	Column 2 Yield[a]	Column 3 Costs[b]	Column 4 Costs[c]	Column 5 Months[d]	Column 6 Hail[e]	Column 7 Drying Cost[f]	Column 8 Hail Cost[g]	Column 9 Fertilizer Cost[h]	Column 10 Storage Cost[i]	Column 11 Management Fee[j]	Column 12 Total Cost[k]	Column 13 Revenue[l]	Column 14 Percent[m]	Column 15 Return[n]
Wheat	41	81.59	59.93	6	3.00	0	1.79	-2.32	7.38	6.67	95.12	141.45	40	20.00
Barley	66	83.13	60.32	5	3.00	0	1.81	-1.56	9.90	7.04	100.32	151.80	15	7.72
Soybeans	32	90.65	60.63	6	5.00	0	3.03	0	5.76	6.94	106.38	192.64	25	21.56
Corn	80	113.61	83.12	5	3.00	7.64	2.49	0	12.00	10.52	146.26	163.20	5	0.84
Sunflower	1,900	96.58	71.39	5	4.40	11.79	3.14	-1.04	10.17	8.54	119.19	182.97	15	9.56
Hay	3.6	119.58	71.59	0	0	0	0	-1.36	0	12.97	142.71	178.20	0	0
Rangeland	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a]Wheat, barley, soybeans, corn in bushels; sunflower in pounds; hay in tons per acre; and rangeland in animal unit months.

[b]Estimated production costs excluding costs for storage, drying, hail insurance, management fees, fertilizer adjustments, and adjustments for stone removal and drainage maintenance.

[c]Costs in column three minus ownership (depreciation, taxes, and insurance) and labor costs.

[d]Months storage.

[e]Hail insurance premium per one hundred dollars coverage for township location group 1.

[f]Corn = (Column 2) x (.50) x (.191)
Sunflower = (Column 2) x (.33) x (.2825)

[g] $\frac{\text{Column 4}}{100}$ x (Column 6)

[h]Wheat = (45 - 41) x (.58) x (-1)
Barley = (70 - 66) x (.39) x (-1)
Sunflower = $\frac{2,000 - 1,900}{50}$ x (.52) x (-1)
Hay = (4 - 3.6) x (10) x (.34) x (-1)

[i](Column 2) x (Column 5) x (.03)

[j](Column 4 + Column 7 + Column 8 + Column 9 + Column 10) x .10

[k](Column 3 + Column 8 + Column 9 + Column 10 + Column 11)

[l](Column 2 x Price) (Value of one animal-unit month)

[m]Percent of crop pattern.

[n][(Column 13) - (Column 12)] x (Column 14)

The sum of figures in Column 15 is net return per acre excluding adjustments for stone removal and drainage maintenance for Fargo silty clay.

Hail costs depended on soil unit location. Management fees were assumed at 10 percent of total operating costs. Net return was adjusted for hail insurance premiums depending on township location. Premiums were established according to location and history of hail damage.

Soil Acreage Data Base

County assessment records identified all rural taxable properties in the county, totalling over 7,000 individual properties. The parcels excluded federal- and state-owned lands, cities and villages, railroads, and property owned by utilities. All properties taxable as agricultural lands were included in the data base. Information contained in assessment records included names(s) of property owner(s), legal description, and number of acres of each soil unit.

Properties were aggregated at the quarter-section level from that information. Quarter-section aggregates identified the number of acres of each soil unit and land type, and economic returns for a quarter-section tract of land were computed.

Economic Return for a Tract of Land

The average economic return for a tract of land was calculated after computing an estimated net return in dollars per acre for each soil unit. Economic returns for tracts were estimated using the following procedure: Multiply the acreage of each soil unit by net return per acre and divide the sum of the products by the total number of acres in the tract. The resulting dollar amount is the average economic return for the farmland tract.

Results

Two forms of estimates can be developed using the detailed soil survey data approach. First, net return estimates can be developed for individual soil units based on crop yields, crop patterns and costs of production. Second, the net return estimates can be aggregated to determine the average net return for ownership tracts, 160-acre tracts, townships, or the county. This section reviews both forms of output.

Net return for an individual soil unit is the basic economic estimate of soil productivity. Net return by soil unit is, therefore, the most flexible and useful result of the model. Returns for individual soil units can be used by assessors to establish average net returns for ownership tracts comprised of one or more known soil units. It is computationally more efficient, however, for the computer model to perform the necessary calculations and derive the weighted average return for each ownership tract. Table 11 presents a summary for one such ownership tract. The table contains the ownership tract identification, soil map symbol, soil unit name, number of acres of each soil unit, estimated net return for each soil unit, weighted average net return for the tract, and an index. The index number relates the estimated net return for each soil unit to the highest net return generated by the most productive soil unit in the county. The index is expressed as an index number between 300 and 100. Thus, the net return on Fairdale silt loam (channeled) is 71 percent of the net return generated on the most productive soil unit in the county. The index number at the bottom of the index column expresses the net returns index as an acreage-weighted average. This overall index is a useful indicator of relative productivity at the ownership tract level. The summary table includes sufficient detail for the owner to identify each soil unit, its

TABLE 11. A REPRESENTATIVE OWNERSHIP TRACT SUMMARY

ID Number XXXX
Township Sheyenne
Section X
Quarter X

Soil ID	Soil Unit Name	Map Symbol	Acres	Net Return/ Acre	Index/ Acre
33	Fairdale silt loam, channeled	Fb	12.00	38.47	71
75	Hecla-Hamar loamy fine sands	Hm	14.00	11.77	61
82	Ladelle silty clay loam	La	16.00	56.20	81
86	Maddock loamy fine sand, rolling	MdC	12.00	6.46	55
87	Maddock-Hecla loamy fine sand, undulating	MhB[a]	14.00	7.11	61
103	Serden loamy fine sand	Sd	39.00	5.17	44
123	Wahpeton silty clay	Wa	6.00	61.93	81
	Woodlot		18.00	0.00	0
	Farmstead		4.00	0.00	0
	Roads		2.00	0.00	0
	TOTALS		137.00	$20.61[b]	60

[a]Soil unit was changed from cropland to noncropland use since it was not economically suitable for crop production.

[b]The net return per acre for the entire ownership tract represents an acreage-weighted average of the soil unit returns shown.

corresponding economic return and, thus, better understand the assessed valuation on each tract.

Aggregation of the net returns for individual soil units into township totals (Figure 2) yields an acreage-weighted, average net return for each township. Table 12 contains weighted-average net returns and associated rankings for the 36 townships in Richland County in 1983. The highest net return was in Barney Township ($53.58) and the lowest net return occurred in Sheyenne Township ($11.39). The corresponding true and full equalized values (established by the county for 1983) are shown in Table 12. The highest value occurred in Barney Township ($622.54) and the lowest value was in Sheyenne Township ($185.45). The ranking of townships is quite similar under the computer model approach and current assessment practice in the county. This is as expected, since the county has been using the detailed soil maps and estimated wheat and rangeland yield levels for groups of soil units to array the townships. The comparable rankings under the two methods indicates that the detailed soil survey approach is a viable method for use in the county.

Conclusions and Implications

Agricultural land in North Dakota is currently assessed using several methods. State law requires that equalization of annually assessed values comply with county-average estimates of agricultural value. The county-average values have been referred to as "productivity values," since they are approximations of the capitalized expected return to land. The major problem with the current law is that it does not provide a method for implementing a "true productivity" approach based on detailed soil survey information at the assessment level. That is, various practices are employed by local assessors. Soil information currently plays only a minor

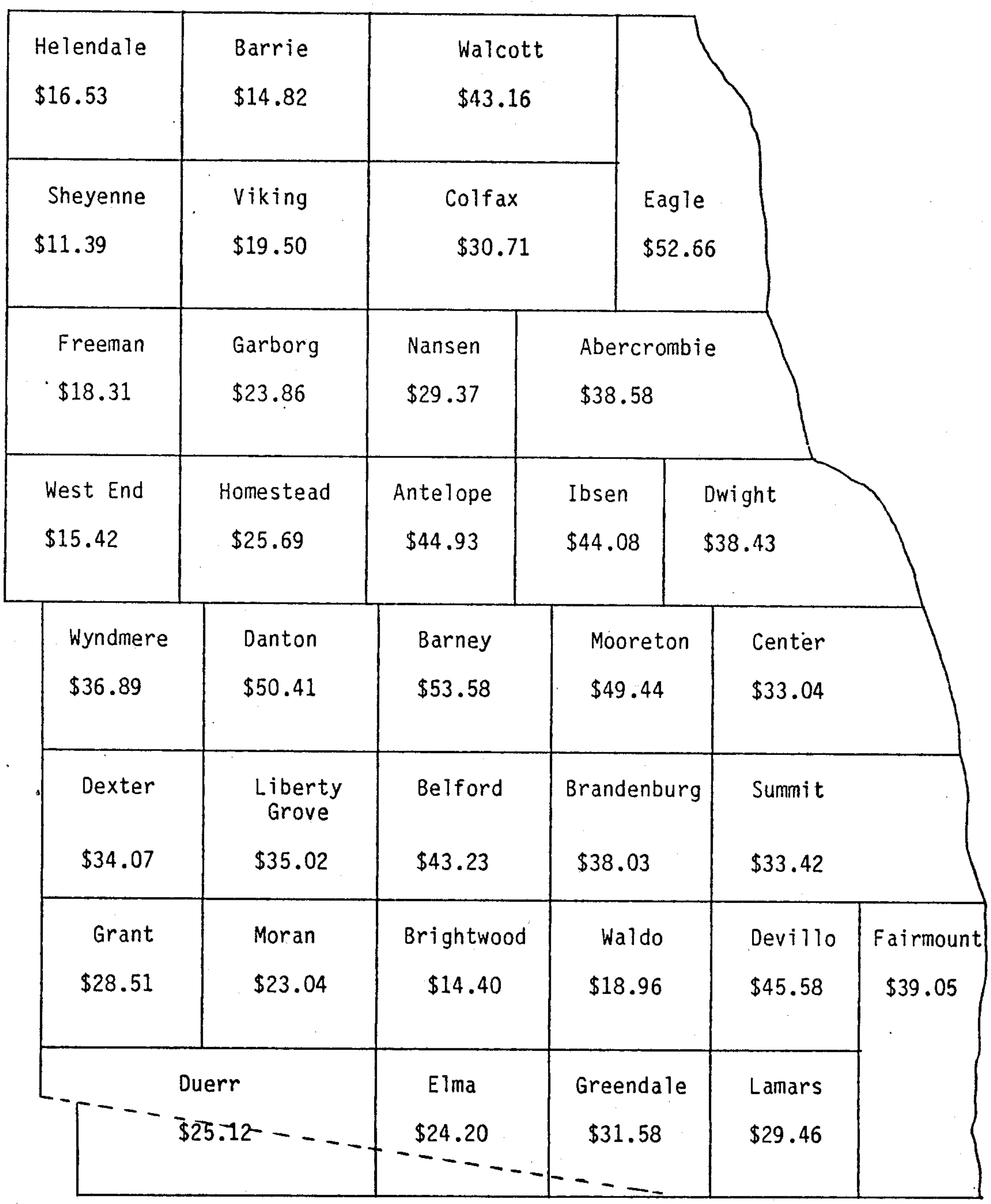

Figure 2. Estimated Net Return by Township in Richland County

TABLE 12. ESTIMATED AVERAGE NET RETURN, TRUE AND FULL VALUES, AND CORRESPONDING RANKINGS FOR AGRICULTURAL LAND BY TOWNSHIP IN RICHLAND COUNTY, 1983

Township	Estimated Average Net Return[a]	Rank by Net Return	True and Full Agricultural Value[b]	Rank by Value
Eagle	$52.66	2	$565.31	6
Walcott	43.16	9	502.90	10
Colfax	30.71	20	442.94	18
Barrie	14.82	34	258.70	34
Helendale	16.53	32	253.88	35
Sheyenne	11.39	36	185.45	36
Viking	19.50	29	377.60	26
Abercrombie	38.58	11	487.99	12
Nansen	29.37	22	512.71	8
Garborg	23.86	27	434.17	19
Freeman	18.31	31	292.45	32
West End	15.42	33	304.40	29
Homestead	25.69	24	403.00	23
Antelope	44.93	6	621.70	2
Ibsen	44.08	7	592.07	3
Dwight	38.43	12	451.89	17
Center	33.04	18	474.89	14
Mooreton	49.44	4	574.28	5
Barney	53.58	1	622.54	1
Danton	50.41	3	590.02	4
Wyndmere	36.89	14	410.98	21
Dexter	34.07	16	378.74	24
Liberty Grove	35.02	15	409.65	22
Belford	43.23	8	498.51	11
Brandenburg	38.03	13	503.89	9
Summit	33.42	17	486.67	13
Fairmount	39.05	10	468.92	15
Devillo	45.58	5	556.71	7
Waldo	18.96	30	378.46	25
Brightwood	14.40	35	288.43	33
Moran	23.04	28	341.69	27
Grant	28.51	23	339.94	28
Duerr	25.12	25	293.07	31
Elma	24.20	26	302.57	30
Greendale	31.58	19	421.33	20
Lamars	29.46	21	464.06	16

[a]Township average net return per acre is estimated by summing the acreage-weighted net returns across quarter-section tracts in the county.

[b]True and full values shown are final equalized values based on 1983 assessment in the county.

role in the determination of value. Counties which have (and use) the detailed soil survey in effect incorporate soil information, yet these efforts generally lack an economic interpretation of productivity. That economic interpretation of soil productivity is accomplished in this study with the use of enterprise budgets which are adapted to soil information and production practices in the county. This study has demonstrated that a true productivity approach can be implemented at the county level.

A computer model was developed which is capable of generating an estimate of the economic return for each soil unit, and for ownership tracts comprised of several soil units. The model is budget-based; this means that the return on an individual soil unit was determined using standard enterprise budgeting methods. Price and cost estimates used in the crop and livestock budgets were based on five and three year averages, respectively. This was done to reduce the impact of price variability on estimates of the return to land.

Estimated of net returns by soil units were combined to develop a comparable economic returns for ownership tracts, and averages for townships. The average return was an acreage-weighted average which reflected soil unit composition. Capability of the model to provide an average return per acre for ownership tracts indicates that the model is a highly useful tool for assessment and equalization at the local level. Comparison of township average net returns and equalized true and full values indicates the detailed soil survey approach is a viable method to implement within the county.

Several implications of this study for farmland assessment and equalization can be cited (along with some limitations). First, use of detailed soil survey information is a practical approach to farmland valuation at the local assessment level, and could be implemented in counties for which a modern soil survey is published. Second, Directors of Tax Equalization in counties which have a modern soil survey need to tabulate the acreage of each soil unit by ownership tract. Acreage tabulation is a prerequisite to using the approach outlined in this study. Third, commodity prices and input costs which underlie the budgeted return to land must be updated on a regular basis to keep estimated return current. Fourth, the crop patterns and yield data base must be reviewed periodically to maintain credibility of the model.

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List of Tables

List of Figures