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ECONOMIES of FARM SIZE in Southwestern North Dakota

F. LARRY LEISTRITZ and WALTER SCHNEEBERGER

DEPARTMENT OF AGRICULTURAL ECONOMICS
AGRICULTURAL EXPERIMENT STATION
NORTH DAKOTA STATE UNIVERSITY
FARGO, NORTH DAKOTA

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by

F. Larry Leistritz and Walter Schneeberger

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

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Highlights

The purpose of this study was to determine the nature of the relationship between farm size and production costs of beef cattle-small grain producers in southwestern North Dakota. Minimum-cost linear programming was the principal analytical technique employed. Programming models were used to derive short-run average cost curves for farms of six different sizes with farm size defined by the number of full-time workers and the complement of machinery. Land was a variable resource in the analysis.

The most common livestock and crop enterprises in the area studied were included as alternatives in the programming models. A high level of managerial efficiency was assumed in developing the input-output data for the models.

Least-cost farm plans and short-run cost curves were developed for six sizes of beef cattle-small grain farms with participation in 1971 government farm programs. Wheat was the dominant crop in all of these farm plans and all farms maintained beef herds. Substantial economies of size were found to exist. Two-man farms had considerably lower costs than the one-man farms. Further cost reductions were observed when the full-time labor force was expanded to three men.

Least-cost farm plans were developed for the same six farm sizes without participation in the government farm programs. The optimal enterprise organizations for the nonparticipating farms were very similar to those of the farms participating in the government programs. The two-man and three-man farms again had substantial cost advantages over the one-man farms. The income levels for all farm sizes were considerably lower without participation in the government programs.

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Introduction

The profitability of North Dakota cash grain and livestock production is influenced by a wide variety of forces. In recent years substantial changes have occurred in demand and supply relationships and in production technology. These changes have resulted in greater capital requirements, higher prices for most inputs, greater productive capacity of labor, and more specialization on North Dakota's farms and ranches.

Most North Dakota farms and ranches are still operated as family units on which the operator and his family supply most of the labor and management. The average size of farms is increasing, however, and farm numbers are declining. Farm and ranch operators are well aware of the "cost-price squeeze" imposed by the combination of rising input prices and relatively stable or declining product prices. This cost-price relationship has provided an added incentive for farm expansion at the same time increased mechanization and larger machines have greatly increased productive capacity per man.

A major question arising from recent technological developments and farm size increases is the relationship between the size of the farm or ranch and the costs and returns from agricultural production. Farm and ranch operators are particularly interested in the relationship between size and net revenue. The nonfarm population is concerned with farm-size trends from the standpoint of production efficiency. In addition, farm leaders and agricultural policy planners need information on cost-size relationships in order to make effective decisions concerning the future of government farm programs.

This study was undertaken to determine the nature of the relationship between firm size and production costs of beef cattle-small grain producers in southwestern North Dakota. The specific objectives were:

1. To compare the efficiency and profitability of various sizes of beef cattle-small grain producing units.

2. To compare the optimal enterprise organizations and production practices for farms of different sizes.

3. To examine the effects of government farm programs on cost-size relationships.

The Study Area

The southwestern North Dakota beef cattle and small grain-producing area as defined for this study included the 14 counties south and west of the

Missouri River (Figure 1). The area had about 12 million acres of land in farms in 1964.[1] Approximately five million acres were used for crop production or summer fallow in 1970, while about 6.9 million acres were used for pasture or hay production.[2]

Beef cattle production is an important source of income in southwestern North Dakota. The value of cattle and calves sold in the 14-county area in 1964 was $34.4 million.[3] Wheat is the principal cash crop grown. In 1969 about 1.6 million acres of wheat were planted in the study area.[4] Other crops grown on substantial acreages are oats, corn, barley, flax, and both wild and tame hay.

Theoretical Framework

Analysis of economies of size in agricultural production is undertaken within the framework of the theory of the firm. Economies of size are present if an increase in the size of the firm leads to decreased costs of production per unit.[5]

In the short run some resources are fixed to the firm, and a manager viewing his firm in the short run must make decisions within the constraints imposed by these fixed resources. Beginning with a relatively low level of output, the average cost of production per unit can be reduced by expanding output and more fully utilizing the fixed resources. However, a minimum cost point will be reached, and continued expansion of output will result in increasing costs per unit of output. This situation is illustrated in Figure 2.

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[1]North Dakota Crop and Livestock Reporting Service, Agricultural Census Data for North Dakota, 1964, United States Department of Agriculture, Statistical Reporting Service--Field Operations Division, Fargo, North Dakota, 1966, pp. 5-6.

[2]Unpublished information from Agricultural Stabilization and Conservation Service, North Dakota State Office, Fargo, North Dakota.

[3]United States Department of Commerce, Bureau of the Census, United States Census of Agriculture, 1964, Vol. 1, Part 18, Washington, D.C., pp. 206-211.

[4]North Dakota Crop and Livestock Reporting Service, op. cit.

[5]For a detailed discussion of the theory of economies of size and a review of empirical studies of economies of size in farming, see Madden, J. Patrick, Economies of Size in Farming, Agricultural Economics Report 107, Economic Research Service, United States Department of Agriculture, Washington, D.C., February, 1967, pp. 2-24 and 34-55.

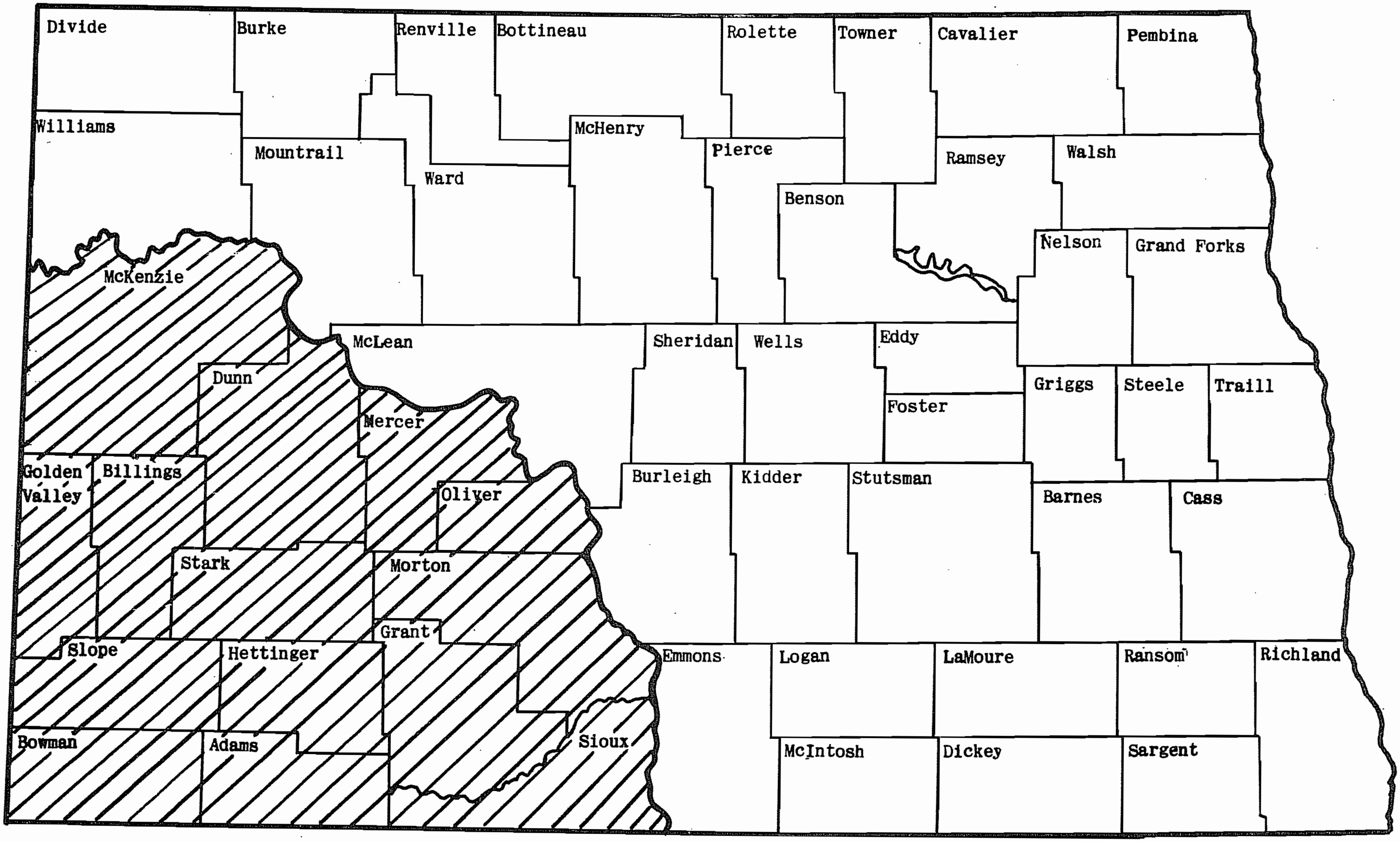

Figure 1. Designation of Counties Included in the Study.

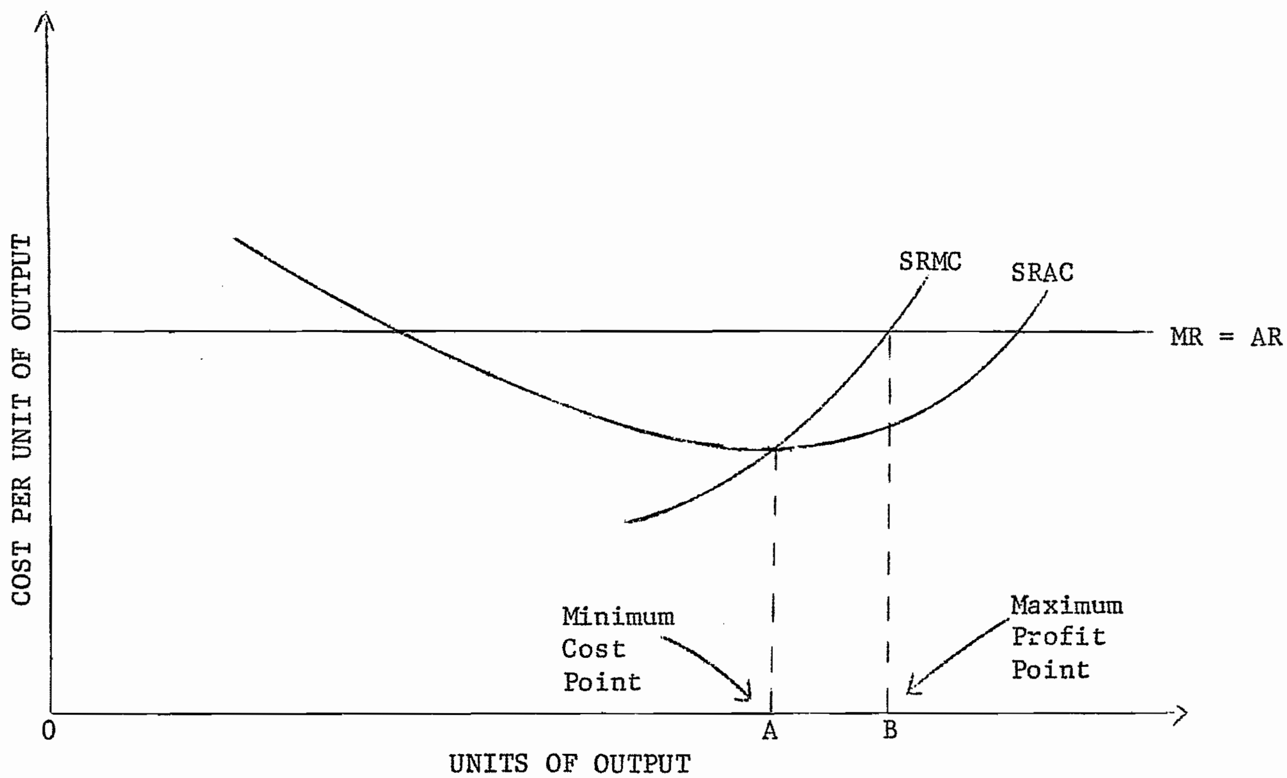

Figure 2. Theoretical Illustration of Short-Run Average Cost and Optimal Output Level of Firm for Minimum Cost and Maximum Profit When Pure Profit Exists.

The short-run average cost (SRAC) curve in Figure 2 shows the behavior of average per unit production costs as output is expanded subject to fixed resources. Costs decrease up to Point A. If the goal of the manager is to minimize per unit costs, the optimum level of output is OA. However, if the goal of the manager is to maximize total profits, the optimum output level is OB. This is the output level at which the additional return from producing one more unit of output (marginal revenue or MR) is just equal to the addition to total costs (marginal cost or MC).

If the size of the firm is increased by adding more of the resources which are fixed in the short run (e.g., by increasing acres of cropland or buying larger machinery), then a new set of short-run costs is applicable, and a new SRAC curve can be constructed. A series of SRAC curves can be constructed, each based on a particular set of fixed resources as is shown in Figure 3. A long-run average cost (LRAC) curve, which can be represented as a line drawn tangent to the SRAC curves, indicates the size of firm which will produce output most efficiently (i.e., at the lowest cost per unit). In Figure 3 the firm size associated with $SRAC_3$ produces at the lowest cost per unit.

In the analysis which follows optimal farm size is considered to be the size which results in the minimum cost per unit of output.

Assumptions and Definitions

Size of Farm

Size of farm was defined by the number of full-time workers employed and the size of machinery used.

Gross Income

Gross income was defined as total receipts from the sale of agricultural products plus ASCS wheat certificate, feed grain support, and conservation payments for farms participating in government farm programs. Gross income was the measure of firm output in this study.

Management

A high level of managerial efficiency was assumed. This assumption was reflected by crop yields which were higher than the area average. A similar high level of efficiency was assumed in livestock production.

Costs

All resources except management were valued at current market prices or current opportunity cost. An interest rate of 7 percent was charged on

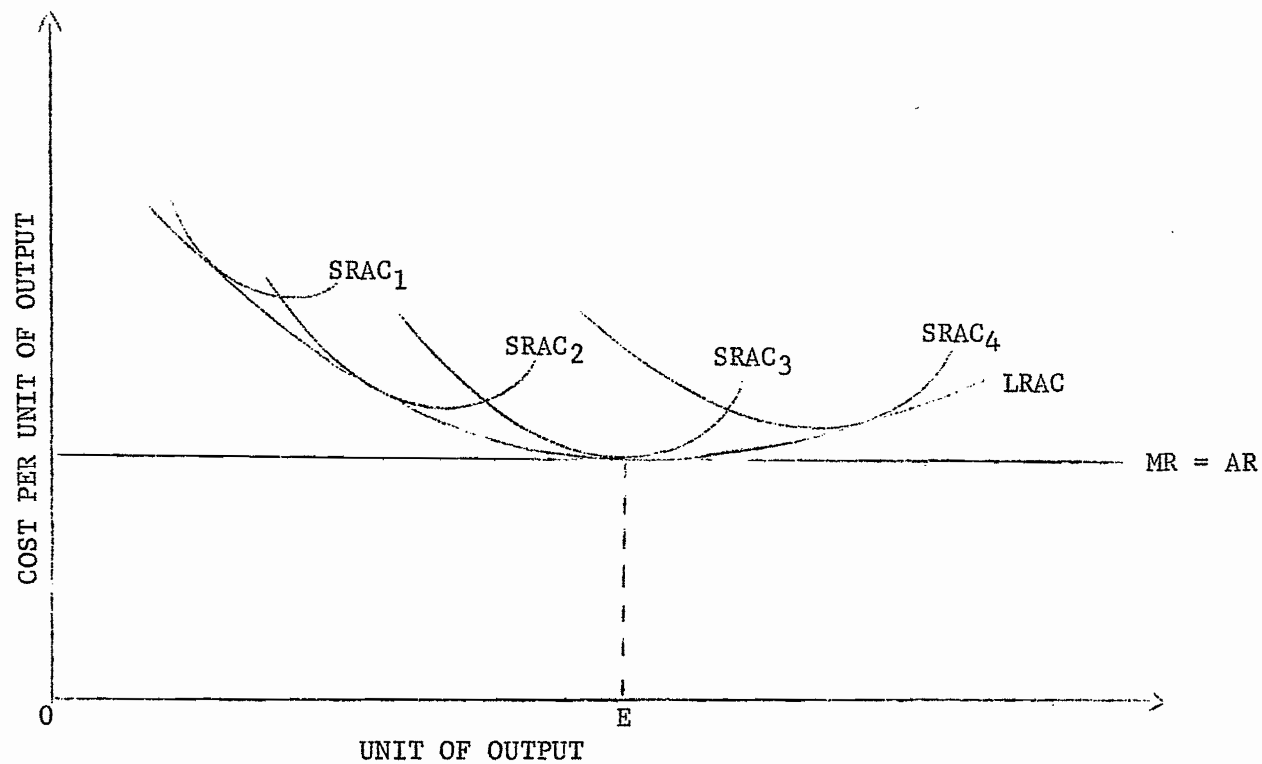

Figure 3. Theoretical Illustration of Short-Run Average Cost Curves and a Long-Run Average Cost in an Equilibrium Situation.

investments in land and depreciable assets and 8 percent was charged on operating capital. Input costs were projected to reflect conditions which prevailed in 1971.

Ownership

The operator was assumed to own all of the land used in the farming operation.

Net Income

Net operator income was defined as gross income less annual operating expenses, depreciation, and interest on investment.

Net management income was defined as net operator income less the opportunity cost of the operator's labor.

Analytical Procedure

Minimum-cost linear programming models were employed to determine enterprise combinations and output levels giving minimum per unit production costs for selected levels of fixed resources. Fixed resources were the farm's complement of machinery and full-time labor force. Output was measured as dollars of gross income. Costs were measured as cost per dollar of gross income. Short-run average cost (SRAC) curves were developed by varying the gross income produced by a particular size of farm and computing the cost per dollar of gross income at each income level.

Cost curves were developed for six farm sizes. The full-time labor force (including the farm operator) ranged from one to four men. Three different machinery sizes were considered: four-plow, six-plow, and eight-plow. The long-run average cost (LRAC) curve was developed as an envelope curve drawn tangent to the various SRAC curves. Long-run average cost curves were developed for farms participating in government farm programs and also for farms not participating in these programs.

Input-Output Data

The input-output data used in this study were synthesized from the results of production experiments and surveys of farm and ranch operators. Above average managerial efficiency was assumed in developing the input-output coefficients.

Small Grain and Forage Enterprises

The crops commonly grown in the study area were included as alternatives in the model. Crop alternatives included were spring wheat following fallow, barley following fallow, oats following small grain, barley following small grain, flax following small grain, corn silage, tame hay (a crested wheatgrass-alfalfa mixture), and native hay.[6] The yields, returns, and selected production costs for these crops are shown in Table 1. The field operations necessary for each crop are listed in Appendix Table 1 and the variable machinery costs are presented in Appendix Table 2.

Purchases of oats and barley for livestock feed were allowed, but purchases and sales of hay and corn silage were not allowed in this analysis. To assure sufficient summer-fallow acreage, the crops planted after grain crops (barley following grain, oats after grain, and flax) were restricted to one-third of the total crop acreage.

Livestock Enterprises

The basic livestock enterprise considered in this analysis was the beef cow herd. A calf crop of 90 percent and a replacement rate of 16 percent were assumed. The replacement heifers were produced on the ranch, and one bull was required for every 25 cows.

The calves were weaned at the end of October, and the decision whether to sell or winter the calves had to be made.[7] If the calves were wintered, several alternative rations, each producing a different rate of gain, could be used. Rations producing average daily gains of 1.00, 1.25, 1.50, and 1.75 pounds per day were considered in this analysis.

If the calves were wintered, they could either be sold or placed on tame pasture in the spring. Alternative selling dates considered for calves in a wintering program were January 30 and April 15. If the yearlings were placed on pasture in the spring, several choices existed with respect to selling dates. Alternative selling dates considered for yearlings were June 15, July 15, July 30, and August 30.[8]

An important consideration in choosing a selling date for yearlings in a summer-grazing program is the decline in the rate of gain which can normally be expected to occur as the season advances and the forage species become more mature. Yearling cattle were expected to gain 2.00 pounds per

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[6] Other crop alternatives were included in early runs of the model, but did not enter any of the optimal solutions. They were eliminated from the model to simplify the computational process.

[7] The weaning weights of calves are expected to average 415 pounds and 385 pounds for steers and heifers, respectively.

[8] Additional alternative selling dates were included in the model in the early stages of development. They were eliminated because they were dominated by the four alternatives listed and did not enter any of the optimal solutions.

TABLE 1. YIELDS, RETURNS, AND SELECTED PRODUCTION COSTS FOR CROP ENTERPRISES

Item	Wheat After Fallow	Barley After Fallow	Barley After Small Grain	Oats After Small Grain	Flax	Corn Silage	Tame Hay Mixture	Native Hay
Yield Per Acre	31 bu.	47 bu.	33 bu.	50 bu.	11 bu.	5.00 tons	1.50 tons	.85 tons
Unit Price[a]	$ 1.40	$ .84	$ .84	$ .55	$ 2.36	---	---	---
Gross Returns	43.40	39.48	27.72	27.50	25.96	---	---	---
<u>Selected Production Costs</u>								
Seed	2.50	2.10	2.10	2.10	3.75	$1.70	$1.00	---
Fertilizer	2.16	2.16	3.75	3.91	2.62	3.45	---	---
Spray	1.40	1.40	1.40	1.40	1.40	---	---	---
Custom Cost	1.20	1.20	1.20	1.00	1.65	---	---	---
Crop Insurance[b]	2.34	2.77	1.95	1.37	1.40	---	---	---
Storage	.28	.43	.29	.44	.10	1.99	---	---

[a]Government payments are not included.

[b]The crop insurance premium used insures 45 percent of the gross return.

SOURCE: Johnson, Roger G., Billy B. Rice, and LeRoy W. Schaffner, <u>Crop Costs and Returns</u>, North Dakota State University, Cooperative Extension Service, Fargo, North Dakota, 1971.

day while grazing tame pasture from May 5 to June 15.[9] While grazing native range, yearlings were expected to gain 1.75 pounds per day from June 15 to July 15, 1.50 pounds per day from July 15 to July 30, and 1.25 pounds per day during August.[10]

Ration Calculation

The feed rations which met specified nutritional requirements at least cost were calculated within the linear programming model. For wintering rations, the nutritional requirements of beef cattle were specified in terms of total digestible nutrients (TDN) and total protein (TP). A maximum feed intake restriction was imposed as an additional restraint.[11] The basic source for nutritional requirements was the tables of nutrient

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[9]Grazing trials on tame pasture (crested wheatgrass and crested wheatgrass-alfalfa mixtures) have resulted in average daily gains of 2.0 to 2.8 pounds during the spring grazing period. Studies conducted in southwestern North Dakota are reported in Rogler, G. A. and R. J. Lorenz, Pasture Productivity of Crested Wheatgrass as Influenced by Nitrogen Fertilization and Alfalfa, Technical Bulletin No. 1402, North Dakota Agricultural Experiment Station, April, 1969; and Whitman, W. C., L. Langford, R. J. Douglas, and T. C. Conlon, Crested Wheatgrass and Crested Wheatgrass-Alfalfa Pastures for Early Season Grazing, Bulletin No. 442, North Dakota State University, Agricultural Experiment Station, Fargo, North Dakota, April, 1963, pp. 10-11.

[10]Trials involving the grazing of yearling cattle on native range in southwestern North Dakota and western Nebraska, respectively, are reported in Rogler, G. A., R. J. Lorenz, and H. M. Schaaf, Progress With Grass, Bulletin No. 439, United States Department of Agriculture, Agricultural Research Service, Crop Research Division in cooperation with North Dakota Agricultural Experiment Station, Fargo, North Dakota, May, 1962; and Burszlaff, D. F. and L. Harris, Yearling Steer Gains and Vegetation Changes of Western Nebraska Rangeland Under Three Rates of Stocking, SB 505, Agricultural Experiment Station, University of Nebraska, Lincoln, Nebraska, April, 1969.

[11]The formulation of the ration in this manner is a simplification of a complex problem because the actual level of feed intake appears to depend upon the nutritive value of the feed. As the nutritive value of the feed increases, the level of feed intake increases up to a certain point, and decreases thereafter. For further discussion of this relationship, see Montgomery, M. J. and B. R. Baumgart, "Regulation of Food Intake in Ruminants 1. Pelleted Rations Varying in Energy Concentration," Journal of Dairy Science, Vol. 48, No. 5, May, 1965, pp. 569-574.

requirements of beef cattle published by the National Academy of Sciences.[12] For cattle on pasture total protein was not employed as a nutritional restraint.[13]

Grazing Alternatives

The grazing season was divided into three major grazing periods: spring, summer, and fall. Either native range or tame pasture (crested wheatgrass) could be grazed during the spring grazing period. However, if native range was grazed during the spring (prior to June 15), the total forage production for the season was reduced by 45 percent.[14]

Native range was used for grazing during the summer grazing period (June 15-September 30). For brood-cow grazing, the summer was treated as a single grazing period. For yearlings, however, the summer was divided into three subperiods: June 15 to July 15, July 15 to July 30, and July 30 to August 30.[15]

Several alternative sources of forage are available during the fall grazing period (September 30-October 30). In addition to native rangeland and tame pasture, aftermath grazing is typically available on land used for native and tame hay production and for small grain crops. Table 2 shows the level of TDN production for various types of aftermath pasture.

Experiment Station trials show that application of nitrogen fertilizer can increase the forage production considerably from both tame pasture[16]

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[12]National Academy of Sciences, <u>Nutrient Requirements of Beef Cattle</u>, No. 4, fourth revised edition, 1970.

[13]The initial intent was to use TDN, protein content, and dry matter value for pasture. This would allow the consideration of supplemental protein feeding of yearlings during the late summer grazing period. However, the available estimates of the protein content of native range were not sufficiently exact to allow the incorporation of this constraint into the model.

[14]This restriction is based upon recommendations for western North Dakota. For further discussion see, Dietrich, Irvine T., <u>Pasture Balance for Western North Dakota</u>, Extension Service, North Dakota State University, Fargo, North Dakota, 1965.

[15]This breakdown of the summer grazing period for yearlings is necessary because daily gains are expected to decrease as the quality of pasture decreases in late summer.

[16]For results of trials involving fertilization of tame pasture, see Rogler and Lorenz, <u>op. cit</u>.

TABLE 2. AFTERMATH PASTURE YIELD PER ACRE OF VARIOUS CROPS FOR FALL GRAZING

Item	Pounds of TDN
Wheat	13[a]
Barley	13[a]
Oats	13[a]
Corn Silage	26[a]
Tame Hay	54[b]
Native Hay	54[b]

[a]Krenz, R. D., L. W. Schaffner, and E. Valdivia, Seeding Cropland to Grass in Southwestern North Dakota, Bulletin No. 470, Department of Agricultural Economics, North Dakota Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota, November, 1967, p. 7.

[b]Paulson, G. W., Economic Analysis of Beef Cattle and Grassland Management Systems, unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, North Dakota, May, 1970, p. 43.

and native range.[17] In the linear programming model both tame pasture and native range were allowed to be fertilized with either 40 or 80 pounds of available nitrogen if these practices proved profitable. However, because of limitations imposed by topography and other physical features, only 40 percent of the total acres of native range was considered to be suitable for fertilization. Table 3 shows the levels of forage production from native range and tame pasture under alternative treatments. Table 4 shows the costs and capital requirements for alternative pasture treatments. Estimated beef cattle production costs and capital requirements are presented in Appendix Table 3.

Cattle Prices and Marketing Costs

The beef cattle prices used in this study were based upon monthly price quotations for steers and heifers from the West Fargo Livestock Terminal for the eight-year period, 1963-1970. The average cattle prices were projected to 1971 using a trend equation developed by Dunn.[18] When cattle were sold at the

[17]For results of trials involving fertilization of native rangeland, see Rogler, G. A., "Native Range Fertilization at the Northern Great Plains Research Center, Mandan, North Dakota," Twenty-First Annual Fertilizer Conference, Workship E, Proceedings, Fargo, North Dakota, December, 1969.

[18]Dunn, Edward V., Feasibility Study of Land Owner's Cattle Cooperative, Bullhead, South Dakota, unpublished paper prepared for the North Dakota Center for Economic Development, February, 1971.

TABLE 3. FORAGE PRODUCTION IN POUNDS OF TDN PER ACRE ON TAME PASTURELAND AND NATIVE RANGELAND

Grazing Period	Tame Pastureland			Native Rangeland[a]		
	0 lbs N	40 lbs N	80 lbs N	0 lbs N	40 lbs N	80 lbs N
Spring Grazing	375	652	688			
Summer Grazing				246	483	608
Fall Grazing	56	98	103			

[a]If native range is used for spring grazing, yield is reduced by 45 percent. For further details, see Dietrich, op. cit.

SOURCE: For tame pasture yields under fertilization see Rogler, G. A. and R. J. Lorenz, Pasture Productivity of Crested Wheatgrass as Influenced by Nitrogen Fertilization and Alfalfa, Technical Bulletin No. 1402, Agricultural Research Service, United States Department of Agriculture in cooperation with Department of Animal Science, North Dakota Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota, April, 1969, p. 17; and for native range yields under fertilization see Rogler, G. A., "Native Range Fertilization at the Northern Great Plains Research Center, Mandan, North Dakota," Twenty-First Annual Fertilizer Conference, Workshop E, Fargo, North Dakota, December, 1969, Table 3.

middle of a month, the eight-year monthly average price for that class and weight of cattle updated by trend was used. On the other hand, when cattle were sold at the end of a month, the eight-year average of this and the following month's prices were averaged, projected by trend, and used in the model. Market price quotations were for relatively broad weight classes (e.g., 300-550 and 550-750). In estimating selling prices for the beef cattle activities, weight subclasses were created and the prices were interpolated linearly. Prices for the various weight subclasses are shown in Appendix Table 4.

The costs of marketing livestock have four components: selling charges of the marketing firm, trucking costs, transit insurance charges, and shrinkage losses.[19] For the calculation of trucking costs and shrinkage losses, an average haul of 100 miles was assumed. The shrinkage loss was estimated to be 3 percent and was subtracted from the selling weight. The other marketing costs, shown in Appendix Table 5, were entered as cash costs in the model.

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[19]Dunn, Edward V., Costs and Considerations for Marketing Livestock in North Dakota, Agricultural Economics Report No. 74, Department of Agricultural Economics, North Dakota State University, Fargo, North Dakota, January, 1971, pp. 1-10.

TABLE 4. COSTS PER ACRE AND CAPITAL REQUIREMENTS FOR VARIOUS TAME PASTURE AND NATIVE RANGELAND FERTILIZATION ALTERNATIVES

Item	Tame Pastureland						Native Rangeland		
	0 Lbs N Without Cost-Share	0 Lbs N With Cost-Share	40 Lbs N Without Cost-Share	40 Lbs N With Cost-Share	80 Lbs N Without Cost-Share	80 Lbs N With Cost-Share	0 Lbs N	40 Lbs N	80 Lbs N
Costs									
Establishing Stand[a]	1.15	.27	1.15	.27	1.15	.27			
Fence Repair	.28	.28	.28	.28	.28	.28	.28	.28	.28
Fertilizer 30-0-0			3.64	3.64	7.27	7.27		3.64	7.27
Fertilizer Application			.65	.65	.65	.65		.65	.65
Total Variable Costs	1.43	.55	5.72	4.84	9.35	8.52	.28	4.62	8.25
Fixed Costs									
Well and Fence Depreciation[b]	.78	.50	.78	.50	.78	.50	.42	.42	.42
Total Costs	2.21	1.05	6.50	5.34	10.13	8.97	.70	4.99	8.62
Capital Requirements									
Long-Term Capital[c]	17.24	11.57	17.24	11.57	17.24	11.57	8.88	8.88	8.88
Operating Capital	1.43	.55	5.72	4.84	9.35	8.47	.28	4.57	8.20

[a]Includes seedbed preparation, seed, seed companion, and seeding operation. Life span of pastureland is presumed to be ten years. Government cost share is approximately 80 percent of the cost of the seeding process.

[b]Based on 25-year life span of well and fence.

[c]Includes investment in well and fence.

SOURCE: Based on budgets in Paulson, G. W., Economic Analysis of Beef Cattle and Grassland Management Systems, unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, North Dakota, May, 1970, p. 45.

Field Machinery and Buildings

Three sizes of machinery complements were used in this analysis. The smallest machinery complement was organized around a 60-70 horsepower wheel tractor and a matched set of farm machinery. The largest machinery complement was organized around a 120-140 horsepower tractor. The size and composition of these machinery sets were determined by such factors as terrain, draft requirements, and investment costs. Appendix Table 6 shows the composition of the various machinery complements. Special purpose machines necessary for corn silage production were added to the basic machinery complement if silage production was economical.

Machinery and other depreciable assets were inventoried at 55 percent of new cost. The investment requirements and fixed costs for the six selected machinery combinations are shown in Table 5.

TABLE 5. AVERAGE INVESTMENT AND FIXED COST FOR SIX SELECTED MACHINERY COMBINATIONS[a]

	1-Man			2-Man	3-Man	4-Man
Item	4-Plow	6-Plow	8-Plow	8-Plow	8-Plow	8-Plow
Average Investment[b]	$26,017	$27,935	$32,921	$41,834	$55,242	$65,836
Annual Depreciation[c]	3,343	3,607	4,227	5,693	7,143	8,632
Insurance, Housing[d]	391	419	495	628	826	988
Interest[e]	1,821	1,955	2,305	2,928	3,867	4,609
Misc. Expense[f]	140	140	140	140	204	204
Total Fixed Cost	5,695	6,121	7,167	9,379	12,143	14,433

[a]The values are obtained from Eidsvig, D. H. and C. E. Olson, Determining Least-Cost Machinery Combinations, Bulletin No. 479, Department of Agricultural Economics, Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota, January, 1969, pp. 21-24. Machinery purchase costs were increased by 20 percent based upon United States machinery price indices and telephone interviews with several machinery dealers in Fargo, North Dakota. (Specialized machinery for corn silage production is included in the above figures.)

[b]$\frac{\text{Original cost plus salvage value}}{2}$

[c]$\frac{\text{Original cost minus salvage value}}{\text{Useful life}}$

[d]1.5 percent of average investment.

[e]Seven percent of average investment.

[f]Includes license, insurance, and farm liability.

Farm resources were expected to include adequate buildings to house farm machinery and store grain and a complete set of tools for machinery maintenance and repair. The optimum size of building to provide winter shelter for cattle was selected by the model based upon the number of livestock being wintered.[20]

Labor Requirements and Labor Distribution

Four different labor forces, ranging from an owner-operator to an owner-operator and three full-time employees, were considered in the analysis. An operator was assumed to be willing to supply 300 hours of labor per month from April through August and 260 hours per month for the remaining months. The total amount of labor supplied annually by an operator could not exceed 2,600 hours. A full-time hired worker was assumed willing to supply up to 270 hours per month for the months of April through August and up to 250 hours per month during the remaining months. The total hours worked annually by a hired worker could not exceed 2,500 hours. The total labor supply provided by the operator and full-time workers is summarized in Table 6.

The full-time labor force could be supplemented during the months of June, July, and August by hiring part-time help for up to 270 hours per month.

Labor Requirements for Crops

If high yields are to be obtained, field operations must be performed in a timely manner. The planting and harvesting periods for small grain crops are considered to be especially critical. The field operations must be performed within a relatively short period of time, and unfavorable weather conditions often substantially reduce the number of days available for field work.

The planting period was divided into three subperiods which corresponded to the recommended planting periods for the various crops grown (see Table 7). A restriction of hours available for planting was imposed on each of the three periods. Because the three periods overlap, a restriction on the total hours available for planting was also imposed.

The harvest period was divided into three subperiods, and restrictions analogous to the planting time restrictions were imposed. Table 8 shows the harvesting periods, days available for harvesting, and maximum hours available during the harvesting period on a one-man farm.

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[20]This approach is based upon the assumption that building costs are constant per animal within the range of herd size being considered.

TABLE 6. ESTIMATED MAXIMUM AMOUNT OF LABOR AVAILABLE FOR FARM WORK FROM SELECTED LABOR FORCES

	Labor Force			
Period	One Man	Two Men[a]	Three Men[a]	Four Men[a]
Total[b]	2,600	4,840	7,080	9,320
January	260	484	708	932
February	260	484	708	932
March	260	484	708	932
April	300	540	780	1,020
May	300	540	780	1,020
June	300	540	780	1,020
July	300	540	780	1,020
August	300	540	780	1,020
September	260	494	708	932
October	260	494	708	932
November	260	494	708	932
December	260	494	708	932

[a]As hired workers were added to the labor force, the operator was expected to devote a portion of his time to supervision. When one full-time hired worker was employed, the operator was estimated to spend 10 percent of his time (260 hours annually) in supervisory activities. When two and three full-time workers were employed, the supervisory component of the operator's time increased to 20 and 30 percent, respectively.

[b]These figures are restrictions imposed on the total labor supply per year and not the total of the maximum number of hours available for work per month.

TABLE 7. TOTAL DAYS IN PLANTING PERIOD, ACTUAL PLANTING DAYS, AND HOURS AVAILABLE FOR PLANTING ON A ONE-MAN FARM

Crop	Period	Total Days	Actual Planting Days[a]	Total Planting Hours[b]
Wheat	April 10-May 10	31	18	252
Barley	April 20-May 20	31	18	252
Oats	April 20-May 20	31	18	252
Flax	May 1-May 31	31	18	252
Corn	May 15-May 31	10	6	84

[a]Estimated to be 60 percent of total days in planting period.

[b]Calculated assuming that a maximum of 14 hours per day are available for field work.

SOURCE: Olson, C. E., R. G. Johnson, B. B. Rice, and D. H. Eidsvig, Weather and Profitable Machinery Size, Circular A-534, Cooperative Extension Service, North Dakota State University, Fargo, North Dakota, August, 1969.

TABLE 8. TOTAL DAYS IN HARVESTING PERIOD, ACTUAL HARVESTING DAYS, AND HOURS AVAILABLE FOR HARVESTING ON A ONE-MAN FARM

Crop	Period	Total Days	Actual Harvesting Days[a]	Total Harvesting Hours[b]
Wheat	Aug. 1-Aug. 31	31	25	300
Barley	July 25-Aug. 31	38	30	360
Oats	July 25-Aug. 31	38	30	360
Flax	Sept. 1-Sept.30	30	24	284

[a]Estimated to be 80 percent of total days.

[b]Calculated assuming that a maximum of 12 hours per day are available for field work.

SOURCE: Olson, *et al*., Circular A-534, Table 2.

Labor Requirements for Livestock

The hours of labor required per head decline as the size of the beef-cow herd increases.[21] Pure linear optimization does not allow for nonlinear relationships of this type. However, a technique proposed by Zapf[22] allows the introduction of decreasing input requirements per unit into a linear model. The characteristic features of Zapf's approach are that a minimum level of the activity is forced into the solution, and a maximum level of the activity is also specified. Between the minimum and maximum activity levels, a linear relationship is assumed to describe the total input requirement. For activity levels between the minimum and maximum, the per unit input coefficients of the LP matrix are not defined; they are determined internally when the optimum solution is computed.[23]

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[21]For instance a survey of beef cow-calf operators in South Dakota revealed that cow herds of less than 50 cows required an average of 18.2 hours of labor per cow annually, while herds of 100-149 cows required only 9.1 hours per cow. For further details, see Allen, Herbert R. and Rex D. Helfinstine, *An Economic Analysis of Ranch Organization in Central South Dakota*, 1969, pp. 42-43.

[22]Zapf, R. "The Use of Linear Optimization for Planning Agricultural Firms," (in German), *Berichte ueber Landwirtschaft*, Sonderheft 179, pp. 60ff.

[23]Rintelen, P. and R. Zapf, "Guiding Plans of Organization of Agricultural firms for the Schwaebisch-bayrische Huegelland and the Junagebiet under Present and Probable Conditions in 1970," (in German), *Bayrisches Landwirtschaftliches Jahrbuch*, Sonderheft 4, Bayrischer Landwirtschaftsverlag, 1966.

In this analysis the Zapf tying equation was used to incorporate nonlinear labor requirements for the beef cow and calf wintering activities into the linear programming model. The labor requirements for the various livestock activities are shown in Table 9. A disadvantage of using the tying equation technique is that a minimum level of an activity must be forced into the solution. To offset this problem, when the activity was found in the optimal solution at the minimum level, a second computer run was made (using constant labor requirements) to determine whether inclusion of the enterprise was profitable.[24]

TABLE 9. LABOR REQUIREMENT BY MONTHS FOR VARIOUS BEEF CATTLE ENTERPRISES

	Labor Requirements in Hours Per Unit for Various Herd Sizes					
Period	50 Cows	280 Cows	510 Cows	80 Heifers	125 Calves	Bull
January	1.825	.598	.477	.57	.225	.90
February	1.825	.598	.477	.57	.225	.90
March	2.325[a]	1.143[a]	1.027[a]	.57	.225	.90
April	2.850[a]	1.687[a]	1.573[a]	.57	.225	.90
May	1.270[a]	.900[a]	.864[a]	.45	.117	.72
June	.860	.330	.278	.38	.105	.54
July	.230	.070	.054	.38	.105	.60
August	.230	.070	.054	.38	.105	.60
September	.230	.070	.054	.38		.60
October	.230	.070	.054	.38		.60
November	.230	.070	.054	.57	.225	.90
December	1.825	.598	.477	.57	.225	.90
ANNUAL	13.930	6.139	5.443	5.77		9.00

[a]Calving is spread over three months: ¼ in March, ½ in April, and ¼ in May.

SOURCES: Allen, H. and R. Helfinstine, Analysis of Ranch Organization in Central South Dakota, Economics Department, Agricultural Experiment Station, South Dakota State University, Brookings, South Dakota, April, 1969, p. 42.

Paulson, G. W., Economic Analysis of Beef Cattle and Grassland Management Systems, unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, North Dakota, May, 1970, p. 31.

Unpublished survey data, Department of Agricultural Economics, North Dakota State University, Fargo, North Dakota.

[24]For more discussion of the Zapf tying equation technique and its use in this study, see Schneeberger, Walter, Economies of Size of Southwestern North Dakota Beef Cattle-Small Grain Farms, unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, August, 1971, pp. 32-38.

Salaries and Operator Labor Valuation

Employees must have high qualifications, and they must be reliable in order to achieve the assumed level of efficiency. The salaries paid should reflect these qualifications. Survey data indicate that in 1967 farmers and ranchers in southwestern North Dakota paid an average yearly cash wage per employee of $3,132 and fringe benefits per employee of $1,353. Therefore, average total compensation per employee in 1967 was $4,485.[25] The salary considered necessary to find qualified employees was set at $5,500 in this analysis. On three- and four-man farms the annual salary of the first employee was increased to $5,800 and $6,100, respectively.

The operator's labor must be evaluated if comparable cost curves are to be obtained for farms of different sizes. In this study operator labor was valued at $6,500 per year. The wage rate for seasonal labor during June, July, and August was $1.70 per hour.

Land Use and Government Farm Programs

Land was treated as a variable resource in this analysis so no fixed number of acres was associated with a particular combination of machinery and labor force. A restriction was imposed on the type of land available. Of the total land in farms in the study area in 1964, 55.7 percent was used only for pasture, 42.4 percent was cropland, and 1.9 percent was used for native hay production.[26] Land available to farms in this analysis was assumed to have the same proportions of pasture, hay, and cropland as the area average. Farmland in southwestern North Dakota had an average value per acre of $72 in 1970,[27] and that value was used to establish investment requirements and capital charges in this analysis. Land taxes were estimated to be $0.77 per acre.

Optimal farm plans were developed with and without participation in the 1971 government wheat and feed grain programs. Cost sharing of tame pasture establishment costs was included in the model when government program participation was allowed.[28]

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[25] Reff, T. L., An Evaluation of Salaries and Benefits Received by Hired Farm Labor in North Dakota, Plan B Research Paper, Department of Agricultural Economics, North Dakota State University, Fargo, North Dakota, May, 1968, p. 21.

[26] United States Census of Agriculture, 1964, op. cit., pp. 201-206.

[27] Johnson, J. E. and H. Vreugdenhil, "North Dakota Farmland Values Leveled Off in 1970," North Dakota Farm Research, Vol. 28, No. 5, North Dakota Agricultural Experiment Station, Fargo, North Dakota, 1971, p. 26.

[28] Two government sources of such cost sharing are available to farmers and ranchers of the study area, the Great Plains Conservation Program and the Agricultural Conservation Program. The payments and required conserving practices of the two programs are quite similar.

Results

The empirical findings of this study provide a basis for comparing the efficiency and profitability of various sizes of southwestern North Dakota beef cattle-small grain farms. Least-cost farm plans and short-run average cost (SRAC) curves were developed for six different farm sizes. Farm size was measured by the number of full-time workers and the size of the field machinery used. Long-run average costs (LRAC) curves provided a convenient means of comparing the average production costs of farms of different sizes. LRAC curves developed for farms participating in 1971 government farm programs were compared to LRAC curves for farms not participating in government programs to assess the effect of government programs on the economies of farm size.

Least-Cost Production Plans

On an optimally organized[29] beef cattle-small grain farm in southwestern North Dakota, one full-time worker handled from 754 to 1,133 acres of cropland, depending on the size of field machinery used (Table 10). As additional full-time employees and equipment were added, the acreage operated increased, but at an uneven rate. When farm size increased from one man with eight-plow equipment to two men with eight-plow equipment, the acreage of cropland operated increased from 1,133 acres to 2,041 acres, an increase of 908 acres. When farm size was further expanded to three men, 3,163 acres of cropland were used, an increase of 1,122 acres compared to the two-man operation (see Table 10).

Crop and Livestock Enterprises

On optimally organized farms, one man handled from 78 to 88 brood cows. When a second full-time worker was added to the farm's fixed resource base, the number of brood cows was increased to 213. As the farm size was further expanded to three full-time workers, the beef herd was expanded to 331 cows.

Two forces influence the rate of expansion of crop acreage and the beef herd when farm size is expanded beyond the one-man level. First, livestock labor requirements per head decline as the herd is expanded. Harvesting labor requirements per acre also decline as a larger combine is used on the two-man farm than on the one-man operations. Second, the amount of time which the farm operator can devote to field work declines as the farm expands because the operator must spend increasing amounts of his time in supervisory and coordinating activities.

The cropland was primarily used for wheat and for tame hay and pasture. Wheat was planted on 30 to 35 percent of the cropland acreage of the one-man

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[29] In this report "optimal" refers to the organization which gives minimum average cost per dollar of gross income.

TABLE 10. LEAST-COST PRODUCTION PLANS FOR SOUTHWESTERN NORTH DAKOTA BEEF CATTLE-SMALL GRAIN FARMS OF SIX SELECTED SIZES PARTICIPATING IN 1971 GOVERNMENT FARM PROGRAMS

		1-Man			2-Man	3-Man	4-Man
Item	Unit	4-Plow	6-Plow	8-Plow	8-Plow	8-Plow	8-Plow
Total Land	Acres	1,780	1,961	2,674	4,817	7,464	9,734
Cropland	"	754	831	1,133	2,041	3,163	4,125
Wheat Following Fallow	"	240	247	393	621	920	1,080
Barley Following Fallow	"	26	46	---	---	---	114
Flax	"	---	---	13	198	392	523
Grass-Alfalfa Mixture	"	112	132	145	323	477	762
Tame Pasture, 0 Lbs. N	"	110	113	189	278	454	155
Tame Pasture, 40 Lbs. N	"	---	---	---	---	---	297
Native Rangeland	"	992	1,093	1,490	2,683	4,158	5,422
Spring Grazing, 0 Lbs. N	"	209	253	258	624	904	1,111
Summer & Fall Grazing, 0 Lbs. N	"	783	870	846	2,093	3,254	4,498
Native Hayland	"	34	37	51	88	143	187
Cut for Hay	"	34	7	---	54	143	---
Cows	Number	78	86	88	213	331	457
Steers Grazed Until July 31	"	35	38	39	94	147	203
Heifers Grazed Until July 31	"	22	25	26	61	95	131
Seasonal Labor Hired	Hours	67	105	180	194	271	310
July	"	31	49	---	107	259	270
August	"	36	56	180	87	12	40

farms. Larger farms used a slightly smaller part of their cropland for wheat production, but wheat was still the primary crop grown. Tame hay and pasture were used to fulfill the conserving base requirement of the government program. On no farm was tame hay or pasture planted in excess of the conserving base requirement (29.4 percent of cropland). Tame pasture was fertilized only on the four-man farm. The only other crops to enter the optimal farm plans were barley following fallow and flax following small grain.

Native rangeland was not fertilized in any of the optimal farm plans. Because the tame pasture acreage was inadequate to meet the total requirement for spring grazing, some of the native rangeland was used for spring grazing on all farms.

The beef herd was an important enterprise on all farms. All calves produced were wintered and summer grazed until the end of July. The most efficient ration for wintering calves was found to be one providing an average daily gain of 1.5 pounds.

Capital Requirements

The capital requirements of the six optimal farm plans are presented in Table 11. The total capital requirements per farm range from $206,645 for the one-man farm with four-plow equipment to $1,080,235 for the four-man farm with eight-plow equipment. Land is the major component of the total capital requirement, representing from 62 to 67 percent of the total capital required by the various farm plans.

The investment per man is highest on the one-man farm with eight-plow equipment, but declines only slightly as the number of full-time men increases. Lower investments per man for machinery and land are partially offset on the larger farms by larger investments for livestock.

Income and Resource Returns

Gross income, which includes the receipts from all sales plus government payments, ranges from $31,000 on an optimally organized one-man farm with four-plow machinery to $176,000 for an optimally organized four-man farm with eight-plow machinery (Table 12).

Net management income is computed as a residual by deducting all costs, including an allowance for operator labor, from gross returns. Net management income is negative for the four smallest farm sizes, indicating that these farms do not have receipts sufficient to cover their full costs.

Net operator income is net management income plus the $6,500 allowed for operator labor. This measure reflects the return to the farm operator's labor and management after all other costs have been covered. Net operator income ranges from a low of $1,620 for the one-man farm with eight-plow equipment to $9,742 for the four-man farm (Table 12).

TABLE 11. CAPITAL REQUIREMENTS OF LEAST-COST PRODUCTION PLANS FOR FARMS PARTICIPATING IN 1971 GOVERNMENT FARM PROGRAMS

Item	Unit	1-Man			2-Man	3-Man	4-Man
		4-Plow	6-Plow	8-Plow	8-Plow	8-Plow	8-Plow
Long-Term Capital	Dollars	196,611	215,874	274,511	503,260	770,675	1,008,790
Land	"	128,160	141,192	192,528	346,824	537,408	700,848
Machinery	"	26,017	27,935	32,921	41,834	55,242	65,836
Other	"	42,434	46,747	49,062	114,602	178,025	242,106
Operating Capital	"	9,854	10,692	12,901	31,620	51,688	71,445
Total Capital	"	206,465	226,566	287,412	534,890	822,363	1,080,235
Total Capital Per Full-Time Worker	"	206,465	226,566	287,412	267,445	274,121	270,059

TABLE 12. GROSS INCOME, TOTAL COSTS, AND SELECTED MEASURES OF RETURNS OF LEAST-COST PRODUCTION PLANS FOR FARMS PARTICIPATING IN GOVERNMENT FARM PROGRAMS

Item	Unit	1-Man			2-Man	3-Man	4-Man
		4-Plow	6-Plow	8-Plow	8-Plow	8-Plow	8-Plow
Gross Income	Dollars	31,000	34,000	41,000	85,000	132,000	176,000
Total Costs[a]	"	35,800	38,491	45,880	86,314	130,607	172,758
Cost Per Dollar of Gross Income	"	1.155	1.132	1.120	1.105	0.989	0.982
Net Management Income	"	-4,800	-4,491	-4,880	-1,314	1,393	3,242
Operator Labor Allowance	"	6,500	6,500	6,500	6,500	6,500	6,500
Net Operator Income[b]	"	1,700	2,009	1,620	5,186	7,893	9,742
Interest on:							
Long-Term Capital[c]	"	13,763	15,860	20,119	37,442	57,565	70,615
Operating Capital[d]	"	788	855	1,032	2,530	4,135	5,716
Total	"	14,551	16,715	21,151	39,972	61,700	76,331
Return to Operator Labor, Management, and Capital	"	16,251	18,724	22,771	45,158	69,593	86,073

[a]Total costs include charges or allowances for all inputs except management.

[b]Net operator income is net management income plus operator labor allowance.

[c]Interest is charged at a rate of 7 percent on long-term capital.

[d]Interest on operating capital is charged at a rate of 8 percent.

Many farm operators have a high equity in their land and other farm capital resources. These operators receive not only a return to their labor and management, but also a return on their investment. Table 12 shows the returns to operator labor, management, and capital for the six farm sizes. These returns range from a low of $16,251 for the one-man farm with four-plow machinery to $86,073 for the four-man farm.

Economies of Size

The short-run average cost curves derived for the six different farm sizes in the analysis are shown in Figure 4. On the one-man farms, average production costs declined rapidly as output was expanded until the capacity of the labor and machinery complement was reached. Among the three one-man farms, the farm with six-plow machinery produced at lowest cost. However, none of the one-man farms covered full costs and produced a positive return to management.

The two-man farm had substantially lower average costs than any of the one-man farms. It did not produce a positive return to management, however. The three-man and four-man farms were able to cover full costs and produce a positive return to management. The average costs of these two farms were nearly identical.

The long-run average cost curve is approximated by a curve fitted to the SRAC curves for each of the farm sizes from one to four men (Figure 4). The least-cost point on this curve is not defined because average production costs decline throughout the range of sizes studied.

Effect of Government Program Participation on Least-Cost Farm Plans

In order to test the effect of the government farm programs on farm resource returns and economies of farm size, the linear programming model was run with the government program restrictions and payments deleted. The least-cost production plans for farms not participating in government farm programs are shown in Appendix Table 7. The enterprise organizations are very similar to those found with program participation. Wheat is again the dominant crop. Barley, flax, and oats also enter the least-cost plans for some farms. The acreages of tame hay and pasture are smaller than those of the farms participating in government programs, and all tame pasture is fertilized. The size of the cow herd is nearly identical on participating and nonparticipating farms. Calves are wintered and grazed as yearlings. The main difference in the grazing programs of participating and nonparticipating farms is that the four smallest nonparticipating farms graze their yearlings until August 31 before sale, whereas all participating farms sell their yearlings on July 31.

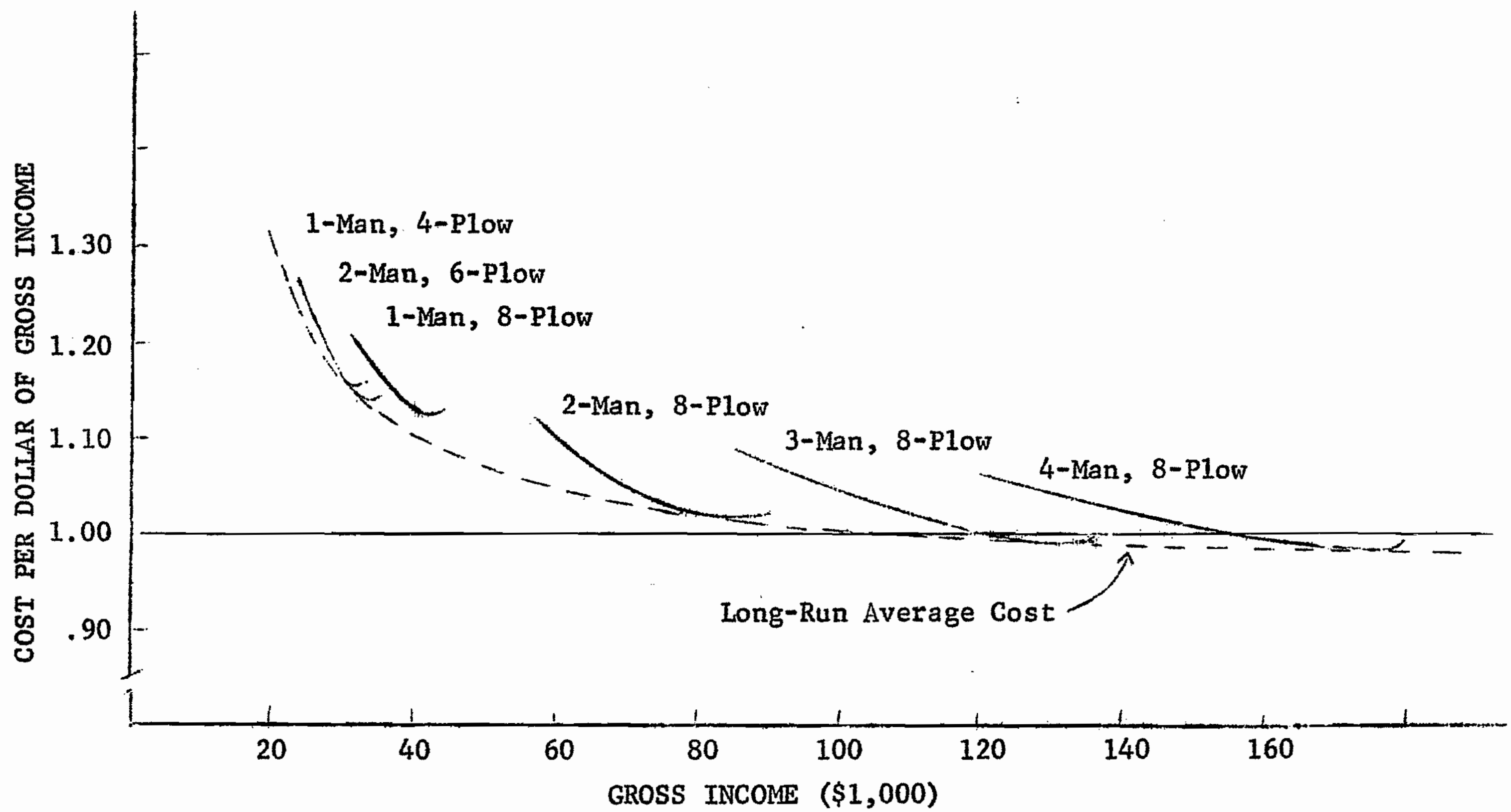

Figure 4. Short-Run Average Cost Curves and Planning Curve for Southwestern North Dakota Beef Cattle-Small Grain Farms of Six Selected Sizes Participating in 1971 Government Farm Programs.

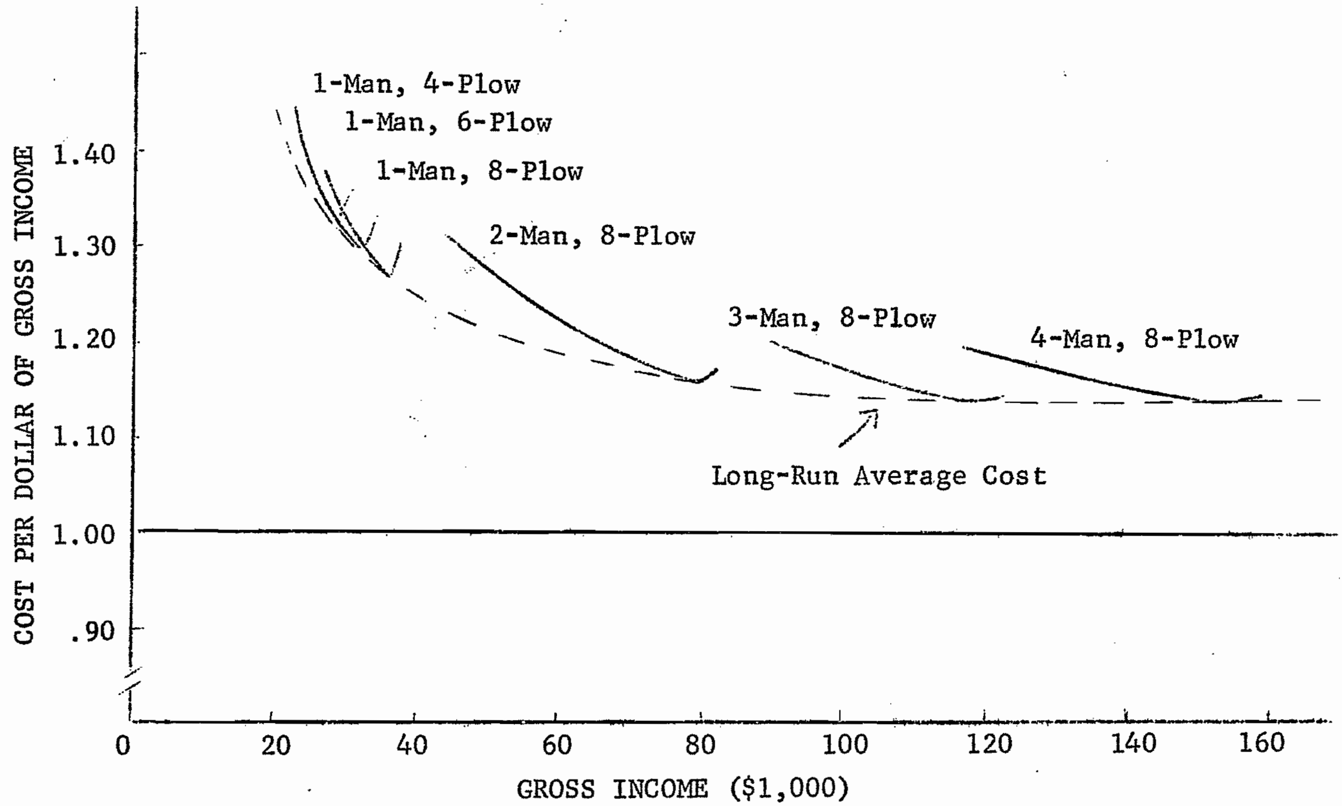

Figure 5. Short-Run Average Cost Curves and Planning Curve for Southwestern North Dakota Beef Cattle-Small Grain Farms of Six Selected Sizes Not Participating in 1971 Government Farm Programs.

The LRAC curve for the six selected farm sizes not participating in government farm programs was downward sloping over the entire range of size considered in the analysis. However, none of the six selected farm sizes provided a return sufficient to cover its full cost of production without participating in the government programs. The return to operator labor and management was negative for all six farm sizes when government program participation was not allowed.

Conclusions

Several conclusions follow from the cost analysis of the several farm sizes and the relationships among them.

1. Substantial economies of size are present in beef cattle and small grain production in southwestern North Dakota. The LRAC curves developed for both government program participants and nonparticipants are downward sloping throughout the size range studied (up to four full-time men).

2. The principal effect of government farm program participation is on the level of farm income. Enterprise organization and the shape of the LRAC curves of nonparticipating farms are quite similar to those of participants.

3. Average costs decline rapidly on one-man farms as the capacity of labor and machinery is approached.

4. For one-man farms participating in government farm programs and having average proportions of cropland and rangeland the most efficient machinery complement is based upon a six-plow (80-100 HP) tractor.

5. Two-man farms with an eight-plow machinery complement achieve substantial cost reductions compared to one-man farms.

6. Three-man farms are able to produce at a slightly lower cost per unit than two-man farms and can compete effectively with four-man farms.

7. The most profitable crop enterprise in southwestern North Dakota is wheat following fallow. Barley, oats, and flax are also included in some optimal farm organizations.

8. Beef cow herds are included in all optimal farm plans. The calves are wintered on a ration providing a daily gain of 1.5 pounds and summer grazed as yearlings.

9. Fertilization of tame pasture with 40 pounds of nitrogen is found to be a profitable practice for farms not participating in government programs. Farms participating in government programs generally did not find tame pasture fertilization to be profitable. Native range was not fertilized in any of the optimal farm plans. (Farms participating in government farm programs used conserving base land for pasture and so pasture was a relatively abundant resource on these farms.)

APPENDIX

APPENDIX TABLE 1. NUMBER OF MACHINE OPERATIONS ASSUMED IN CROP PRODUCTION

Machine Operation	Crop: Wheat Following Fallow	Barley Following Fallow	Barley Following Grain	Oats Following Small Grain	Small Grain After Corn	Flax	Corn Silage	Grass-Alfalfa Mixture	Native Hay	Fallow
Plow			1	1		1	1	1[a]		
Disk					2					
Harrow							1			
Plant							1	1[a]		
Cultivate	1	1					4[b]			4
Drill	1	1	1	1	1	1				
Spray	1	1	1	1	1	1				
Swath	1	1	1	1	1	1				
Combine	1	1	1	1	1	1				
Haul and Store Small Grain	1	1	1	1	1	1				
Mow (Swath)								1	1	
Rake									1	
Stack Hay								1	1	
Move Stacks								1	1	
Chop Corn Silage							1			
Haul and Store Corn Silage							1			

[a] Every fourth year.

[b] Includes two times row cultivation.

APPENDIX TABLE 2. VARIABLE MACHINERY COSTS PER ACRE FOR VARIOUS CROP ENTERPRISES OF SIX SELECTED FARM SIZES[a]

		Crop							
Size	Item	Wheat Following Fallow	Barley Following Fallow	Barley Following Small Grain	Oats Following Small Grain	Flax	Corn Silage	Grass-Alfalfa Mixture	Native Hay
1-Man	Preharvest Cost	$2.86	$2.86	$1.65	$1.65	$1.65	$4.09	$ .82	---
(4-Plow)	Harvest Cost	2.30	2.55	2.31	2.56	1.80	7.90[b]	2.30	$2.10
1-Man	Preharvest Cost	2.38	2.38	1.50	1.50	1.50	3.62	.80	---
(6-Plow)	Harvest Cost	2.30	2.55	2.31	2.56	1.80	7.75[b]	2.30	2.10
1-Man	Preharvest Cost	2.51	2.51	1.46	1.46	1.46	3.77	.70	---
(8-Plow)	Harvest Cost	2.30	2.55	2.31	2.56	1.80	7.55[b]	2.30	2.10
2-Man	Preharvest Cost	2.51	2.51	1.46	1.46	1.46	3.77	.70	---
(8-Plow)	Harvest Cost	2.15	2.44	2.16	2.45	1.75	4.41[c]	2.30	2.10
3- & 4-Man	Preharvest Cost	2.51	2.51	1.46	1.46	1.46	3.77	.70	---
(8-Plow)	Harvest Cost	2.07	2.31	2.08	2.32	1.74	4.41[c]	2.30	2.10

[a]Based upon Eidsvig and Olson, Determining Least-Cost Machinery Combinations, Bulletin No. 479, Department of Agricultural Economics, Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota, January, 1969, pp. 24-26.

[b]Includes custom rate for chopping.

[c]Two-row harvesting equipment assumed.

APPENDIX TABLE 3. COSTS AND CAPITAL REQUIREMENTS FOR SELECTED BEEF CATTLE ENTERPRISES

Item	Cow and Calf	Bull	Feeding Beef Calves from November to: January 31	April 15	June 15	July 15	July 31	August 31
Annual Inputs								
Supplement, Grain[a]	$ 3.44	$ 18.77						
Minerals and Salt	2.10	2.10	$ .39	$ .69	$ .95	$ 1.07	$ 1.13	$ 1.26
Veterinary Services	2.00	2.00	.62	1.11	1.51	1.71	1.81	2.00
Miscellaneous Expenses[b]	2.75		.92	1.49	1.69	1.92	2.03	2.26
Buildings and Equipment Depreciation[c]	5.87		3.23	3.87	3.92	3.92	3.92	3.92
Buildings and Equipment Repairs	2.57	2.57	1.40	1.70	1.70	1.70	1.70	1.70
Total	18.73	25.44	6.56	8.86	9.77	10.32	10.59	11.14
Capital Requirement								
Cattle Investment	250.00	500.00						
Buildings and Equipment Investment	71.19		39.16	47.46	47.46	47.46	47.46	47.46
Total Long-Term Capital	321.19	500.00	39.16	47.46	47.46	47.46	47.46	47.46
Operating Capital	12.86	25.44	3.33	4.99	5.85	6.40	6.67	7.22

[a]Eighty pounds supplement for cow: 4.3 cents per pound; 10.8 cwts. feed grain for bull (2/3 barley, 1/3 oats): $1.74 per cwt.

[b]Sprays, telephone, electricity, accounting, breeding fees, association and legal fees for feeding cattle activities, prorated over the number of days fed.

[c]When calves are wintered until the end of January, .55 of cow investment; 2/3 otherwise.

SOURCE: Adapted from Paulson, G. W., Economic Analysis of Beef Cattle and Grassland Management Systems, unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, North Dakota, May, 1970, p. 31.

APPENDIX TABLE 7. LEAST-COST PRODUCTION PLANS FOR SOUTHWESTERN NORTH DAKOTA BEEF CATTLE-SMALL GRAIN FARMS OF SIX SELECTED SIZES NOT PARTICIPATING IN 1971 GOVERNMENT FARM PROGRAMS

		1-Man			2-Man	3-Man	4-Man
Item	Unit	4-Plow	6-Plow	8-Plow	8-Plow	8-Plow	8-Plow
Total Land	Acres	1,749	2,080	2,282	5,029	7,483	9,757
Cropland	"	741	882	967	2,131	3,171	4,135
Wheat Following Fallow	"	305	276	411	777	1,050	1,080
Barley Following Fallow	"	15	106	---	---	---	136
Oats Following Small Grain	"	---	---	---	---	---	85
Flax	"	---	---	17	219	393	527
Grass-Alfalfa Mixture	"	50	58	63	208	437	726
Tame Pasture, 40 Lbs. N	"	51	60	65	150	241	365
Native Rangeland	"	974	1,158	1,271	2,801	4,168	5,435
Spring Grazing, 0 Lbs. N	"	201	232	253	585	940	1,180
Summer & Fall Grazing, 0 Lbs. N	"	658	793	874	2,036	3,164	4,417
Cut for Hay	"	115	133	144	180	45	---
Native Hayland	"	34	40	44	97	144	187
Cut for Hay	"	34	40	44	97	144	25
Cows	Number	68	79	86	199	321	448
Steers Grazed Until July 31	"	---	15	9	22	144	199
Steers Grazed Until August 31	"	30	20	30	66	---	---
Heifers Grazed Until July 31	"	20	23	25	57	92	128
Seasonal Labor Hired	Hours	191	334	352	510	389	378
July	"	94	132	133	270	270	270
August	"	97	202	219	240	119	108
Operating Capital	Dollars	10,679	12,168	13,487	35,138	54,923	74,258
Long-Term Capital	"	189,175	221,484	244,670	512,527	766,159	1,007,483
Gross Income	"	27,000	31,500	35,000	78,000	117,500	154,500
Total Cost	"	35,845	40,620	44,390	90,355	133,424	175,396
Net Management Income	"	-8,845	-9,120	-9,390	-12,355	-15,924	-20,896
Least Cost Per Dollar of Gross Income	"	1.328	1.290	1.268	1.158	1.136	1.135

APPENDIX TABLE 4. BEEF CATTLE PRICES USED IN THE ANALYSIS[a]

Selling Date	Steers (choice)		Heifers (choice)	
	Weight Group (pounds)	Price Per Cwt	Weight Group (pounds)	Price Per Cwt
October 31	300 -550	$30.11	300 -350	$27.01
January 31	462.5-537.5	28.89	437.5-512.5	25.82
	537.5-612.5	28.29	512.5-587.5	25.37
April 15	537.5-612.5	28.75	512.5-587.5	26.08
	612.5-687.5	27.97	587.5-662.5	25.46
	687.5-762.5	27.31	662.5-737.5	24.84
June 15	612.5-687.5	28.85	587.5-662.5	26.35
	687.5-762.5	28.16	662.5-737.5	25.72
	762.5-837.5	27.47	737.5-812.5	25.09
July 15	687.5-762.5	28.12	662.5-737.5	25.76
	762.5-837.5	27.50	737.5-812.5	25.12
	837.5-912.5	26.88	812.5-887.5	24.48
July 31	687.5-762.5	28.05	662.5-737.5	25.65
	762.5-837.5	27.36	737.5-812.5	25.01
August 31	762.5-837.5	27.03	737.5-812.5	24.65
	837.5-912.5	26.54	812.5-887.5	24.14

[a]Price based on monthly price quotations from the West Fargo Livestock Terminal Market from 1963-1970. The average price is increased by the trend factor, and a price differential of 25 cents between Fargo and the area studied is subtracted.

APPENDIX TABLE 5. MARKETING COSTS FOR VARIOUS BEEF CATTLE WEIGHT GROUPS USED IN THE ANALYSIS[a]

Item and Weight	Selling Cost[b]	Trucking Cost	Insurance	Total Cost
Calves (400 lbs)	$2.34	$2.00	$.28	$ 4.62
Cattle (under 625 lbs)	3.00	2.00	.28	5.28
Cattle (over 625 lbs)	3.00	3.00	.28	6.28
Cows (1,100 lbs)	4.55	4.00	.28	8.83
Bulls (1,800 lbs)	4.55	6.00	.28	10.83

[a]Shrinkage loss is not included.

[b]Includes commission, yardage, feed, and bedding.

SOURCE: Dunn, Edward V., Costs and Considerations for Marketing Livestock in North Dakota, pp. 5, 6, and 26.

APPENDIX TABLE 6. ESTIMATED NUMBER OF MACHINERY NEEDED FOR EACH PARTICULAR FARM SIZE[a]

	Specification			Labor Force					
				1-Man			2-Man	3-Man	4-Man
Machinery	a	b	c	4-Plow	6-Plow	8-Plow	8-Plow	8-Plow	8-Plow
Tractor	60-70HP	80-100HP	120-140HP	1a	1b	1c	2c	2c	3c
Plow	4-14 inch	6-16 inch	8-16 inch	1a	1b	1c	1c	1c	2c
Cultivator	15½ foot	18½ foot	24 foot	1a	1b	1c	1c	1c	2c
Drag Harrow	35 foot	35 foot	45 foot	1a	1b	1c	1c	1c	1c
Disk	14 foot	19 foot	32 foot	1a	1b	1c	1c	1c	1c
Press Drill	12 foot	16 foot	28 foot	1a	1b	1c	1c	1c	1c
Combine, Self-Prop.	30 inch	40 inch	50 inch	1a	1a	1a	1b	1c	1c
Grain Elevator	45 foot			1	1	1	1	1	1
Tractor	40HP			1	1	1	1	2	2
Swather, Self-Prop.	16 foot			1	1	1	1	2	2
Mower	7 foot			1	1	1	1	2	2
Rake	9 foot			1	1	1	1	2	2
Truck	2 ton			1	1	1	1	2	2
Pickup	½ ton			1	1	1	1	1	1
Wagon				1	1	1	1	2	2
Loader				1	1	1	1	2	2
Stake Frame				1	1	1	1	2	2

[a]The special purpose machines required for corn silage production will be included only if the production of corn silage is found to be profitable.