Economics of Ranch Management Alternatives in Southwestern North Dakota

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Highlight: *The fundamental management problem of northern plains ranchers is to increase ranch income while maintaining or improving the productivity of the range resource. This study used linear programming to evaluate the profitability of alternative range and livestock management practices. Sale of yearlings was found to be more profitable than selling calves. Establishment of crested wheatgrass for spring grazing allowed deferment of native range and was profitable if yearling prices exceeded $40 per cwt. Fertilization of crested wheatgrass pastures and native hayland at a rate of 40 pounds actual nitrogen per acre was profitable, but native range fertilization was not profitable using prices for the 1970-73 period. Recent price trends place added emphasis on efficient use of the range resource.*

The range cattle industry is an important sector of agriculture in the Northern Great Plains. For instance, in North Dakota, sales of cattle and calves accounted for 31% of total sales of crops and livestock in 1973 (Price and Taylor, 1974). In the neighboring states of Montana, Wyoming, and South Dakota, range cattle have an even greater relative importance. Wheeler (1970) reports that sales of livestock in 1968 represented about 75% of the gross value of agricultural production marketed in the northern plains area of those three states. Over the past 10 to 15 years, the number of beef cattle on farms and ranches in the northern plains area has increased. For example, in the 14 North Dakota counties south and west of the Missouri River, cattle numbers have increased 83% from 1960 to 1974 (Price and Taylor, 1974).

The trend of increasing cattle numbers places added pressure on the range resource and poses challenges for the range manager. Additional livestock numbers can be supported on a fixed land base by converting cropland to tame pasture or hay production to supplement the range resource, by using purchased feed to supplement the range, or by increasing grazing intensity on rangelands. Grazing intensity can be increased through various range improvement practices, such as range fertilization. Recent articles (Goetz, 1969; Lorenz and Rogler, 1973) report substantial responses of northern plains mixed grass rangelands to nitrogen fertilization. However, a recent survey (Leistritz, 1972) indicates that less than one-fifth of western North Dakota ranchers use fertilizer on any of their grazing lands. Wheeler (1970) reports that overgrazing has resulted in a general decline in range productivity in the northern plains, indicating a need for change in traditional ranch management practices.

The fundamental management problem facing northern plains ranchers involves the allocation and use of scarce resources (land, labor, and capital) so as to maximize profit while maintaining or enhancing rangeland productivity.

Ranchers are confronted with a need to maintain or improve the condition of their rangeland while also maintaining or increasing their sales of beef cattle. Saunderson (1973) points out that rising land prices have placed stockmen under pressure to increase beef production per unit of land. Ranch decisions are further complicated by rapidly fluctuating prices of cattle, feed, and other inputs.

The purpose of this study is to determine the most profitable range and livestock management practices for northern plains cattlemen. Specific objectives include the evaluation of (1) fertilization of native range, (2) use of cropland for tame pasture or hay production to supplement the rangeland feed base, and (3) sale of yearlings rather than calves.

Procedure

The nature of northern plains ranching makes the determination of the most profitable range management practice difficult. An analytical technique is needed which allows the simultaneous selection of (1) the number and type of livestock, (2) the allocation of cropland among the alternatives of cash crop production, feed grain and hay production, and pasture, (3) the allocation of rangeland to spring, summer, and fall grazing, and (4) the rate of fertilization of both the range and the tame pastures. Linear programming is such a technique and is the principal analytical procedure of this study.

Linear programming is a mathematical procedure which allows returns to the fixed resources to be maximized subject to a set of production restraints which are considered simultaneously.[1] Linear programming was used in this study to determine ranch management practices which maximize returns to the ranch operator's labor, management, and land for a representative ranch. The data used in the programming reflect present range management technology and were obtained from surveys of range livestock producers in western North Dakota, from experiment station trials, and from the North Dakota Crop and Livestock Reporting Service. The

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[1] A nontechnical discussion of linear programming may be found in Levin and Lamon (1969). More detailed treatments are found in Heady and Candler (1958) and Wagner (1969).

study area consisted of the 14 counties in North Dakota located south and west of the Missouri River.

The representative ranch studied consisted of 2,243 acres of which 606 acres were cropland, 65 acres were used for native hay production, and 1,572 acres were rangeland. The cropland included 255 acres of sandy soil on rolling land which was considered marginal for crop production. Of the rangeland, only 629 acres or 40% was suitable for fertilization, based on soil type and terrain. Ranch labor was provided by the operator and his family although a full-time man could be hired if needed.

Livestock Management Alternatives

The basic livestock enterprise was the beef cow-calf herd with the rancher having three alternative methods of marketing:

1) Calves are weaned in October and sold around November 1.

2) Calves are weaned, fed through the winter, and sold the end of April.

3) Calf is weaned, fed through the winter, summer grazed, and sold either in June, August, or October depending on range condition and prices.

A 16% cow herd replacement rate and a 90% calf crop were assumed with calves being born in March and April. One bull was required for every 25 cows and had a 4-year useful breeding life.

Weaned calves were sold at weights of 430 and 410 pounds for steers and heifers, respectively. Calves fed during the winter for sale in April were fed a grain-roughage ration to gain 1.75 pounds per day (average weighted daily gain for steers and heifers). If the operator intended to summer graze yearlings they were wintered on a high roughage ration to gain 1.00 pound daily and placed on native range or tame pasture about May 10.

Calf and yearling prices used in the programming model were based on a 3-year average (1970-73) of prices received at the Union Stockyards, West Fargo. Marketing costs were based on Dunn (1971).

Range Management Alternatives

The grazing season in southwestern North Dakota begins about May 10 and lasts from 6 to 8 months. Six- and 8-month grazing were included as alternatives available for grazing cows:

1) Graze native range continuously with supplemental grazing of crop and hayland aftermath beginning in September.

2) Graze crested wheatgrass (*Agropyron desertorum*) from May 10 to June 20 and defer native range for summer and fall grazing.

3) Graze crested wheatgrass pastures from May 10 to June 20, graze native range from June 20 to September 10, then move to Russian wildrye (*Elymus junceus*) pasture until November.

The grazing season for yearlings was divided into three periods:

1) Spring grazing from May 10 to June 20. The yearlings gain at a rate of 2.25 pounds per day and can be grazed on either native range or crested wheatgrass.

2) Summer grazing from June 20 to August 1. Yearlings graze native range and gain at a rate of 1.75 pounds per day.

3) Fall grazing from August 1 to October 1. Yearlings graze native range and gain 1.00 pound per day.

The yearlings could be sold at the end of any of the three periods. Several range and pasture fertilization alternatives were available:

1) Native rangeland could be fertilized with 40 pounds of actual N. (Only 40% of the rangeland acreage was judged suitable for fertilization, however.)

2) Crested wheatgrass pasture could be fertilized with 40 or 80 pounds of actual N.

3) Russian wildrye pasture could be fertilized at a rate of 40 pounds of actual N.

All tame pasture was established on cropland acreage and the decision whether or not to fertilize the pasture was based on the value of the added production relative to the added cost. Cost-sharing for pasture establishment was available from the Great Plains Conservation Program. Ammonium nitrate (33% actual N) was used for fertilization.

Grain and Hay Alternatives

Wheat, barley, oats, and alfalfa hay could be grown as cash crops. The prices for the small grains were based on 1974 farm program guarantee prices. Forage crop alternatives included alfalfa, corn silage, and native hay; and oats and barley could be grown as feed crops. Native hay could be fertilized with 40 pounds actual N per acre. Yields attained on marginal cropland as compared to good cropland were estimated to be approximately 70% for grain crops and corn silage and 90% for alfalfa (Table 1).

Results of Programming Analysis

Linear programming analysis was used to determine the optimum ranch organization given alternative livestock production and pasture management systems. A recent ranch survey (Leistritz, 1972) has shown that western North Dakota ranchers typically sell their calves shortly after weaning and do not typically fertilize rangeland. An initial or "baseline" solution, developed for purposes of comparison, indicated the profit-maximizing ranch organization when only these traditional management practices were allowed. Subsequent analysis involved increasing the livestock marketing and pasture management alternatives.

Baseline Solution

The baseline solution (Solution 1) indicates the profit-maximizing ranch organization using traditional pasture

Table 1. Forage and cash crop yields on good and marginal cropland, southwestern North Dakota.

Crop	Unit	Yield on good cropland	Marginal cropland
Wheat following fallow	bushel/acre	33.70	23.70
Barley following fallow	bushel/acre	54.80	38.50
Oats following small grain	bushel/acre	57.00	40.20
Corn silage	ton/acre	5.30	3.70
Alfalfa hay	ton/acre	1.50	1.35
Crested wheatgrass for spring pasture	AUM/acre[a]	0.88	.80
Crested wheatgrass for spring grazing:			
With 40 pounds actual N	AUM/acre[a]	1.50	1.37
With 80 pounds actual N	AUM/acre[a]	1.61	1.46

[a]An AUM is the amount of forage required per month by a 1,000 pound dry cow.

management techniques and cattle marketing practices (Table 2). For this solution, tame pasture establishment and native range fertilization were not allowed, and sale of calves at weaning was the only cattle marketing alternative considered. Wheat after fallow occupied most of the good cropland with the remainder (11 acres out of 351) devoted to oats production. The oats were used as winter feed for the cow herd. Marginal cropland was used for wheat after fallow and for alfalfa hay production. The cow herd totaled 110 and 82 calves were sold annually. The rancher's return to his labor and management was $6,787.

Alternative Cattle Marketing Programs

For this solution (Solution 2), the alternatives of selling either backgrounded calves or yearlings were included in the model. Sale of yearlings after summer grazing was the most profitable alternative. Sale of backgrounded calves was more profitable than selling weaned calves but less profitable than selling yearlings. In order to provide additional winter feed, 26 acres of good cropland was shifted from wheat-fallow to oats (Table 2). Labor and management returns for this solution were $9,635, an increase of 42% from the Solution 1 level.

Alternative Pasture Management Programs

The alternatives of establishing tame pasture and of fertilizing tame pasture, native hayland, and native range were added to the model for Solution 3. The optimum ranch organization indicated that 49 acres of good cropland should be used for oats production with the remainder in wheat-fallow (Table 2). All marginal cropland was used for forage production—142 acres for alfalfa hay and 113 acres for crested wheatgrass. All tame pasture and native hayland was fertilized with 40 pounds of actual N, but no native range was fertilized. Russian wildrye for fall grazing was not established in this solution. Of the 1,572 acres of native range, 650 acres were used for deferred grazing. Labor and management returns for this solution were $11,325 which was 67% greater than that for Solution 1 and 18% greater than for Solution 2.

Extended Grazing Season

An 8-month grazing season (May 10 to December 31) was used to determine the effect on ranch organization of the reduced labor and winter feed requirements associated with this management strategy. The 8-month grazing season was analyzed in Solution 4, using the livestock marketing and pasture management strategies included in Solution 3.

The livestock and crop production pattern with an 8-month grazing season did not differ greatly from that with a 6-month season (Table 2). The acreage of alfalfa hay was reduced by 33 acres, as a longer grazing season implies a reduced hay requirement per head. The major change in pasture management with this solution was the large increase in the acreage of native range on which deferred grazing was practiced, 1,380 acres compared to 650 acres for Solution 3. The returns to labor and management for Solution 4 were

Table 2. Optimum ranch organization with various alternative cattle marketing and pasture management programs considered.

Activities	Unit	Solution 1 baseline solution[a]	Solution 2 alternative cattle marketing programs[b]	Solution 3 tame pasture and native range fertilization[c]	Solution 4 extended grazing season[d]
Good cropland use					
Wheat	Acres	170	157	151	152
Fallow	Acres	170	157	151	152
Oats	Acres	11	37	49	47
Marginal cropland use					
Wheat	Acres	65	64	0	0
Fallow	Acres	65	64	0	0
Alfalfa hayland	Acres	125	127	142	109
Crested wheatgrass, 40 lb N	Acres			113	146
Russian wildrye, 40 lb N	Acres				
Native rangeland use					
Native hayland - 0 lbs N	Acres	65	65	0	0
Native hayland - 40 lb N	Acres			65	65
Native grazing - 0 lb N	Acres	1,572	1,572	922	192
Native grazing - 40 lb N	Acres			0	0
Native grazing, referred - 0 lb N	Acres			650	1,380
Cattle					
Cow herd	Number	110	94	125	122
Weaned calves sold[e]	Number	82	0	0	
Background calves sold[f]	Number			0	
Yearling sold[g]	Number		69	93	90
Cull cows sold	Number	17	14	19	18
Return to operator					
labor and management[h]	Dollars	6,787	9,635	11,325	11,022

[a]No tame pasture establishment or range fertilization was allowed. Sale of calves at weaning was only cattle market alternative.
[b]Marketing of backgrounded calves and yearlings was allowed. Tame pasture establishment and range fertilization were not allowed.
[c]Tame pasture was established to provide spring (May 10–June 20) grazing for cows and yearlings. Native range could be fertilized with 40 pounds of N, and native range grazing could be deferred until June 20.
[d]An 8-month grazing season (May 10–December 31) was used. Cattle marketing and pasture management alternatives were the same as in Solution 3.
[e]Marketed about November 1.
[f]Marketed about April 30.
[g]Marketed about August 1.
[h]Net returns to operator for his labor and management. Computed by subtracting a capital charge of 7% on long term and 8% on short term investment from net ranch income.

$11,022 or 3% less than for Solution 3. This rather small difference in profitability indicates that the choice of grazing season length will probably be influenced greatly by year-to-year variations in winter and available feed supplies.

Effects of Varying Fertilizer Prices

Fertilizer costs are a source of considerable uncertainty. Consequently, price of nitrogen fertilizer was varied to determine the effects of higher prices on the profitability of tame pasture and native range fertilization. Price of ammonium nitrate (33% actual nitrogen) was varied from $50 to $140 per ton. The prices of cattle, grain, and other inputs and the production activities were the same as in Solution 3. With a fertilizer price of $50 a ton, 492 acres of native range and 84 acres of crested wheatgrass were fertilized with 40 pounds of actual N per acre. When the price increased to $65 per ton, native range fertilization was eliminated, but crested wheatgrass increased to 113 acres, partially replacing the native range production. The crested wheatgrass acreage fertilized remained constant at all price levels up to $140 per ton, the highest price included in the analysis. Native hayland (65 acres) was profitably fertilized at all price levels.

Conclusions

Under the conditons imposed in the model ranch of this study, ranch income and returns to the operator's labor and management can be substantially increased through departures from traditional management practices. Sale of yearlings was more profitable than selling calves at weaning. Crested wheatgrass for spring grazing was a more profitable use of marginal cropland than wheat at yearling prices of $40 per cwt and higher compared to a wheat price of $2.05 per bushel. However, yearling prices of $51 per cwt would be needed before good cropland would be used for tame pasture. When crested wheatgrass was established, fertilization at a rate of 40 pounds of actual nitrogen per acre was substantially more profitable than the alternatives of either no fertilization or fertilization at the rate of 80 pounds of actual nitrogen per acre. Fertilization of suitable native hayland also was a profitable practice under a wide range of fertilizer prices. Profitable fertilization of native rangeland on an annual basis required ammonium nitrate prices $65 per ton or less. Thus widespread fertilization of native range is unlikely, given present cattle price-fertilizer cost conditions.

Recent increases in fertilizer and grain prices and changes in the cattle price structure will influence the profitability of the various alternatives. Prices of yearlings became much higher relative to the price of calves in 1974 than was the case in the 1970–1973 period. Production of yearlings will be even more profitable, relative to calves, under these conditions. Yearling production also provides the rancher with added flexibility to adjust his herd size to annual fluctuations in the range feed supply. Higher grain prices, of course, make the conversion of cropland to tame pasture less attractive. If high grain prices continue, future research might be directed to the use of selective fertilization to increase cool season grass production of selected native range sites for spring grazing. Periodic applications of herbicides in conjunction with nitrogen to improve range condition (Schneiter and French, 1968) also may be a fruitful subject for economic analysis.

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