An Economic Analysis of Retention of Yearlings on Range and Potential Effects on Beef Production

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Highlight: Optimum range livestock marketing schemes were developed for two typical Utah ranch sizes (150 and 300 head of brood cows) using linear programming analysis. Based on average Utah cattle prices for 1970–75, the range livestock management alternative which maximized net ranch income for both ranch sizes was to reduce the cow herd 25% and use the released feed to retain all steer calves for sale as yearlings. Optimum disposition of heifer calves was sale at weaning time. The reduction in breeding herd to accommodate retained yearlings would decrease the number of feeder livestock marketed. Potential decreases in U.S. beef production from 1 to 4% were estimated if 25 to 100% of the ranches in the 11 western states adopted the optimum management alternative. These reductions would result in an increase in United States wholesale beef prices of 1 to 6%.

Recent high prices for heavy feeder cattle relative to those paid for lightweight feeder calves has stimulated new interest in range livestock management alternatives for marketing yearlings rather than weaner calves. The extremely high feed grain prices since 1974 have made it cheaper for feeders to purchase livestock gain from ranchers than to produce the gain in a feedlot (Stenquist 1975). If the time of low feed grain prices and huge feed grain surpluses is indeed over (Brunk 1975; Nielsen 1975), feedlot operators may come to prefer grass-fed yearlings to lightweight calves. Considering these factors, it was hypothesized that Utah ranchers might find it more profitable to market grass-fed yearlings than the traditional weaners.

This study was designed to investigate various Utah range livestock production options and evaluate their effects on net ranch income. A majority of those who have investigated the profitability of retaining ownership of beef calves to sell as yearlings have used a budgeting technique that compared a cow-yearling operation retaining all calves to a cow-calf operation selling all calves. In contrast, we used linear programming to develop an optimum combination of various livestock marketing alternatives that would maximize net ranch income. We also estimated the effects on beef supply and price which might result if our optimum management strategies were widely adopted.

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Methods

Linear programming was used as the optimization procedure because it allowed us to simultaneously examine a large set of input and production constraints and determine the most economically efficient mix of production activities from among all available alternatives. Linear programming techniques have been shown to be well suited to aiding decisions concerning the allocation of scarce resource between management alternatives in order to maximize income or minimize cost (Agrawal and Heady 1972; Beneke and Winterboer 1973; Jameson et al. 1974).[1]

Two typical Utah ranch sizes (150 and 300 head of brood cows) described by Roberts and Gee (1963), were modeled and called 150RANCH and 300RANCH for easy reference. Inventory and budget data for these two ranch sizes from Workman (1970) and Roberts and Gee (1963) provided the basic input for the analysis.[2] Resource constraints were formulated from forage balance charts and typical feed use patterns of the two ranch sizes as determined by Abdalla (1976). Total feed (pasture, range, hay, barley, crop aftermath, and federal permits) available to the 150RANCH was 2,472 animal unit months (AUM) and 4,993 AUM for the 300RANCH.

Ranch Management Options

The cattle production alternatives we considered were similar to those used by Leistritz and Qualey (1975) with the addition of options 3, 5, and 6 as follows:

1. Baseline (current) operation: cow/calf operation, all homegrown calves except replacement heifers sold November 1.
2. Cow/short-yearling operation, weaner calves wintered and sold April 1.
3. Same as No. 2 with additional calves purchased November 1, wintered, and sold April 1.
4. Cow/long-yearling, calves wintered, summered on range and sold October 1.
5. Same as No. 4 with additional calves purchased November 1, sold October 1.
6. Same as No. 4 with additional calves purchased April 1, sold October 1.

For the baseline cow-calf operation, weaning weights of calves were 380 lb for heifers and 400 lb for steers. The calf crop was 80% and 15% of the breeding herd was replaced annually. The 150RANCH ran one bull for 25 cows with a 4-year active life. The 300RANCH ran one bull for 20 cows with a 3-year active life. Short-yearling steers

[1] Readers desiring detailed discussions on linear programming techniques, uses, and limitations are referred to these authors.

[2] These data were gathered from numerous ranches and then composited according to the size categories of 50, 150, 300, and 500 head of brood cows. The 150 and 300 head size were chosen for the study as most representative of the majority of Utah's ranches.

weighed 490 lb on April 1 and short-yearling heifers weighed 470 lb. Sale weights of long-yearlings were 740 lb for steers and 680 lb for heifers.

Costs of Production

Cattle prices used were 6-year (1970–75) average prices paid at the North Salt Lake Stockyards, Salt Lake City, Utah (Table 1). Analyses at 1973 and 1975 prices were also included for comparison with the average price situation and to provide samples of the effects market fluctuations have on ranch income. Since current budget data for cattle ranching enterprises in Utah were not available, costs of production for the two Utah ranch sizes for 1968 (Workman 1970) were updated to 1976. Cash costs of production for short and long yearlings were calculated from Kearl (1969). Federal indices of prices paid by farmers for production items of both farm and non-farm origin (United States Department of Agriculture 1976) were used to update all price data to May 1976.

Table 1. Average price ($/cwt) paid for cattle in Utah 1970–1975, North Salt Lake Stockyards.[1]

	300–400 lb November 1		400–500 lb April 1		600–700 lb October 1	700–800 lb October 1
Year	Steers	Heifers	Steers	Heifers	Heifers	Steers
1970	$34.78	$31.52	$39.50	$34.96	$22.85	$30.06
1971	40.66	36.17	36.37	32.75	30.95	33.59
1972	54.00	45.90	40.38	37.77	38.67	39.96
1973	61.38	52.00	60.75	52.16	40.25	46.19
1974	30.76	25.56	52.41	46.81	24.69	27.73
1975	34.30	24.26	30.63	23.60	32.06	35.88
Avg	$42.65	$35.90	$43.34	$38.00	$31.58	$35.57

[1] Averages are based on price information from weekly issues of *Market News*, published in Ogden, Utah, by the Livestock Div. of the Agr. Market. Serv., U.S. Dep. Agr.

For optimization purposes, only variable costs that affect the optimum allocation of resources were included. Thus, fixed costs such as depreciation, taxes, and insurance were not included even though they must be paid from what is reported here as net ranch income. These costs remain the same regardless of the type of operation.

Total per unit costs for the 150RANCH cow-calf, short-yearling, and yearling activities were $112 to $118, $45, and $31 to $37, respectively, depending on the proportion of Federal rangeland grazed. For the 300RANCH total costs were $125 to $132, $45, and $31 to $37 for the cow-calf, short-yearling, and long-yearling activities, respectively. The higher production costs for the 300-RANCH cow-calf activity were due primarily to higher per unit expenditures for feeds and veterinary services (Workman 1970).

A baseline solution was first obtained by restricting the optimization procedure to the calf production activity to allow for later comparison with optimization solutions. Then the other five activities were added to the models and an optimum strategy was developed for each ranch size.

Possible reductions in beef produced in Utah and the 11 western state region were evaluated at four arbitrary levels of rancher adoption of the optimum strategy. Assuming that all ranches in the region are currently cow-calf operations selling weaner calves, the decrease in the number of calves produced as a result of required reductions in breeding herds to accommodate yearlings was calculated for situations where 25, 50, 75, and 100% of the total operators adopted the optimum strategy. The required reduction in herd size to adopt the optimum strategy was assumed to be that required by the two representative Utah ranch sizes.

The number of calves marketed was calculated as the number of beef calves weaned in the state or region minus 15% for replacements (Abdalla 1976). The percent reduction in herd size, multiplied by the number of calves marketed by either 25, 50, 75, or 100% of the ranches in the state or region, was used as the number of calves which would not be marketed at these four levels of rancher adoption. To determine the effect of the potential decreases in calves on U.S. live weight beef production, it was assumed that all calves and yearlings are currently fed to 1,100 pounds for slaughtering. The decreased number of calves multiplied by 1,100 pounds is the maximum possible reduction in U.S. beef production due to rancher adoption of the optimum strategy in Utah and the region.

The effect of a possible 11-western-state reduction in beef production on U.S. wholesale beef prices was evaluated by using the concept of price elasticity of demand. The price elasticity of demand is the percentage change in the quantity purchased, divided by the percentage change in the price of the product (Leftwich 1973). Workman et al. (1972) calculated the price elasticity of demand for beef in the U.S. to be −0.67. This value indicates that the quantity of beef purchased would decrease by 0.67% as the result of a 1% price increase. The inverse of the price coefficient,

$$\frac{1}{-0.67} = -1.49,$$

shows that a 1% decrease in the quantity of beef produced would cause a 1.49% increase in the price of beef (Workman et al. 1972). Thus, the percentage change in the price of beef resulting from rancher adoption of the optimum strategy is −1.49 times the percentage change in the quantity of beef produced.

Results and Discussion

Solutions to Baseline Cow-Calf Operations

For the 150RANCH model, the baseline solution resulted in a breeding herd of 159 cows. Spring range was the most limiting resource, with other resources becoming constraining almost simultaneously. The capital requirement (total annual cash costs) was $14,420, and net ranch income was $2,148.

Spring range was also the factor that limited the 300RANCH baseline cow-calf operation to 294 head of brood cows. Capital requirement was $28,879, and net ranch income was only $849. This low net return was due to the significantly higher costs of production on the 300-head ranches than on the 150-head ranches. Solutions for the baseline cow-calf operations of both ranch sizes are summarized in Table 2.

Table 2. Organization of the baseline solutions for the cow-calf operations for the two ranch sites.

Item	150RANCH	300RANCH
Cows	159	294
Bulls	7	15
Replacement heifers	24	44
Livestock marketed		
Cull cows	24	44
Steer calves	64	118
Heifer calves	40	73
Limiting resource	Spring range	Spring range
Operating capital requirement	$14,420	$28,879
Net ranch income	$ 2,148	$ 849

Optimum Strategies

Ideally, ranch organizations should be changed each year to employ the specific production and marketing strategies that would maximize net ranch income for that particular year, thereby maximizing long-term net ranch income. However, since prices cannot be foreseen for enough in advance to allow ranchers to make the necessary decisions, and since a constantly changing ranch organization would be unrealistic, an optimum strategy based on average price data is an appropriate means of maximizing long-term net ranch income.

The income-maximizing ranch organization for the 150-RANCH combined cow-calf and long-yearling options. The sale of heifer calves at weaning and the retention of all steer calves for sale as long-yearlings resulted in a net ranch income

of $2,268, approximately 6% over that of the baseline cow-calf operation. Capital requirements decreased by $483 and a herd of 120 brood cows supplied the calves for the operation with no purchases of additional weaner calves or short yearlings. Spring range was the most limiting resource. Optimum production and marketing strategies for both ranch sizes are presented in Table 3.

Table 3. Organization of the optimum strategy for ranch operations for the two ranch sites.

Item	150RANCH	300RANCH
Cows	120	222
Bulls	5	11
Replacement heifers	18	33
Livestock marketed		
Cull cows	18	33
Heifer calves	30	55
Long yearling steers	48	89
Limiting resource	Spring range	Spring range
Operating capital requirement	$13,937	$27,334
Net ranch income	$ 2,268	$ 2,049

Sensitivity analysis of the optimum solution indicated that the 150RANCH solution would be sharply affected by a drop in price for long-yearling steers. If the gross return for these yearlings were lowered by only $1.06 to $262.16, while all other factors were held constant, net ranch income from the optimum solution would be almost identical to that from the baseline cow-calf operation. This sensitivity to decreased yearling prices was also reflected by the small ($120) difference in net ranch income between the baseline cow-calf and optimal solutions. The choice between the baseline cow-calf and the optimum cow-calf long-yearling operation may therefore be simply a matter of rancher preference. Lower prices of yearlings, however, might be accompanied by proportionately lower calf prices, in which case the long-yearling option could remain optimal.

The optimum strategy to maximize net ranch income for the 300RANCH was the same as for the 150RANCH. Sale of all heifer calves at weaning and retention of all steer calves for sale as long-yearlings increased net income by $1,200. Operating capital decreased $1,545. The 222 head of brood cows provided all calves for retention and no calves or short-yearlings were purchased. Spring range was again the most limiting resource.

Sensitivity analysis of the 300RANCH optimum solution indicated that it is more stable than the 150RANCH solution in the event of yearling price decreases. With other factors held constant, the gross return for long-yearling steers would have to drop by $13.54 (to $249.68) before the solution changed. This stability is also reflected in the large difference between net ranch incomes from the optimal solution and from the baseline cow-calf operation (Tables 2 and 3).

Analysis Using 1973 Prices

During 1973, Utah cattle prices were considerably higher than the 1970–75 average, with lightweight weaner calves bringing exceptionally high prices. Our analysis using 1973 prices yielded a much different optimum ranch organization than we obtained with 1970–75 average prices.

Optimum ranch organization for the 150RANCH became the baseline cow-calf operation. The resulting net ranch income of $9,340 was 19% higher than the $7,855 which would have been earned if the 1970–75 average price optimum strategy had been employed at 1973 prices.

Optimum ranch organization for the 300RANCH was also essentially the baseline cow-calf operation except that the larger ranch had a slight excess of winter feed, allowing five short-yearling steers to be retained. The net ranch income of $14,076 was 14% greater than the net ranch income ($12,306) that would have been generated at 1973 prices using the 1970–75 average price optimum strategy.

Analysis Using 1975 Prices

In 1975, Utah cattle prices exhibited a rare situation. Lightweight feeder calf prices were considerably below average while those 700- to 800-lb yearlings were not only slightly above average but were actually *higher* than calf prices.

With these conditions, the retention of heifers became profitable on the 150RANCH, and 26 yearling heifers displaced 17 cows, which reduced the breeding herd to 103 cows. As in the original optimum strategy, all steers were retained as long-yearlings. Net ranch income was $2,105. The baseline cow-calf operation, however, would have suffered a loss of approximately $1,450, since 1975 calf prices were too low to cover all production costs.

A similar optimum was indicated for the 300RANCH. The 48 heifer calves not needed for cow herd replacement were retained, displacing 30 cows and reducing the breeding herd to 192 cows. Net return was $2,108, while the baseline cow-calf operation would have lost approximately $5,600.

First-year Cash Flow

During the first year in which an operation switches from the baseline cow-calf operation to a cow-calf/long-yearling strategy, there may be a decrease in cash flow from retaining steer calves. On the 150RANCH, 39 cows must be culled to provide the feed for the 48 retained steer calves. Based on an income of $187.60/head for the 39 cull cows sold and a foregone income of $170.60/head for the 48 steer calves not sold, net decrease in cash flow for the initial year would be $872. This decrease is partially offset during the ensuing production year, however, by a $483 decrease in required operating capital.

On the 300RANCH, 72 cows are culled and 89 steer calves retained, resulting in a $1,676 decrease in initial-year cash flow. This decrease is almost entirely offset by a $1,545 reduction in operating capital required the following year. Additionally, the extremely heavy culling of the cow herd in the first year may well result in an improved calf crop percentage the following fall and a rapid improvement in cow herd quality.

Effects on Beef Production and Price

The 25% decrease in breeding herd to accommodate retained yearlings specified by the 1970–75 average price optimum would result in fewer feeder cattle going to market in Utah and in the region (Table 5). The reduction in regional beef production (Table 5) was used to calculate the associated change in U.S. wholesale beef price. Total liveweight beef production in the United States for 1975 was 40,680,069,000 lb (Abdalla

Table 4. Reduction in number of beef calves marketed in Utah and the western region resulting from 25, 50, 75, or 100% of all ranches adopting the optimum strategy.

Adoption level (%)	Reduction in beef calves marketed (head)	
	Utah	Western Region
25	15,619	347,863
50	31,238	695,726
75	46,857	1,043,589
100	62,476	1,391,452

Table 5. Decrease in the pounds (liveweight) of beef produced in Utah and the western region resulting from 25, 50, 75, or 100% of all ranches adopting the optimum strategy.

Adoption level (%)	Reduction in beef production (pounds)	
	Utah	Western Region
25	17,180,900	382,649,300
50	34,361,800	765,298,600
75	51,541,600	1,147,947,900
100	68,722,500	1,530,597,200

1976). At 25, 50, 75, and 100% optimum strategy adoption at the regional level, total U.S. beef production would be reduced by approximately 0.94, 1.88, 2.82, and 3.76%, respectively. Based on the elasticity coefficient of −1.49, if 15% of the ranchers in the region adopted the optimum strategy the price of beef would increase by 1.4%. Regional rates of optimum strategy adoption of 50, 75, and 100% would result in U.S. beef price increases of 2.8, 4.2, and 5.6%, respectively. Based on the assumptions that: (1) all ranches in the region are presently purely cow-calf operations marketing only weaner calves and (2) that all calves and yearlings marketed from these ranches are fed to slaughter weights of 1,100 lb, these estimates should only be viewed as the *maximum* possible effects on beef price and production if ranches shifted to the cow-calf/long-yearling organization.

The range livestock industry might benefit in two ways by shifting to the optimum strategy. First, marketing steer calves as yearlings would increase net ranch income over that produced by traditional cow-calf operations, and second, the inelastic demand for beef in the United States would mean that the herd size decreases required to accommodate retained yearlings would ultimately bring an increase in beef prices.

Summary and Conclusions

Optimal livestock production and marketing strategies for both ranch sizes called for a combination of cow-calf and long-yearling options. Heifer calves were to be sold at weaning, while the cow herd was reduced by approximately 25% to accommodate retention of all steer calves for 11 months after weaning.

Although optimal strategy net ranch income was higher for the 150RANCH than the 300RANCH, the increase in net ranch income over the baseline cow-calf operation was greater for the 300RANCH than the 150RANCH. The differential was due to higher original costs per cow incurred by the 300RANCH, which meant higher savings when cows were replaced with yearlings. The fact that net ranch income was higher for the 150RANCH than for the 300RANCH should not be construed as indicating a need for a 50% size reduction by the large ranch. More efficient management should give the 300RANCH a net ranch income at least double that of the 150RANCH.

Our analysis using the exceptionally high 1973 weaner calf prices defined a cow-calf operation as the optimum for both ranch sizes. Net ranch income was several times higher than that earned at 1970–75 average prices. In 1975, however, not only were cattle prices much lower than the 1970–75 average, but long-yearlings brought more per pound than did weaner calves. Optimization at 1975 prices therefore required retention of all calves for sale as long-yearlings. Cow-calf operations would have meant losses for both ranch sizes in 1975.

Widespread adoption of the cow-yearling strategy identified as optimum could result in a small (1 to 4%) reduction in U.S. beef production, which could lead to an increase in beef prices to consumers of from 1 to 6%.

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