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Economic Analysis of Long-Term Management Strategies for Two Sizes of Utah Cattle Ranches

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ECONOMIC ANALYSIS OF LONG-TERM MANAGEMENT STRATEGIES FOR TWO SIZES OF UTAH CATTLE RANCHES

by

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Roger E. Banner

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Economic Analysis of Long-Term Management Strategies for Two Sizes of Utah Cattle Ranches

by

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Utah cattle ranchers realize relatively little profit from ranch ownership and management. This study represents an attempt to identify ranch management strategies that produce more profit over time than do conventional strategies.

To identify optimum management strategies for the long term, analyses of ranches under both normal and adverse ranch operation conditions using the COPLAN linear programming model were made for strategy comparison. To depict these ranch business environmental conditions, production levels were estimated from available biological data and price levels were estimated by indexing 1977 ranch product prices (the most current budget data available for Utah). The variability of strategy expected net returns above variable costs over a defined array of ranch operation conditions was estimated to

evaluate income stability for each strategy. Overall profitability comparisons were made among strategies for evaluation in the context of ranch ownership and management. Percent returns on owned ranch capital were estimated as the basis for this comparison.

Optimum strategies based on various ranch operation conditions for a large Utah cattle ranch were similar, as were optimum strategies based on the same conditions for a small Utah cattle ranch. Availability of winter/spring forage should be the principal constraint limiting cow-herd size based on the analyses. Range improvement practices that reduce the winter/spring range forage bottleneck are economically feasible in general, however, such practices must be evaluated on a site-specific basis. Optimum strategies for both large and small ranches focused on: 1) intensively managed cow/yearling enterprises at herd levels corresponding to levels of available winter/spring forage, 2) intensively managed crop production enterprises based on sale of crops, and 3) yearling stocker steer enterprises based on seasonal forage surplus.

The economic analyses showed that alternative (optimum) management strategies could increase profit over conventional strategies dramatically. Optimum strategies for the large ranch produced net returns above variable costs many times greater than those produced by the strategy employed in 1977. Expected net returns above variable costs that resulted from small ranch optimum strategies were vastly superior to those produced by the 1977 strategy. Working capital requirement increased approximately 50 percent over levels required

by strategies employed in 1977 for both large and small ranch optimum strategies. Expected income variances and standard deviations were greater for both large and small ranch optimum strategies than for strategies practiced in 1977; however, income standard deviations expressed as percentages of strategy expected values (relative income variabilities) were much less. Percent returns on owned ranch capital expected from the practice of optimum strategies were eight times greater than percent returns from practice of the 1977 strategy for the large Utah cattle ranch and six times greater than those resulting from employment of the 1977 small ranch strategy.

(132 pages)

INTRODUCTION

During settlement of the Western United States by European man, the geographic region that lies west of the Great Plains and east of the mountain ranges of California and of western Oregon and Washington was referred to as the Great American Desert. The landscape includes rugged mountain ranges, plateaus, basins, and valleys. Blumenstock and Thornthwaite (1941) classified the region climatically as taiga and subhumid in certain mountainous areas and semiarid and arid over the remainder of the region. Ranch businesses that developed in this region evolved under particular constraints on what can and cannot be done (Box 1978). The climate is variable, the soils are generally low in productivity, and water is scarce. This region can be characterized as a harsh region of environmental extremes.

Just as the physical or production environment may be thought of as inhospitable, similar characterizations may be made of the economic environment of Western ranch businesses. Historically, the product prices received and production costs encountered have resulted in returns to ranch operation and investment that would be considered low in other forms of business enterprises. Although ranching has not been a lucrative proposition, since the early 1950's appreciation of land values has made ranch ownership a sound and stable investment (Winter and Whittaker 1979, Herdt and Cochrane 1966). Estimates of annual land appreciation of ranches (rangeland and arable land) during the late 1970's range from around nine to

fifteen percent (U. S. Department of Agriculture 1977, King 1981). In order for ranchers to realize the benefit of the land appreciation today, the property can be sold or mortgaged at current interest rates. In some instances ranchers must borrow against their equity in land to cover losses incurred in operation of the ranch business, reducing future participation in benefits derived from land investment.

Problem Statement

The problem for Utah ranchers is one of making operation of the ranch a more profitable practice over the long-run given the existing ranch business environment. To address this problem, ranch management alternatives and organizational strategies which include elements of risk of unfavorable production and product price levels must be identified. Adoption of an optimum management strategy by an individual rancher operating in competitive markets would improve the profitability and economic stability of the ranch business.

Study Purpose and Objectives

The purpose of this study was to identify ranch management strategies that maximize net return above variable costs over the long-run for two composite Utah cattle ranches defined as large (287 cows) and small (140 cows). Identification of optimum ranch management strategies in the context of favorable as well as unfavorable ranch operation conditions was attempted to identify ways for ranchers to improve profitability of their ranch businesses. In addition, a

better understanding was sought of the relationships among various enterprises included in the ranch business.

This study was designed to meet three objectives through economic analysis of the ranch under risk. These objectives were:

1. To apply different levels of Utah ranch business environmental parameters of production and product price/production factor cost relationships, as a means of evaluating management strategies over time in economic analyses of Utah cattle ranches.

2. To identify ranch management strategies that increase net returns above variable cost for Utah cattle ranches considering inherent strategy risk.

3. To evaluate estimated differences among existing and developed strategies when applied over time in terms of net return above variable cost, stability of income, and return on owned ranch capital.

Delineation of the Research Problem

Production

Forage, irrigated crop, and livestock production as affected by favorable and unfavorable climatic conditions in Utah were estimated. Favorable climatic conditions included conditions that were average or better. Such climatic conditions correspond to those conditions that are thought of as "normal". Unfavorable climatic conditions included conditions considered abnormally or disruptively dry ranging descriptively from mild to extreme drought. Values used in the analyses were average values for the specified climatic

conditions. Frequencies of occurrence of favorable and unfavorable climatic conditions were assigned based on historical occurrence of these conditions, as revealed by a climatological index developed by W. C. Palmer (1965).

Product price/production factor cost relationships

Livestock, hay and barley prices were indexed through the use of historical records to simulate favorable and unfavorable price levels relative to 1977 production costs for two composite Utah ranches (Utah ranch inventories and budgets for 1977 represent the most current data base available).

Favorable economic conditions were arbitarily defined as the average of normal to abnoramlly high product price levels relative to variable production costs. Unfavorable economic conditions were arbitrarily defined as the average of abnormally low product price levels relative to variable production costs. Frequencies of occurrence of favorable and unfavorable ranch price levels were assigned based on the ratios of historical ranch product price indices to historical ranch production cost indices.

Ranch business environment

The ranch business environment was characterized in terms of four unique categories or states of nature. These four states of nature were derived from all combinations of the identified production and economic conditions and are presented below:

1. Favorable production/favorable price levels.

2. Favorable production/unfavorable price levels.

3. Unfavorable production/favorable price levels.

4. Unfavorable production/unfavorable price levels.

Probability levels estimated for each of the four states of nature were derived as the product of the frequency of occurrence of the production condition and the frequency of occurrence of the economic condition. Since long-run strategies were of interest, occurrence of the production and economic conditions were treated as though random although it is recognized that occurrence follows cyclic patterns.

Analysis

Ranch budgets and resource inventories based on 1977 data were used to apply linear programming analysis to each of the two composite Utah ranches. Net return above variable costs for strategies employed on the two ranches in 1977 were estimated based on average production and 1977 price levels. Optimum strategies and net returns above variable costs were estimated for average production and 1977 price levels and for the various production and product price conditions associated with the four states of nature defined as the ranch business environment. All management strategies for each ranch were then subjected to analysis under the four states of nature to estimate long-term expected values for the various management strategies. Income variabilities were then estimated for risk comparison among strategies. In addition expected net returns above variable costs of the various strategies were used to estimate expected returns on owned ranch capital.

LITERATURE REVIEW

Ranch Economic Analysis and Planning

The ranch budget and resource inventory are the basis for the evaluation of current and alternative ranch resource allocation strategies. In this evaluation, the budget becomes the basic working tool to be used in planning future operations (Gray 1968). Fellows (1960) defined a budget as an estimation of possible changes in costs and returns over a given period of time when there is a contemplated change in use of resources. He reviewed and summarized the role of budgeting in determining the condition leading to an equilibrium position of a firm with limited capital, including the element of risk (the position of profit maximization with limited resources and limited knowledge of future events). Heady and Jensen (1954) referred to that equilibrium position as the position wherein limited resources are continually allocated to a use as long as the added return is greater than the added cost (marginality principle) and as long as there is no other use of the limited resource by the firm that adds a greater return (opportunity cost principle). These authors presented the opportunity cost principle as follows in terms quite relevant to this study: "If you add more to costs than to returns by processing feed through livestock, sell it; don't feed it" (Heady and Jensen 1954: 107). Examples of the use of budgets and resource inventories in economic analysis and planning for ranch

businesses are numerous, a few of which are reported by Hewlett and Workman (1978), Brownson et al. (1975), Gee and Pursley (1972), and Kearl (1978).

Ranch budgets and inventories are often reported as composites of a population of ranches to allow some general relationships applicable to much of the population to be identified. While specific records and data for an individual ranch will supply more applicable information to that ranch, interpretation of results of the analysis of composite ranch budgets often provides information about appropriate or promising alternatives that should be considered at the individual ranch level. Workman (1970), Capps (1980), Christensen et al. (1973), and U. S. Department of Agriculture (1977) represent sources of composite budget and resource inventory data for Utah ranches. Similar information is available for ranches in other states within the Intermountain Area (Godfrey 1976, Peryam and Olson 1975, Mitchell and Garrett 1977, Bartlett et al. 1979, Cornelius 1978).

Budgeting

As alluded to in the previous section, a budget is really only another term for a plan of operation and budgeting is another term for planning. According to Heady and Jensen (1954), complete budgeting refers to making a plan for the entire ranch or for all decisions of one enterprise. Partial budgeting refers to estimating the outcomes or returns for a small part of the business, such as alfalfa fertilization or retention of calves. Two important assump-

tions underlying budgeting are that relationships are linear or that relationships occur in discontinuous segments, both are assumptions with similar implications (Heady 1952). Also, in complete or partial budgeting, all factors of production but one are valued and assumed to be allocated at the levels where their marginal value products (MVPs) are equal to their marginal factor costs (MFCs), the condition necessary for realization of maximum profits (Nielsen 1965, Heady 1952). This implication could result in suboptimization of the plan due to inadequate consideration of the opportunity cost principle.

Linear programming

Linear programming originated largely during World War II as a method of determining shipping routes that would minimize travel distance for limited shipping facilities available to the Allies, and as a method of solving other problems of allocation of scarce resources (Heady and Candler 1958). Applications in agricultural production were initially reported in the early 1950's. Ranch planning applications began toward the end of that decade (Barr and Plaxico 1961, Brown 1961).

A linear programming problem has three quantitative components: an objective, alternative methods for attaining the objective, and resource or other constraints (Heady and Candler 1958). The problem can be presented symbolically as demonstrated by Agrawal and Heady (1972) in the following form:

Objective with alternatives:

$$\text{Maximize } Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$$

Subject to resource or other constraints:

$$a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n \leq b_1$$

$$a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n \leq b_2$$

$$\vdots \qquad \vdots \qquad \qquad \vdots$$

$$a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n \leq b_m \qquad \text{where:}$$

$$x_1 \geq 0,\ x_2 \geq 0,\ \ldots,\ x_n \geq 0.$$

Lewis and Taylor (1977) in a linear programming analysis of ranches in Wyoming pointed out certain assumptions that are implied in linear programming that must be considered:

1. Additivity of resources and constraints: the total amount of a given resource used must equal the sum of the amounts of that resource used by the individual activities.

2. Linearity of the objective function: doubling the amount of sales will double the amount of income unless specifically formulated otherwise.

3. Non-negativity of the decision variables: all activities and decision variables must be greater than or equal to zero.

4. Divisibility of activities and resources: use of resources and activities can occur in frantional quantities.

5. Finiteness of resource and activity restrictions: an optimal solution cannot be calculated if there are infinite numbers of activities and resources.

6. Parameters are fixed in time: coefficients are known with certainty.

Of these six assumptions, most do not pose any significant limitations to the analysis. However, the assumption of linearity of the objective function can lead to erroneous computed results if substantial non-linear relationships exist over the range of the analysis. For example, variable costs per cow are assumed to be constant yet variable costs per cow calculated on the basis of a 100 cow-herd may be less than per cow costs of a 50-cow herd or more than per cow costs of a 150-cow herd. This may occur due to non-divisibility of resource units. In considering a unit of labor, the requirement per cow may decrease as cow numbers are increased (marginal labor costs decrease) until an additional unit of labor must be employed. Conversely, the labor requirement per cow may increase as herd size decreases to a point where a unit of labor can be released. Although these assumptions are not thought to impose severe limitations over the range of values used in this study, such limitations must receive ample consideration in the interpretation of results. Another of the assumptions that limits linear programming and analysis and other forms of analysis is the assumption that coefficients are known with certainty. In reality, coefficients used are estimates that represent the best information available. This limitation can also be overcome with full consideration in the interpretation phase of the analysis.

Linear programming is an analytical process of solving numerous simultaneous linear functions. When linear programming is applied to ranch planning the budgeting process is performed through equating constant marginal factor costs (MFCs) and marginal value products

(MVPs) until resources becoming limiting for all factors identified by the analyst as relevant to the overall ranch management system. Use of linear programming in ranch planning and economic analysis increased through the 1970's and includes applications by Bartlett et al. (1974), Child and Evans (1976), Ching et al. (1977), and Torell et al. (1979).

Other programming approaches

Whitson (1975) and Scott and Baker (1972) applied quadratic programming as a means of evaluating risk and incertainty in ranch and farm planning. While quadratic programming allows tradeoff between net income and stability of income to be quantified, Whitson identified certain limitations of quadratic programming models including computational difficulties associated with the use of available computer programs.

Goal programming was applied by Bottoms and Bartlett (1975) for planning of range use in a multiple-use context. These authors stated that a weakness of linear programming is the use of a single criterion (profit maximization, or conversely, cost minimization) for determining the optimal strategy. Goal programming on the other hand does not require that multiple goals be defined in strictly economic terms (dollars). For this reason, goal programming may have limited application in planning for use of privately-owned resources, since profit maximation is generally the objective of private enterprise. It is conceivable, however, that certain private

interests may receive more utility from a non-market use of resources such as wildlife use than from additional profit.

Decision theory

Application of decision theory adds yet another dimension to ranch economic analysis and planning. This area of analysis aids decision-making under risk and uncertainty. Anderson et al. (1976) define decision-making under risk as decision-making when more than one state of nature exists and probability estimates are available for each state of nature. These authors define decision-making under uncertainty as decision-making when more than one state of nature exists but nothing is known about the probabilities of the states of nature. Chernoff and Moses (1959) give a useful overview of decision theory with examples of its application.

Some applications of decision theory to farm and ranch management decision-making have been reported by Dean et al. (1966), Halter et al. (1969), and Halter and Dean (1971). Decision theory analysis required identification of a number of management strategies and a series of states of nature that is all inclusive. Probability levels associated with the various states of nature are estimated as are the values of the various management strategies operating under each state of nature. An expected value is calculated for each management strategy by summation of the products of the probability level of the states of nature and the respective values of the management strategy operating within the states of nature. A tabular example of the procedure is presented symbolically in Table 1. This procedure weights value of various management strategies by probability

Table 1. Decision theory analysis.

Strategies	S_1 (P_1)[1/]	S_2 (P_2)	...	S_n (P_n)
X_1	$(X_1S_1)(P_1) + (X_1S_2)(P_2) + \ldots + (X_1S_n)(P_n) = EVX_1$[2/]			
X_2	$(X_2S_1)(P_1) + (X_2S_2)(P_2) + \ldots + (X_2S_n)(P_n) = EVX_2$			
.	.	.		.
.	.	.		.
.	.	.		.
X_m	$(X_mS_1)(P_1) + (X_mS_2)(P_2) + \ldots + (X_mS_n)(P_n) = EVX_m$			

Where: $\sum_{j=1}^{n} P_j = 1$.

[1/] Probability level of state of Nature S_1.

[2/] EVX_1 = Expected Value of Strategy X_1.

of occurrence of various states of nature. An example of this procedure is presented by Halter and Dean (1971).

In decision theory analysis of this kind, the criteria for acceptance or rejection of alternative strategies must be established by the individual decision-maker. The decision-maker maximizes expected utility based on the individual's unique utility curve. As Whitson (1975) showed, stability of income may be more important or provide greater utility to an individual rancher than high net income. Halter et al. (1969) have provided an excellent explanation of this approach and have offered guidance in specification of individual utility curves.

Environment/Plant Production Relationships

Primary production

Environmental parameters used to estimate plant productivity have included various values of temperature, precipitation, radiation, evaporation, and soil moisture individually or in combination. All have proved useful in estimating production.

Many researchers have used measurements of evaporation or evapotranspiration (ET) to "estimate" production. Albrecht (1971) related productivity to a variety of environmental parameters including temperature, precipitation, and radiation and concluded that potential evapotranspiration (ETP) was the most accurate predictor. In a study of bluebunch wheatgrass in Idaho, Isaac (1974) concluded that indices including some form of ET were the most useful

in examining variations in production of forage. Rosenzweig (1968) used ET as a measure of the available water and energy for production estimation. In the area of agronomic crop yields, Hanks (1974) found ETP to be closely correlated with yields. Although techniques using ET and ETP have produced relatively accurate production estimates, Major (1963) stated that special consideration must be given to microclimatic differences.

Precipitation has frequently been used as a predictor of production. Blaisdell (1956) studied factors affecting production of native range plants in Idaho and concluded that early spring growth was primarily regulated by temperature; however, subsequent growth was controlled more by available moisture. Precipitation prior to the growing season was determined to be the most important factor affecting herbage production due to the effect it had upon available moisture for plant growth. Mueggler (1972) found a strong relationship between production and growing season precipitation and temperatures in southwestern Montana. Sneva and Hyder (1962) found that in a single growing season herbage production depended largely on the amount of precipitation received immediately prior to and during the growing season. However, in forecasting forage production on semi-arid ranges in the Intermountain area, these authors included September through June precipitation in their prediction equation. Rauzi (1964) and Currie and Peterson (1966) found precedent conditions (fall precipitation) to have significant influence upon plant response in the succeeding spring in some years. These findings

support use of precedent conditions in the prediction equation developed by Sneva and Hyder (1962).

Other researchers have also developed predictive tools for forecasting plant productivity. Palmer (1965) developed the Palmer Drought Index, an index based on ETP, to be used as an index of environmental conditions conducive to plant growth. This index is commonly used to forecast range forage and dryland crop production and water availability for irrigation and other uses.

Secondary effects of variation in plant productivity

Just as plant productivity is affected by environmental factors, animal productivity is affected by periods of low forage production. Neumann and Snapp (1969) reported that weaning weight of calves and subsequent year calf crop were reduced due to drought in New Mexico. In Texas, drought reduced cow weights by 75 to 100 pounds, calf weights by 75 to 125 pounds, and subsequent year calf crop by over 20 percent due to reduced forage production (Maddox 1972).

Product Price/Production Cost Relationships

In ranch planning and economic analysis, the analyst must utilize appropriate price levels for products and production factors to insure meaningful analysis. Some analysts have used actual prices for the year under study (U. S. Department of Agriculture 1977), some have used average prices for a number of preceding years (Hewlett and Workman 1978), some have used procedures that provide weighted averages or normalized prices (Capps 1980), and some used techniques

to predict prices in the near future (Kearl 1978). The pricing method is based primarily on the objectives of the study.

Use of indices and ratios in pricing

Various product price/production cost relationships are routinely reported as a service of the United States Department of Agriculture (U.S.D.A.). Included are various reports published by the U.S.D.A. Agricultural Marketing Service and the U.S.D.A. Economics, Statistics, and Cooperatives Services. Of special interest in this study are periodic reports entitled, "Livestock, Meat, Wool Market New Weekly Summary and Statistics" (U. S. Department of Agriculture 1957-1980), "Agricultural Prices" (U. S. Department of Agriculture 1955-1980), "Crop Production" (U. S. Department of Agriculture 1931-1980), and "Meat Animals--Production, Disposition, and Income" (U. S. Department of Agriculture 1962-1979). These reports offer the opportunity for analysis of historical product price/production cost relationships through analysis of price averages, price indices and price index ratios.

Price indexing

Of particular interest in this study are indices of prices paid and prices received by farmers. These indices are often termed parity prices. Tomek and Robinson (1981) offer an informative discussion of parity prices or price indices. Parity prices are prices which give farm products the same purchasing power with respect to articles farmers buy as they had in a defined base period and they

serve as the basis for determining government support prices. Carefully constructed price indices provide a reasonably accurate measure of changes in relative prices over a period of time. They do not serve as a good indicator of well-being or of relative income changes because price indices do not reflect changes in output per unit of input (efficiency). Gains in efficiency can offset all or part of a decline in product price.

Index ratios

The parity ratio is the Index of Prices Received by Farmers divided by the Index of Prices Paid by Farmers for items used in production. Using a 1910-1914 base, a ratio of 1.0 means that product prices have risen exactly the same percentage as the index of prices of production factors since 1910-1914 (Tomek and Robinson 1981). This comparison to the base period does not take changes in efficiency or changes in demand into account. In this study parity ratios were compared only among the past 26 years (1955-1980) in an effort to reduce the influence of gains in production efficiency and changes in demand yet still allow a historical analysis of relationships.

METHODS AND PROCEDURES

Preview of the Analysis

Ranch budgets, inventories and organizational strategies reported by Capps (1980) represented the most current data base and were used as the basis for analysis of two composite Utah cattle ranches. These ranches were referred to as the large Utah cattle ranch with a cow herd numbering 287 brood cows and the small Utah cattle ranch with a cow herd of 140 brood cows. Ranches were identified through frequency distribution analysis of survey data collected as part of Utah Agricultural Experiment Station Project 772. Survey information was used by Capps to develop 1977 composite ranch profiles.

Both ranches included livestock and crop (hay and barley) enterprises. In this analysis these enterprises were considered separate entities each producing a product. Ranch variable costs were apportioned by enterprise and use of crops by livestock was allowed at the market value in the optimization process. This basis for analysis followed guidelines suggested by Heady and Jensen (1954) to assure that opportunity costs of selling crops were considered.

Large ranch profile

A modified income statement for the large Utah cattle ranch is presented in Table 2. This ranch ran 287 cows and a herd complement of 12 bulls and 37 yearling replacement heifers. Death loss from the

Table 2. Modified income statement for a 287 cow Utah cattle ranch, 1977.

ANNUAL CASH RETURNS			$ 38,944
Cull cows 23 @ $26.20/cwt		5,906	
Cull bulls 3 @ $34.16/cwt		1,549	
Calves 107 @ $40.35/cwt		17,817	
Yearlings 58 @ $39.05/cwt		13,572	
ANNUAL CASH COSTS			43,873
Hired Labor		5,719	
Repairs		4,744	
buildings and improvements	1,662		
machinery and equipment	3,082		
Veterinary and supplies		605	
Machine operation		4,030	
Machine hire		1,186	
Bull purchases 3 @ 750/head		2,250	
Property tax		2,315	
livestock	424		
other	1,891		
Insurance		800	
Utilities		800	
Irrigation water		3,150	
Feed and supplements		6,376	
Seed and fertilizer		2,967	
Miscellaneous		1,306	
Private lease fees		2,574	
Forest Service grazing fees		1,377	
BLM grazing fees		1,866	
Interest on cash costs @ 8.6%, 6 months		1,809	
DEPRECIATION			9,826
Machinery		5,655	
Improvements		3,405	
Buildings		766	
NET RANCH INCOME			-14,755
DEBT SERVICE COSTS			14,265
Working capital (operating and short-term		3,206	
Real estate debt)		11,059	
NET RETURN AVAILABLE FOR FAMILY LIVING EXPENSES			-29,020
LAND APPRECIATION, COMPOUND INTEREST, 1970-79			38,531
Rangeland 9.4%		25,050	
Irrigated cropland 7.8%		13,481	

Table 2 (continued).

PAYMENT TOWARD MORTGAGE PRINCIPAL	$ 6,152
GROSS PROCEEDS TO RANCH INVESTMENT	15,663
VALUE OF OPERATOR MANAGEMENT AND LABOR	10,000
NET PROCEEDS TO OWNED RANCH CAPITAL	5,663
PERCENT RETURN ON $620,764 OWNED RANCH CAPITAL	.91%

1/ Based on a 70 percent, $170,000 loan established in 1958 with the Federal Land Bank (30-year loan at five percent interest).

cow herd was five percent annually. Sale animals included cull cows and bulls, 107 calves weaned and sold at 415 pounds in October and 58 yearlings sold in August at 600 pounds. The livestock investment was valued by Capps (1980) at $106,413. Alfalfa hay was raised on 97 acres and produced three tons per acre annually. Barley was raised on 38 acres and produced 69 bushels per acre. Other privately owned land included 168 acres of meadow which were grazed at the rate of .44 acres per Animal Unit Month (AUM) of forage, 790 acres of foothill rangeland in fair condition requiring 10 acres per AUM and 634 acres of improved rangeland (crested wheatgrass) requiring 1.67 acres per AUM. Additionally, leases and permits included contributions of 373 AUMs from leased private land, 728 AUMs from national forest land, and 1235 AUMs from land administered by the Bureau of Land Management. Total investment in deeded land and grazing permits was valued at $545,175.

Small ranch profile

A modified income statement for the small Utah cattle ranch is presented in Table 3. This ranch ran 140 cows and a herd complement of five bulls and 18 yearling replacement heifers. Cow herd death loss was four percent. Sale animals included cull cows and bulls and 81 calves sold in October at 435 pounds. The livestock investment was valued by Capps (1980) at $45,658. Alfalfa hay was raised on 54 acres and produced three and one-half tons per acre annually. Barley was raised on 15 acres and yielded 77 bushels per acre. Other privately owned land included 48 acres of meadow grazed at the rate of .44 acres per AUM and 1400 acres of foothill rangeland in fair condition requiring 10 acres per AUM of forage. Additionally, leases and permits included contributions of 195 AUMs from leased private land, 340 AUMs from national forest lands, and 455 AUMs from land administered by the Bureau of Land Management. Total investment in deeded land and grazing permits was valued at $340,237.

Linear programming analysis

Linear programming optimization was applied through the use of COPLAN, a computer program developed specifically for use in ranch resource planning at Colorado State University and described by Child and Evans (1976).

The two Utah cattle ranches were modeled and returns to variable costs estimated for the way the ranches were organized and managed in 1977. Only those activities and alternatives practiced in 1977 were considered in the analyses. Although livestock and crops were

Table 3. Modified income statement for a 140 cow Utah cattle ranch, 1977.

ANNUAL CASH RETURNS			$17,847
Cull cows 12 @ $26.20 cwt		3,081	
Cull bulls 1 @ $34.66/cwt		549	
Calves 81 @ $40.35/cwt		14,217	
ANNUAL CASH COSTS			19,055
Hired labor		1,138	
Repairs		3,064	
buildings and improvements	916		
machinery and equipment	2,148		
Veterinary and supplies		203	
Machine operation		2,413	
Machine hire		679	
Bull purchases 1 @ $750/head		750	
Property tax		1,348	
livestock	207		
other	1,141		
Insurance		266	
Utilities		566	
Irrigation water		821	
Feed and supplements		1,410	
Seed and fertilizer		1,924	
Miscellaneous		998	
Private lease fees		1,359	
Forest Service grazing fees		643	
BLM grazing fees		687	
Interest on cash costs @ 8.6%, 6 months		786	
DEPRECIATION			4,191
Machinery		2,924	
Improvements		752	
Buildings		515	
NET RANCH INCOME			-5,399
DEBT SERVICE COSTS			10,617
Working capital (operating and short-term		2,160	
Real estate[1]/ debt)		8,457	
NET RETURN AVAILABLE FOR FAMILY LIVING EXPENSE			-16,016
LAND APPRECIATION, COMPOUND INTEREST, 1970-79			25,466
Rangeland, 9.4%		18,581	
Irrigated cropland, 7.8%		6,885	

Table 3 (continued).

PAYMENT TOWARD MORTGAGE PRINCIPAL	$ 4,945
GROSS PROCEEDS TO RANCH INVESTMENT	14,395
VALUE OF OPERATOR MANAGEMENT AND LABOR	10,000
NET PROCEEDS TO OWNED RANCH CAPITAL	4,395
PERCENT RETURN ON $338,120 OWNED RANCH CAPITAL	1.3%

1/ Based on a 70 percent, $130,000 loan established in 1957 with the Federal Land Bank (30-year loan at five percent interest).

both produced, ranch organization indicated that ranchers viewed crop production as a part of the livestock enterprise rather than as a separate enterprise. Livestock count and forage balance charts presented by Capps (1980) showed that the management strategies practiced required feeding of crops produced to ranch livestock.

In subsequent analyses, crops, livestock, and forage production were considered as independent enterprises in order to incorporate opportunity costs into the analysis. All products raised on the ranch were offered for sale at market value. Use of hay by ranch livestock required "purchase" of ranch hay at market prices.

Various management alternatives were considered for the identified enterprises. Alternatives considered for the privately owned rangelands included different levels of application of range improvement practices with alternatives for use of forage produced by ranch livestock or sale of AUMs of forage through leasing. In addition to the alternative of applying no range improvement practices, three land

treatment practices were considered on foothill range dominated by sagebrush: spraying with herbicide (2,4-D), burning and seeding, and plowing and seeding.

Barley production was considered to be a part of a ten year crop-rotation system necessary for alfalfa production. Two levels of alfalfa management were included as alternatives for consideration with level of fertilization and water management the primary differences.

Meadow alternatives included grazing of forage by ranch livestock under three levels of meadow management (fertilization and water management), sale of AUMs of forage under three levels of meadow management, hay production for use by ranch livestock, and hay production for sale.

Livestock management alternatives considered included management according to the 1977 herd structure, management at a higher intensity by decreasing the cow to bull ratio from current levels, improving the herd health program, improving record keeping, and adopting strict culling practices. A third alternative for cow herd management included early weaning of calves with intensive management. Alternatives for sale of calves or retention of calves for sale as yearlings were considered. Purchase of yearling stocker steers was also an alternative considered in the analysis; however, maximum number of purchased steers considered as set at the number of steer calves raised in 1977. This constraint was incorporated to limit the alternatives to what were deemed realistically accept-

able choices for Utah ranches that have historically been operated as cow/calf production systems.

Decision theory analysis

In order to analyze Utah cattle ranches operating under the existing business environment, four environmental scenarios were developed which portrayed possible production and economic conditions. These four scenarios or states of nature were defined as:

1. favorable production/favorable price levels,
2. favorable production/unfavorable price levels,
3. unfavorable production/favorable price levels,
4. unfavorable production/unfavorable price levels.

Favorable conditions from the production or economic viewpoint were defined as those conditions that could be considered normal or better. Since cattle ranching in Utah has evolved over approximately 130 years it was assumed that management strategies have evolved in concert with the environment and the assumption was made that ranches have been organized to operate under the usual environment. Unfavorable conditions were defined as those conditions that could be considered disruptive enough to be abnormally[1/] adverse. From the production standpoint unfavorable conditions were considered to be mild to extreme drought conditions. From the economic standpoint unfavorable conditions were considered to be those conditions where price levels relative to production costs were definitely below the average.

[1/] Quantitative assessment of qualitative terms is presented under topical discussion.

Six different management strategies based on different expectations of the Utah ranch business environment were analyzed for each of the two Utah cattle ranches. These strategies were identified as:

1. the management strategy practiced in 1977 based on average production and 1977 price levels,

2. an optimum 1977 strategy based on average production and 1977 price levels,

3. an optimum strategy based on favorable production and favorable price levels,

4. an optimum strategy based on favorable production and unfavorable price levels,

5. an optimum strategy based on unfavorable production and favorable price levels,

6. an optimum strategy based on unfavorable production and unfavorable price levels.

These six strategies were then compared for each ranch by developing expected values for each strategy. Each strategy was constrained to operate under the four states of nature identified as making up the Utah ranch business environment. Expected incomes for each strategy operating under each of the four states of nature were weighted by estimates of probability of occurrence of each state of nature. This procedure resulted in weighted expected values of the various strategies for each ranch. Table 4 provides a symbolic example of decision theory analysis applied in this study.

Probability-weighted variance and standard deviation of the expected income contributions to the expected values of the various

Table 4. Decision theory analysis - an example.

Strategies	States of Nature									
	S_1		S_2		S_3		S_4			
	(P_1)[1/]	+	(P_2)	+	(P_3)	+	(P_4)	=	1	
X_1	$(11)(P_1)$	+	$(12)(P_2)$	+	$(13)(P_3)$	+	$(14)(P_4)$	=	EVX_1[2/]	
X_2	$(21)(P_1)$	+	$(22)(P_2)$	+	$(23)(P_3)$	+	$(24)(P_4)$	=	EVX_2	
X_3	$(31)(P_1)$	+	$(32)(P_2)$	+	$(33)(P_3)$	+	$(34)(P_4)$	=	EVX_3	
X_4	$(41)(P_1)$	+	$(42)(P_2)$	+	$(43)(P_3)$	+	$(44)(P_4)$	=	EVX_4	
X_5	$(51)(P_1)$	+	$(52)(P_2)$	+	$(53)(P_3)$	+	$(54)(P_4)$	=	EVX_5	
X_6	$(61)(P_1)$	+	$(62)(P_2)$	+	$(63)(P_3)$	+	$(64)(P_4)$	+	EVX_6	

States of Nature:
- S_1 = Favorable production/favorable price levels.
- S_2 = Favorable production/unfavorable price levels.
- S_3 = Unfavorable production/favorable price levels.
- S_4 = Unfavorable production/unfavorable price levels.

Strategies (LP):
- X_1 = 1977 "as is" strategy.
- X_2 = 1977 optimum strategy.
- X_3 = Optimum strategy for S_1 ranch business environment.
- X_4 = Optimum strategy for S_2 ranch business environment.
- X_5 = Optimum strategy for X_3 ranch business environment.
- X_6 = Optimum strategy for S_4 ranch business environment.

1/ P = Probability.

2/ EV = Expected Value.

strategies were then calculated as a measure of income variability. In addition, the standard deviation of each strategy was reported as a percentage of the strategy expected value. This allowed comparison of strategy income variability on an equitable basis.

Estimation of returns on owned ranch capital

Expected values of each strategy were entered as net returns above variable costs replacing annual cash returns and annual cash costs in modified income statements for each Utah cattle ranch (Tables 2 and 3). Depreciation and taxes on real estate, equipment, and improvements were deducted from returns to variable costs for calculation of net ranch income. Debt service costs adjusted by strategy working capital requirement were deducted for calculation of net return available for family living expense. Land appreciation and payment toward mortgage principal were added to calculate gross proceeds to ranch investment. Value of operator management and labor was deducted to calculate net proceeds to owned ranch capital and percent return on owned ranch capital was calculated based on levels of owned ranch capital determined by each strategy. This was done to evaluate effects of management strategies on the overall profitability of ranch ownership and operation.

Estimation of State of Nature Probability

As previously stated, probability estimates are necessary for calculation of weighted expected values of management strategies operating under each of the various states of nature. In this

study, four states of nature have been identified through combinations of two conditions of two parameters assumed to be independent of each other. This assumption was made based on the implicit assumption that Utah cattle ranches are firms operating in purely competitive markets. The implication of this assumption is that action or production of individual firms has no effect on market prices. In terms specific to this study, favorable or unfavorable local production conditions have no effect on market prices for agricultural products since the industry is large and products can be readily transported from one locale to another.

Production conditions probabilities

Production probabilities were estimated from historical records of meteorological drought in Utah expressed by the Palmer Drought Index (Utah State Department of Climatology 1981, Palmer 1965). The Palmer Drought Index is a function of temperature, precipitation, and soil moisture. It represents an objective numerical approach to estimates of potential evapotranspiration and permits an objective evaluation of climatic events. Developed in the Midwest for agricultural needs, this index is presently calculated for many climatic regions within the United States including seven regions in Utah and is routinely reported in popular periodicals such as "Western Livestock Roundup". The Environmental Data Service of the National Oceanic and Atmospheric Administration publishes weekly maps of the index for the United States. Although Palmer has expressed reservations about using the index in areas other than the middle to

eastern part of the country, analysis of the Utah area (with the exception of the Dixie Climatic Division) shows that the index performs well (Jensen 1978).

The index is generally calculated on a regional basis, and it can be refined and fitted to local areas. In this study, climatic probabilities were derived from monthly indices recorded for the seven climatic regions of the state. Palmer (1965) assigned descriptive names to various portions of the index range as follows:

Index value	Description
$\geq$ 4.00	extremely wet.
3.00 to 3.99	very wet.
2.00 to 2.99	moderately wet.
1.00 to 1.99	slightly wet.
.50 to .99	incipient wet spell.
.49 to -.49	near normal.
-.50 to -.99	incipient drought.
-1.00 to-1.99	mild drought.
-2.00 to-2.99	moderate drought.
-3.00 to-3.99	severe drought.
$\leq$ -4.00	extreme drought.

Palmer pointed out that incipient drought describes a dry spell in which need for rain becomes apparent. Extreme drought corresponds to a very serious situation which results from many months, or even years, or abnormally dry weather. During extreme drought, agricultural crops are a complete failure, industries and municipalities

face the need for water rationing, and local and regional economies are disrupted.

In this study, drought indices were considered for the crop year defined by Sneva and Hyder (1962) as September through June. Fifty years (1931-1980) of September through June monthly recorded indices from seven climatic regions in Utah were used for estimating the probabilities of favorable and unfavorable conditions for production. Unfavorable climatic conditions were defined as those conditions reflected by Palmer Drought Index values of -1.00 or less. Conditions resulting in index values from -.50 to -.99 were also considered as unfavorable climatic conditions if they occurred within a series of index values of -1.00 or less. Over the seven regions, an average of 195 monthly index values of a total of 500 monthly index values fell within the index value range defined as unfavorable climatic conditions. Therefore, the estimated probability of unfavorable climatic condition was determined to be 195/500 or .39. Favorable climatic conditions were defined as those reflected by Palmer Drought Index values greater than -1.00 with the exception for values of -.50 to -.99 under specific circumstances previously discussed. Of the 500 monthly index values considered, 305 fell within the range of values defined as favorable climatic conditions and the estimated probability for favorable climatic conditions was 305/500 or .61 based on the regional average.

Economic condition probabilities

Production costs incurred by each Utah ranch were identified

in ranch budgets reported by Capps (1980) and estimated in categories reported in "Prices Paid and Received by Farmers" (U. S. Department of Agriculture 1955-1980). The proportion of total expenses falling into each category served as a weighting factor for tailoring indices of prices paid to the individual ranches. These categories and the weighting factors for the large and small Utah cattle ranches are presented in Table 5.

Table 5. Categories and proportions of associated production costs incurred by Utah cattle ranches, 1977.

	Wages	Bldg.	Auto.	Other Mach.	Farm & Mach. Supplies	Fuels & Energy	Feeds	Seed	Fert.	Int.
Large Ranch	.138	.040	.052	.052	.196	.117	.295	.018	.054	.038
Small Ranch	.065	.053	.082	.080	.174	.171	.235	.028	.082	.030

Products of each Utah cattle ranch were also placed into categories reported in "Prices Paid and Received by Farmers" (U. S. Department of Agriculture 1955-1980). The proportion of the ranch budget expended on production of these products was used as a weighting factor for tailoring indices of prices received to the two ranches. These categories and the weighting factors for the large and small Utah cattle ranches are presented in Table 6.

Parity indices (1910-1914 base period) for the various production cost categories over 26 years (U. S. Department of Agriculture

Table 6. Categories of ranch products and proportions of associated production costs incurred by Utah cattle ranches, 1977.

	Livestock	Feed Grains and Hay
Large Ranch	.63	.37
Small Ranch	.52	.48

1955-1980) were weighted by specific ranch budget expenditures to identify a single index of prices paid for each of the 26 years. Likewise, prices received indices for Utah ranch products were weighted by associated production costs for each of the years 1955 to 1980. Annual prices received to prices paid index ratios were then calculated for each year to provide a bsis for comparing economic conditions over time. Examples of index ratio determinations are presented for the large and small Utah cattle ranches in Table 7 and Table 8, respectively.

Favorable and unfavorable economic conditions (price levels) were determined through analysis of the index ratio populations. Favorable price levels were defined as those years when index ratios fell within the 99 percent confidence interval of the sample mean or higher. Unfavorable price levels were defined as those years when index ratios fell below the 99 percent confidence interval of the sample mean. Probability of occurrence of favorable price levels for the large ranch was estimated to be .69 by dividing the number of favorable index ratios (18) by the total number of ratios (26). Probability of occurrence of unfavorable price levels was estimated

Table 7. Prices received to prices paid index ratio determination for the large Utah cattle ranch (1910-1914 Base).

Year	Wages .138	Bldg. .040	Auto. .052	Other Mach. .052	Farm & Mach. Sup-plies .196	Fuels & Energy .117	Feeds .295	Seed .018	Fert. .054	Int. .038	Prices Paid Index (wtd.)	Live-stock .63	F.G.&H. .37	Prices Received Index (wtd.)	Index Ratio
1955	519[1/]	356	358	312	259	164	211	235	155	139	271	234	183	215	.79
1956	536	371	367	326	260	167	206	208	152	158	274	226	182	210	.76
1957	562	383	395	342	262	173	201	215	153	173	293	244	166	215	.73
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1977	1915	928	1151	1120	441	357	398	621	266	1651	753	481	316	420	.56
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1980	2426	1185	1417	1483	591	672	501	736	357	3115	983	878	417	707	.72

[1/] Source of indices: U. S. Department of Agriculture 1955-1980.

Table 8. Prices received to prices paid index ratio determination for the small Utah cattle ranch (1910-1914 Base).

	Wages	Bldg.	Auto.	Other Mach.	Farm & Mach. Sup-plies	Fuels & Energy	Feeds	Seed	Fert.	Int.	Prices Paid Index	Live-stock	F.G.&H.	Prices Received Index	Index Ratio
Year	.065	.053	.082	.080	.174	.171	.235	.028	.082	.030	(wtd.)	.52	.48	(wtd.)	
1955	519[1/]	356	358	312	259	164	211	235	155	139	253	234	183	210	.83
1956	536	371	367	326	260	167	206	208	152	158	256	226	182	205	.80
1957	562	383	395	342	262	173	201	215	153	173	263	244	166	206	.78
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1977	1915	928	1151	1120	441	357	398	621	266	1651	678	481	316	402	.59
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1980	2426	1185	1417	1483	591	672	501	736	357	3115	934	878	417	657	.70

[1/] Source of indices: U. S. Department of Agriculture 1955-1980.

to be .31 by dividing the number of unfavorable index ratios (8) by the total number of ratios (26). The same procedures were used to estimate the probability of favorable and unfavorable price levels for the small Utah ranch and the results were identical.

Probability estimates for the occurrence of four states of nature

States of nature probabilities were estimated by multiplying the calculated probability of the occurrence of the production conditions by the calculated probability of occurrence of the price levels. The results of this procedure yielded probability estimates as follows:

1. favorable production/favorable price levels (.61 x .69) = .42 probability,
2. favorable production/unfavorable price levels (.61 x .31) = .19 probability,
3. unfavorable production/favorable price levels (.39 x .69) = .27 probability,
4. unfavorable production/unfavorable price levels (.39 x .31) = .12 probability.

Determination of Coefficients in the Linear Programming Models

Large and small Utah cattle ranches were initially modeled as operated in 1977, then modeled with alternatives included for the purpose of identifying optimum strategies. These analyses were based on average production (Capps 1980) and 1977 price coefficients (U.S.

Department of Agriculture 1957-1980) modified by the addition of new alternatives. In addition, optimum strategies were developed based on the four states of nature identified for a total of six strategies per ranch. Production coefficients were estimated for favorable and unfavorable production conditions. Product prices were indexed to reflect favorable and unfavorable levels with production costs held constant at 1977 levels. Price of purchased hay was indexed along with ranch-raised hay sale prices. The index ratios used for pricing ranch products were:

1. Large ranch feed grains and hay prices

   1977 index ratio = .42,

   favorable index ratio = .56,

   unfavorable index ratio = .42.

2. Large ranch livestock prices

   1977 index ratio = .64,

   favorable index ratio = .84,

   unfavorable index ratio = .72.

3. Small ranch feed grains and hay prices

   1977 index ratio = .47,

   favorable index ratio = .61,

   unfavorable index ratio = .47.

4. Small ranch livestock prices

   1977 index ratio = .71,

   favorable index ratio = .92,

   unfavorable index ratio = .79.

Derivation of these ratios may be best explained through reference to Table 7 and use of ratios for the large ranch as an example. The 1977 index ratio of .42 for feed grains and hay prices was determined by dividing the 1977 index for feed grains and hay prices (316) by the prices paid index (753). Similarly, the favorable index ratio was determined as the average of favorable feed grain and hay index ratios. Determination of favorable and unfavorable feed grains and hay index ratios followed the same procedures used in derivation of probability estimates for favorable and unfavorable price levels; favorable $\geq$ sample mean (99 percent confidence interval included) and unfavorable < sample mean (99 percent confidence interval included).

Determination of favorable and unfavorable price levels relative to 1977 costs may best be explained with an example. The 1977 alfalfa hay price of $61.00 per ton was indexed to the favorable price level of $81.33 per ton by solving a proportionality involving the 1977 alfalfa price, the 1977 index ratio (.42), the favorable price index ratio (.56), and the unknown favorable price level (X). For this example, the proportional relationship was solved as follows:

$$\frac{x}{} = \frac{\$61.00}{.42},$$

$$x = \$81.33.$$

This procedure was followed for all relative price determinations.

Ranch model coefficients

Estimated production coefficients for range forage were based on data reported by Cook (1966), Nielsen and Hinckley (1975), Sneva and Hyder (1962), and U. S. Department of Interior (1978). Crop production coefficients were estimated from Utah Agricultural Statistics (Utah Department of Agriculture 1980). Livestock production and requirement coefficients were estimated from Utah Agricultural Statistics and data published by Maddox (1972), Neumann and Snapp (1969), Raleigh (1970) and National Academy of Sciences (1976). Forage requirements were based on 750 pounds of dry matter per month for a 1000-pound cow with calf.

Production cost coefficients were estimated from data reported by Capps (1980) and technical guides used by U. S. Department of Agriculture (1980). Land treatment costs were amortized over the expected lives of the various projects and added as annual management costs. Fees applicable to leasing of additional private land were arbitrarily raised by 10 percent to portray increased demand on resources already allocated. Variable production costs per cow used in the analyses included all variable costs of cattle production with the exception of forage costs which were dealt with in the linear programming model. Certain supplemental feed costs (feed costs included in 1977 budgets) were included to insure adequate nutrition of livestock. To simplify the linear programming model, receipts from sale of cull animals were not considered as revenue but were deducted from total livestock variable costs. By doing so, variable

costs per cow reflect herd maintenance costs (including raising of replacements) and breeding herd death loss adjusted for salvage value of cull animals. This method decreases total revenue and total costs in the model but does not affect net revenue. Purchased yearling steers were assessed variable costs in proportion to cows that would be displaced. Additional transportation, interest and veterinary expenses were assessed by subtracting the sums of these costs from steer value at time of sale.

Estimation of Expected Income Variability

Procedures used to evaluate expected income variability, a risk related factor, followed methods demonstrated by Halter et al. (1969) and are presented in Table 9. The squared deviations of the overall strategy expected value from the individual expected incomes of the strategy operating under the various states of nature were weighted by the probabilities associated with the various states of nature and summed to estimate overall management strategy income variance.

Strategy income variance and standard deviation provide an estimate of income variability associated with a particular strategy. In order to allow comparison of strategies from a different perspective, the ratios of the standard deviations of the strategies to the expected values of the strategies were calculated. This procedure allowed comparison of strategy income variability (income standard deviation) relative to strategy expected value.

Table 9. Management strategy income variance.

States of Nature	Expected Income	Squared Deviation	Probability	Weighted Variance
1	X_1	$(X_1-EVX)^2$	P_1	$(P_1)(X_1-EVX)^2$
2	X_2	$(X_2-EVX)^2$	P_2	$(P_2)(X_2-EVX)^2$
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
n	X_n	$(X_n-EVX)^2$	P_n	$(P_n)(X_n-EVX)^2$

$$\text{Strategy Income Variance} = \sum_{j=1}^{n} (P_n)(X_n-EVX)^2$$

$$\text{Strategy Income Standard Deviation} = \sqrt{\sum_{j=1}^{n} (P_n)(X_n-EVX)^2}$$

$$\frac{\text{Strategy Income Standard Deviation (\$)}}{\text{Strategy Expected Value (\$)}} = \%$$

Where:

X_n = Expected income from strategy X operating under state of nature n.
EVX = Expected value of management strategy X obtained through decision theory analysis.
P = Probability of states of nature.

Estimation of Return on Owned Ranch Capital

Expected values for the management strategies evaluated for large and small Utah cattle ranches were entered in modified income statements (Tables 2 and 3) in place of annual cash returns and annual cash costs. Depreciation and taxes on property other than livestock were then subtracted to determine the appropriate net income. Income statements were then completed from the basis of the management strategy net income to estimate the corresponding percent return on owned ranch capital. This procedure allowed evaluation of management strategies currently employed and developed in terms of the contribution made to improving overall profitability of ranch ownership and operation.

RESULTS AND DISCUSSION

Utah cattle ranchers are receiving rates of return on owned capital that are well below the rate of inflation. This erosion of ranch equity is making it increasingly difficult for ranchers to continue operation of the ranch while meeting family living expense. To change this situation and make ranch operation and ownership more profitable over the long-run, improved management strategies need to be identified. Since the ranch business operates in both favorable and unfavorable physical and economic environments, management strategies must include consideration of the risk of adverse situations as well as what may be considered the normal situation. In order to evaluate different ranching strategies, estimates of net returns above variable production costs resulting from application of these strategies over the range of the ranch business environment are needed. In addition to this information, estimates of income variability over this range are necessary to put strategy returns to variable costs into proper perspective. It is then desirable to estimate the percent return on owned ranch capital expected from strategy adoption which allows total strategy effectiveness to be reviewed. This study is an effort to identify and evaluate ranch management strategies that will increase the profitability of Utah cattle ranches considering the various expressions of the ranch business environment.

The Ranch Business Environment

Optimum strategies for large and small Utah cattle ranches operating under four distinct environments or states of nature were identified. In addition, optimum strategies were identified for the average ranch production environment with 1977 prices. These otpimum strategies were identified for favorable production/favorable price levels for the large Utah cattle ranch (LF/FO)[1/] and for the small Utah Cattle ranch (SF/FO), favorable production/unfavorable price levels for the large ranch (LF/UO) and the small ranch (SF/UO), unfavorable production/favorable price levels for the large ranch (LU/FO) and the small ranch (SU/FO), unfavorable production/unfavorable price levels for the large ranch (LU/UO) and the small ranch (SU/UO), and average production/1977 price levels for the large ranch (L770), and the small ranch (S770). Strategies under which Utah cattle ranches were operating in 1977 were identified as 1977 "As is" for the large ranch (L77AI) and the small ranch (S77AI). Production levels and prices that represent these various expressions of the ranch business environment were used in linear programming analysis to determine the optimum resource allocations and to estimate net returns above variable costs of these strategies operating under each state of nature.

[1/] The first letter in this code, L, denotes large ranch, F/F denotes favorable production/favorable price levels, and 0 denotes optimum strategy.

Linear Programming Analysis

Production levels, price levels, and management alternatives

Linear programming analyses were made utilizing three production levels (average, favorable, and unfavorable production) and three price levels (1977, favorable, and unfavorable prices) to identify optimum strategies by ranch for five specific situations and to estimate returns to variable costs from these strategies. Likewise, management strategies employed in 1977 were simulated under the same five scenarios. Production costs for crop and livestock enterprises were based on proportional expenditures for the large and small ranches in 1977. Production costs were held constant at 1977 levels throughout the analyses while product prices were varied to portray specific prices relative to production costs. Animal requirements were based on 750 pounds of forage per month per cow (assumed to weigh 1000 pounds) with proportional requirements for other classes of livestock (forage requirement for a 600-pound animal of .6 of 750 pounds of forage per month). Land resources used in the analyses were based on the large and small ranch profiles reported by Capps (1980). The management year was divided into six seasons based on marketing and management activities as follows:

1. March through April - Season 1,
2. May through June 15 - Season 2,
3. June 16 through August - Season 3,
4. September - Season 4,
5. October - Season 5,
6. November through February - Season 6.

Average production and 1977 price levels for the large Utah cattle ranch. Values used to portray alternatives and corresponding average production and 1977 price levels are presented in Table 10.

Management costs identified with grazing leases and permits included the 1977 fees and interest at 8.6 percent for six months. BLM grazing permits allowed use from October through April, Forest Service permits were available from mid-June through September, and private lease was available from May through September. The additional private lease alternative was arbitrarily limited to 25 percent of the amount of private lease utilized by the large ranch in 1977. It was assumed that no leasable private range was going unleased and that leasing of additional range could only occur at higher lease rates. Rates for leasing additional range were arbitrarily increased by 10 percent to depict an upward pressure on private lease rates.

Barley and alfalfa production costs were effectively considered as costs of alfalfa crop-rotation. Both costs were included as alfalfa production costs in the analyses. Acreage devoted to alfalfa was increased and acreage devoted to barley was decreased in analyses for identification of optimum strategies to conform to a strict ten-year rotation of alfalfa. Differences in cost for alternative levels of alfalfa production were due primarily to level of fertilization. Both barley and alfalfa production contributed one AUM/acre (750 pounds forage/acre) of aftermath that could be grazed

Meadow alternatives included grazing under various levels of management (primarily fertilization) and hay production. Forage

Table 10. Average production and 1977 price values for the large Utah cattle ranch.

Alternative	Production	Mgt. Cost	Product Price
BLM	1235 AUMs	$1.57/AUM	
Forest Service	728 AUMs	$1.97/AUM	
Private lease	373 AUMs	$7.20/AUM	
Additional private lease	93 AUMs	$7.92/AUM	
Barley	69 bu/ac.	$130/ac.	$4.05 cwt.
Alfalfa	3 T/ac.	$111.72/ac.	$61/T
Alfalfa	4 T/ac.	$113.14/ac.	$61/T
Meadow	1600#/ac.	$10.21/ac.	$6.90/AUM
Meadow, 100# Nitrogen	2000#/ac.	$21.71/ac.	$6.90/AUM
Meadow, 125# Nitrogen	3000#/ac.	$23.96/ac.	$6.90/AUM
Meadow hay	2 T/ac.	$51.45/ac.	$50.80/T
Native foothill range	75#/ac.		$6.90/AUM
Native foothill, burn & seed	375#/ac.	$1.85/ac.	$6.90/AUM
Native foothill, plow & seed	450#/ac.	$2.83/ac.	$6.90/AUM
Native foothill, spray	218#/ac.	$1.04/ac.	$6.90/AUM
Crested wheatgrass	450#/ac.		$6.90/AUM
Sale of forage		$.10/ac.	
Purchase of alfalfa and grass hay (delivered)		$65/T	
Cow herd, as is	70% calf crop	$46/cow	
steer, October	420#/head		$187/head
heifer, October	400#/head		$145/head
yrlg. steer, August	620#/head		$243/head
yrlg. heifer, August	$580#/head		$202/head
Cow herd, intensive management	84% calf crop	$52/cow	
steer, September	410#/head		$182/head
steer, October	420#/head		$187/head
steer, February	520#/head		$192/head
heifer, September	390#/head		$141/head
heifer, October	400#/head		$145/head
heifer, February	500#/head		$157/head
yrlg. steer, April	580#/head		$250/head
yrlg. steer, June	660#/head		$254/head
yrlg. steer, August	760#/head		$285/head
yrlg. steer, September	780#/head		$299/head
yrlg. heifer, April	550#/head		$197/head
yrlg. heifer, June	615#/head		$209/head
yrlg. heifer, August	660#/head		$229/head
yrlg. heifer, September	680#/head		$231/head
Purchase yearling steers		$46/head + interest	
yrlg. steer, April	580#/head		$250/head
yrlg. steer, June	660#/head		$254/head
yrlg. steer, August	760#/head		$285/head
yrlg. steer, September	780#/head		$299/head

production from the meadow was entered into the linear programming analysis serially to depict growth or increase in forage availability through the growing season. Meadow hay production also provided one AUM/acre of aftermath grazing. Sale of forage (AUMs) resulting from various meadow management alternatives as well as all other forage production alternatives was considered at the additional cost of $.10/acre to cover the added expense of marketing forage.

Native foothill rangeland alternatives included management "as is" as well as applications of three range improvement practices: burning and seeding, plowing and seeding, and spraying with herbicide to control sagebrush. "As is" management cost for the foothill range was considered to be the opportunity cost of selling AUMs of forage. This cost was incorporated in the analysis by including sale of forage from the foothill rangeland as an alternative. Range improvement costs of $5.68/acre for burning, $1.29/acre for determent and $9.61/acre for seeding ($16.58/acre total) were amortized over 15 years at 8.6 percent interest to arrive at the annual management cost of $1.85/acre. Plowing, seeding and deferment costs totalled $31.20/acre and when amortized over 25 years at 8.6 percent interest resulted in $2.83/acre annual costs. Spraying and deferment costs totalled $7.57/acre and when amortized over 12 years at 8.6 percent yielded annual costs of $1.04/acre. Foothill rangeland was assumed to be unavailable for grazing from November to March, due to snow cover.

Management cost associated with the existing crested wheatgrass seeding was considered to be the opportunity cost of selling the forage produced.

Forage production from native foothill rangeland and crested wheatgrass seedings was entered into the analyses as forage became available through plant growth over the growing season.

Hay purchases were assumed to be divided equally between alfalfa hay and grass hay. The price of $65/T includes the costs of hay, interest and transportation.

Production of the cow-herd "as is" was based on a herd structure of 287 cows, 37 yearling replacements, 37 replacement heifer calves and 12 bulls or a 13 percent replacement rate for cows and 27:1 cow to bull ratio. The 70.4 percent calf crop was obtained over an extended calving period resulting in 28 percent of the calves being late and small at weaning. These late calves were kept and sold as yearlings. Annual death loss rate was five percent for the breeding herd and 6.9 percent for ranch-raised yearlings. Variable costs per cow excluding forage costs were $46/cow.

The alternative cow herd with intensive management was based on a herd structure where cow replacement rate was 15 percent, herd health program was intensified, and cow to bull ratio was 19:1. Culling practices under this level of management do not allow an extended calving period and calf crop percentage was assumed to be 84 percent. The alternative of retaining calves until they are yearlings was included. Annual death loss rate was five percent for

the breeding herd and 6.9 percent for ranch-raised yearlings. Variable costs per cow of $52 included all livestock costs with the exception of forage.

The alternative of purchasing yearling steers was based on the same production levels as raised yearlings from the intensively managed cow herd with the exception of a higher annual rate of death loss of 8.9 percent.

Purchased steer variable costs included $11/head for added transportation and veterinary expenses and $35/head for ranch livestock variable costs for a total of $46 per head deducted from the sale price. In addition, interest at 8.6 percent annually (.72 percent/month) was assessed from time of purchase until time of sale.

Favorable production and favorable price levels for the large Utah cattle ranch. Values used to portray alternatives and corresponding favorable production and price levels are presented in Table 11.

Grazing permits and leases were assumed to be based on long-term productivity and therefore were held constant. Under certain situations short-term non-renewable increases in grazing use are allowed by BLM and Forest Service. However, such actions were considered exceptions. Barley production was held at 69 bu/acre while production of alfalfa, meadow and rangeland forage were increased. Alfalfa and meadow production were increased three percent based on agricultural statistics (Utah Department of Agriculture 1980) and rangeland forage production was increased 18 percent on land that

Table 11. Favorable production and price levels for the large Utah cattle ranch.

Alternative	Production	Mgt. Cost	Product Price
BLM	1235 AUMs	$1.57/AUM	
Forest Service	728 AUMs	$1.97/AUM	
Private lease	373 AUMs	$7.20/AUM	
Additional private lease	93 AUMs	$7.92/AUM	
Barley	69 bu/ac.	$130/ac.	$5.40/cwt
Alfalfa	3.09 T/ac.	$111.72/ac.	$81.40/T
Alfalfa	4.12 Tac.	$113.14/ac.	$81.40/T
Meadow	1740#/ac.	$10.21/ac.	$9.23/AUM
Meadow, 100# Nitrogen	2060#/ac.	$21.71/ac.	$9.23/AUM
Meadow, 125# Nitrogen	3090#/ac.	$23.96/ac.	$9.23/AUM
Meadow hay	2.06 T/ac.	$51.45/ac.	$67.80/T
Native foothill range	88#/ac.		$9.23/AUM
Native foothill, burn & seed	435#/ac.	$1.85/ac.	$9.23/AUM
Native foothill, plow & seed	522#/ac.	$2.83/ac.	$9.23/AUM
Native foothill, spray	257#/ac.	$1.04/ac.	$9.23/ac.
Crested wheatgrass	522#/ac.		$9.23/AUM
Sale of forage		$.10/ac.	
Purchase of alfalfa and grass hay (delivered)		$86.60/T	
Cow herd, as is	72% calf crop	$46/cow	
steer, October	440#/head		$257/head
heifer, October	420#/head		$214/head
yrlg. steer, August	620#/head		$319/head
yrlg. heifer, August	580#/head		$264/head
Cow herd, intensive management	86% calf crop	$52/cow	
steer, September	430#/head		$251/head
steer, October	440#/head		$257/head
steer, February	540#/head		$262/head
heifer, September	410#/head		$209/head
heifer, October	420#/head		$214/head
heifer, February	520#/head		$223/head
yrlg. steer, April	620#/head		$350/head
yrlg. steer, June	690#/head		$348/head
yrlg. steer, August	790#/head		$389/head
yrlg. steer, September	810#/head		$407/head
yrlg. heifer, April	580#/head		$258/head
yrlg. heifer, June	640#/head		$289/head
yrlg. heifer, August	700#/head		$310/head
yrlg. heifer, September	720#/head		$325/head
Cow herd, intensive management early weaning	86% calf crop	$52/cow	
steer, September	430#/head		$251/head
steer, October	460#/head		$268/head
steer, February	560#/head		$271/head
heifer, September	410#/head		$209/head

Table 11 (continued).

Alternative	Production	Mgt. Cost	Product Price
heifer, October	440#/head		$224/head
heifer, February	540#/head		$232/head
yrlg. steer, April	640#/head		$362/head
yrlg. steer, June	710#/head		$358/head
yrlg. steer, August	810#/head		$399/head
yrlg. steer, September	830#/head		$417/head
yrlg. heifer, April	600#/head		$297/head
yrlg. heifer, June	650#/head		$293/head
yrlg. heifer, August	720#/head		$319/head
yrlg. heifer, September	740#/head		$334/head
Purchase yearling steers		$46/head + interest	
yrlg. steer, April	620#/head		$350/head
yrlg. steer, June	690#/head		$348/head
yrlg. steer, August	790#/head		$389/head
yrlg. steer, September	810#/head		$407/head

had not been seeded and 16 percent on seeded rangeland, based on studies by Sneva and Hyder (1962).

All management costs with the exception of purchased hay costs were held constant. Cost of purchased hay was indexed upward along with ranch-produced hay prices based on the favorable year index to make prices paid for hay consistent with prices received for ranch hay.

Livestock production was increased by increasing calf crop percentages by two percent (although it is recognized that there is a lag) and by increasing weight gains on calves and yearlings by approximately five and four percent, respectively. Annual rate of death loss was five percent for the breeding herd, 6.9 percent for ranch-raised yearlings, and 8.9 percent for purchased yearlings.

An alternative livestock management system was considered in the analyses for determination of LF/FO, LF/UO, LU/FO, and LU/UO strategies. This alternative involves the same herd structure as described in the discussion of average production and 1977 price values for the large ranch cow herd under intensive management except early weaning at the end of August was included to reduce cow forage requirements at the expense of an increase in calf forage requirements. It was assumed that at the end of the summer, weaned calves gain weight at a more rapid rate on quality forage such as alfalfa aftermath than unweaned calves on range. In addition, some benefits in terms of cow condition could be expected but were not depicted in the analysis.

Unfavorable production and unfavorable price levels for the large Utah cattle ranch. Table 12 shows the production and price values used in the analyses to represent unfavorable production levels and unfavorable price levels.

Based on review of records of AUMs used from public lands (U. S. Department of Interior 1978), available forage from grazing permits and leases was reduced by 10 percent for the BLM permit (from 1235 to 1112 AUMs), seven percent for the Forest Service permit (from 728 to 677 AUMs), and seven percent for the private lease (from 373 to 347 AUMs) to depict unfavorable production. The assumption made was that stocking rates have been based on conservative estimates of average production. The reduced amounts available represent a substantial negative departure from average production as well as higher

Table 12. Unfavorable production and price levels for the large Utah cattle ranch.

Alternative	Production	Mgt. Cost	Product Price
BLM	1112 AUMs	$1.57/AUM	
Forest Service	677 AUMs	$1.97/AUM	
Private lease	347 AUMs	$7.20/AUM	
Barley	69 bu/ac.	$130/ac.	$4.05/cwt
Alfalfa	2.91 T/ac.	$111.72/ac.	$61/T
Alfalfa	3.88 T/ac.	$113.14/ac.	$61/T
Meadow	1521#/ac.	$10.21/ac.	$6.90/ac.
Meadow, 100# Nitrogen	1900#/ac.	$21.71/ac.	$6.90/AUM
Meadow, 125# Nitrogen	2850#/ac.	$23.96/ac.	$6.90/AUM
Meadow hay	1.9 T/ac.	$51.45/ac.	$50.80/T
Native foothill range	50#/ac.		$6.90/AUM
Native foothill, burn & seed	255#/ac.	$1.85/ac.	$6.90/AUM
Native foothill, plow & seed	306#/ac.	$2.83/ac.	$6.90/AUM
Native foothill, spray	144#/ac.	$1.04/ac.	$6.90/AUM
Crested wheatgrass	306#/ac.		$6.90/AUM
Sale of forage		$.10/ac.	
Purchase of alfalfa and grass hay (delivered)		$65/T	
Cow herd, as is	67% calf crop	$46/cow	
steer, October	404#/head		$202/head
heifer, October	376#/head		$164/head
yrlg. steer, August	600#/head		$265/head
yrlg. heifer, August	560#/head		$219/head
Cow herd, intensive management	81% calf crop	$52/cow	
steer, September	404#/head		$202/head
steer, October	415#/head		$208/head
steer, February	515#/head		$214/head
heifer, September	376#/head		$164/head
heifer, October	387#/head		$169/head
heifer, February	487#/head		$179/head
yrlg. steer, April	575#/head		$278/head
yrlg. steer, June	645#/head		$279/head
yrlg. steer, August	720#/head		$ 304/head
yrlg. steer, September	730#/head		$315/head
yrlg. heifer, April	540#/head		$229/head
yrlg. heifer, June	600#/head		$232/head
yrlg. heifer, August	650#/head		$247/head
yrlg. heifer, September	660#/head		$255/head
Cow herd, intensive management early weaning	81% calf crop	$52/cow	
steer, September	404#/head		$202/head
steer, October	434#/head		$217/head
steer, February	534#/head		$222/head
heifer, September	376#/head		$164/head

Table 12 (continued).

Alternative	Production	Mgt. Cost	Product Price
heifer, October	406#/head		$177/head
heifer, February	506#/head		$186/head
yrlg. steer, April	594#/head		$288/head
yrlg. steer, June	670#/head		$290/head
yrlg. steer, August	770#/head		$325/head
yrlg. steer, September	780#/head		$336/head
yrlg. heifer, April	560#/head		$238/head
yrlg. heifer, June	620#/head		$240/head
yrlg. heifer, August	685#/head		$260/head
yrlg. heifer, September	695#/head		$269/head
Purchase yearling steers		$46/head + interest	
yrlg. steer, April	575#/head		$278/head
yrlg. steer, June	645#/head		$279/head
yrlg. steer, August	720#/head		$304/head
yrlg. steer, September	730#/head		$315/head

levels of forage utilization. Under such conditions, it was assumed that no additional private lease was available.

Production levels from crops based on review of agricultural statistics (Utah Department of Agriculture 1980) varied from no reduction in yields of barley, to three percent reduction in alfalfa yields and five percent reduction in meadow hay yields. Meadow forage production yields were arbitrarily reduced 10 percent, native rangeland forage production was reduced 34 percent, and seeded rangeland forage production was reduced 32 percent, based on studies by Sneva and Hyder (1962).

Crop price levels were the same as 1977 crop prices because 1977 feed grain and hay prices depicted average unfavorable price levels. Average unfavorable price levels for livestock were higher than 1977 price levels because the price level in relation to pro-

duction costs in 1977 represented the extreme unfavorable condition.

Livestock production was reduced by lower calf crop percentage, lower weight gain, and increased death loss of yearlings. Calf crop was reduced by three percent for all intensities of herd management. Calf weaning weights and yearling weights were reduced by approximately four and six percent, respectively. Annual rate of death loss on the breeding herd was five percent. Ranch-raised yearling and purchased yearling death loss rates were 11 and 13.7 percent, respectively on an annual basis.

COPLAN data sets derived from values entered in Tables 10, 11, and 12 were used for management strategy determinations for the large ranch are included as Figures 1-6, Appendix A.

Average production and 1977 price levels for the small Utah cattle ranch. Values used to depict alternatives and corresponding average production and 1977 price levels are presented in Table 13.

Management costs for grazing permits and leases included 1977 grazing fees with the addition of 8.6 percent interest for six months. BLM grazing permits allowed use from October through April. Forest Service permits were available from mid-June through September, and private leases were available from May through September. As in the analyses of the large ranch, additional private lease was limited to 25 percent of the existing private lease and fees were increased by 10 percent.

Barley production was considered a necessary activity related to the alfalfa crop-rotation. Therefore, the production costs were

Table 13. Average production and 1977 price levels for the small Utah cattle ranch.

Alternative	Production	Mgt. Cost	Product Price
BLM	455 AUMs	$1.57/AUM	
Forest Service	340 AUMs	$1.97/AUM	
Private lease	195 AUMs	$7.20/AUM	
Additional private lease	49 AUMs	$7.92/AUM	
Barley	77 bu/ac.	$139.41/ac.	$4.05/cwt
Alfalfa	3.5 T/ac.	$123.16/ac.	$61/T
Alfalfa	4.5 T/ac.	$124.58/ac.	$61/T
Meadow	1690#/ac.	$14.21/ac.	$6.90/AUM
Meadow, 100# Nitrogen	2000#/ac.	$25.71/ac.	$6.90/AUM
Meadow, 125# Nitrogen	3000#/ac.	$27.96/ac.	$6.90/AUM
Meadow hay	2 T/ac.	$72.89/ac.	$50.80/T
Native foothill range	75#/ac.		$6.90/AUM
Native foothill, burn & seed	375#/ac.	$1.85/ac.	$6.90/AUM
Native foothill, plow & seed	450#/ac.	$2.83/ac.	$6.90/AUM
Native foothill, spray	218#/ac.	$1.04/ac.	$6.90/AUM
Sale of forage		$.10/ac.	
Purchase of alfalfa and grass hay (delivered)		$65/T	
Cow herd, as is	71% calf crop	$22/cow	
steer, October	450#/head		$193/head
heifer, October	420#/head		$150/head
Cow herd, intensive management	84% calf crop	$28/cow	
steer, September	440#/head		$196/head
steer, October	450#/head		$200/head
steer, February	550#/head		$203/head
heifer, September	410#/head		$149/head
heifer, October	420#/head		$152/head
heifer, February	520#/head		$164/head
yrlg. steer, April	600#/head		$243/head
yrlg. steer, June	670#/head		$258/head
yrlg. steer, August	750#/head		$281/head
yrlg. steer, September	800#/head		$306/head
yrlg. heifer, April	560#/head		$200/head
yrlg. heifer, June	620#/head		$211/head
yrlg. heifer, August	680#/head		$236/head
yrlg. heifer, September	700#/head		$238/head
Purchase yearling steers		$18.90/head + interest	
yrlg. steer, April	600#/head		$243/head
yrlg. steer, June	670#/head		$258/head
yrlg. steer, August	750#/head		$281/head
yrlg. steer, September	800#/head		$306/head

included as alfalfa production costs in the analyses. Cropland was assumed to provide one AUM of aftermath grazing per acre.

Meadow and foothill rangeland management alternatives considered for the small ranch involved the same practices as those discussed for the large ranch. Management costs for meadow were derived from the 1977 expenditures by the small ranch. Rangeland management costs other than land treatment costs were considered to be the opportunity cost of selling AUMs of forage. Sale of forage added a $.10/acre management cost to cover additional expense involved in marketing of the forage. Meadow hay production was assumed to provide one AUM of aftermath grazing in the fall. Foothill rangeland was assumed to be unavailable for grazing from November to March and forabe availability was increased through the growing season to represent plant growth.

Production of the cow herd as structured in 1977 was based on 140 cows, 18 yearling replacements, 18 replacement heifer calves, and five bulls or a 13 percent replacement rate for cows and a 32:1 cow to bull ratio. The calf crop percentage was 70.7 percent and variable costs per cow excluding forage costs were $22/cow based on the livestock enterprise expenditures in 1977.

Production of the intensively managed cow herd was based on an intensive herd health program, an increase in cow replacement rate from 13 to 15 percent, and a decrease in the cow to bull ratio from 32:1 to 20:1. Annual death loss rate for the breeding herd was four percent and ranch-raised yearling death loss was set at 6.9

percent. Non-forage variable costs per cow were determined to increase to $28/cow.

The alternative, purchase of yearling steers, was considered in the analyses based on production levels of ranch yearlings from the intensively managed cow herd. Death loss on purchased steers was set at 8.9 percent. Variable costs were determined to be $18.90 per steer.

Favorable production and favorable price levels for the small Utah cattle ranch. Favorable production and price values used in the analysis of the small ranch are presented in Table 14.

Grazing permits and leases were held constant based on the assumption that permits are based on the long-term productivity of grazing allotments.

Barley production was held at 77 bushels/acre but alfalfa, meadow, and rangeland forage production was increased. Alfalfa and meadow production were increased three percent and rangeland forage production was increased by 18 percent on native range and by 16 percent on seeded range.

Purchased hay costs were increased to be comparable to ranch-raised hay price levels favorable to the small ranch while other management costs were held constant at 1977 levels.

Calf crop percentages were increased by two percent and weight gains of calves and yearlings were increased by approximately four and three percent, respectively to reflect favorable forage production. Annual rate of death loss was four percent for the breeding

Table 14. Favorable production and favorable price levels for the small Utah cattle ranch

Alternative	Production	Mgt. Cost	Product Price
BLM	455 AUMs	$1.57/AUM	
Forest Service	340 AUMs	$1.97/AUM	
Private lease	195 AUMs	$7.20/AUM	
Additional private lease	49 AUMs	$7.92/AUM	
Barley	77 bu/ac.	$139.41/ac.	$5.26/cwt
Alfalfa	3.59 T/ac.	$123.16/ac.	$79.20/T
Alfalfa	4.64 T/ac.	$124.58/ac.	$79.20/T
Meadow	1740#/ac.	$14.21/ac.	$8.92/AUM
Meadow, 100# Nitrogen	2060#/ac.	$25.71/ac.	$8.92/AUM
Meadow, 125# Nitrogen	3090#/ac.	$27.96/ac.	$8.92/AUM
Meadow hay	2.06 T/ac.	$72.89/ac.	$66/T
Native foothill range	88#/ac.		$8.92/AUM
Native foothill, burn & seed	435#/ac.	$1.85/ac.	$8.92/AUM
Native foothill, plow & seed	522#/ac.	$2.83/ac.	$8.92/AUM
Native foothill, spray	257#/ac.	$1.04/ac.	$8.92/AUM
Sale of forage		$.10/ac.	
Purchase of alfalfa and grass hay (delivered)		$84.40/T	
Cow herd, as is	73% calf crop	$22/cow	
steer, October	460#/head		$265/head
heifer, October	430#/head		$216/head
Cow herd, intensive management	86% calf crop	$28/cow	
steer, September	460#/head		$265/head
steer, October	470#/head		$271/head
steer, February	570#/head		$273/head
heifer, September	430#/head		$213/head
heifer, October	440#/head		$221/head
heifer, February	540#/head		$229/head
yrlg. steer, April	630#/head		$351/head
yrlg. steer, June	710#/head		$354/head
yrlg. steer, August	800#/head		$389/head
yrlg. steer, September	820#/head		$407/head
yrlg. heifer, April	585#/head		$286/head
yrlg. heifer, June	645#/head		$287/head
yrlg. heifer, August	730#/head		$319/head
yrlg. heifer, September	750#/head		$334/head
Cow herd, intensive management early weaning	86% calf	$28/cow	
steer, September	460#/head		$265/head
steer, October	490#/head		$282/head
steer, February	590#/head		$282/head
heifer, September	430#/head		$213/head
heifer, October	460#/head		$231/head
heifer, February	560#/head		$237/head
yrlg. steer, April	650#/head		$362/head

Table 14 (continued).

Alternative	Production	Mgt. Cost	Product Price
yrlg. steer, June	720#/head		$359/head
yrlg. steer, August	820#/head		$399/head
yrlg. steer, September	840#/head		$417/head
yrlg. heifer, April	620#/head		$303/head
yrlg. heifer, June	680#/head		$303/head
yrlg. heifer, August	750#/head		$328/head
yrlg. heifer, September	770#/head		$343/head
Purchase yearling steers		$18.90/head + interest	
yrlg. steer, April	630#/head		$351/head
yrlg. steer, June	710#/head		$354/head
yrlg. steer, August	800#/head		$389/head
yrlg. steer, September	820#/head		$407/head

herd, 6.9 percent for ranch-raised yearlings and 8.9 percent for purchased yearlings.

Early weaning at the end of August was considered in the analyses for the determination of SF/FO, SF/UO, SU/FO, and SU/UO strategies. This cow herd management alternative assumed a hert structure identical to the intensively managed cow herd alternative for the small ranch as described in the discussion of average production and 1977 price levels.

Unfavorable production and unfavorable price levels for the small Utah cattle ranch. Unfavorable production and price values used in the analysis for the small ranch are presented in Table 15.

Available forage from grazing permits and leases was reduced by 10 percent for BLM (from 455 to 410 AUMs), by seven percent for Forest Service (from 340 to 316 AUMs), and seven percent for private lease (from 195 to 181 AUMs) to depict unfavorable forage production.

Table 15. Unfavorable production and price levels for the small Utah cattle ranch.

Alternative	Production	Mgt. Cost	Product Price
BLM	410 AUMs	$1.57/AUM	
Forest Service	316 AUMs	$1.97/AUM	
Private lease	181 AUMs	$7.20/AUM	
Barley	77 bu/ac.	$139.41/ac.	$4.05/cwt.
Alfalfa	3.4 T/ac.	$123.16/ac.	$61/T
Alfalfa	4.37 T/ac.	$124.58/ac.	$61/T
Meadow	1521 #/ac.	$14.21/ac.	$6.90/AUM
Meadow, 100# Nitrogen	1900 #/ac.	$25.71/ac.	$6.90/AUM
Meadow, 125# Nitrogen	2850 #/ac.	$27.96/ac.	$6.90/AUM
Meadow hay	1.9 T/ac.	$72.89	$50.80/T
Native foothill range	50#/ac.		$6.90/AUM
Native foothill, burn & seed	255#/ac.	#1.85/ac.	$6.90/AUM
Native foothill, plow & seed	306#/ac.	$2.83/ac.	$6.90/AUM
Native foothill, spray	144#/ac.	$1.04/ac.	$6.90/AUM
Sale of forage		$ .10/ac	
Purchase of alfalfa and grass hay (delivered)		$65/T	
Cow herd, as is	68% calf crop	$22/cow	
steer, October	440#/head		$218/head
heifer, October	410#/head		$177/head
Cow herd, intensive management	81% calf crop	$28/cow	
steer, September	430#/head		$213/head
steer, October	440#/head		$218/head
steer, February	540#/head		$222/head
heifer, September	400#/head		$173/head
heifer, October	410#/head		$177/head
heifer, February	510#/head		$186/head
yrlg. steer, April	590#/head		$282/head
yrlg. steer, June	660#/head		$282/head
yrlg. steer, August	730#/head		$305/head
yrlg. steer, September	750#/head		$320/head
yrlg. heifer, April	550#/head		$231/head
yrlg. heifer, June	600#/head		$230/head
yrlg. heifer, August	660#/head		$248/head
yrlg. heifer, September	670#/head		$256/head
Cow herd, intensive management early weaning	68% calf	$28/cow	
steer, September	430#/head		$213/head
steer, October	460#/head		$228/head
steer, February	560#/head		$230/head
heifer, September	400#/head		$173/head
heifer, October	430#/head		$186/head
heifer, February	530#/head		$193/head
yrlg. steer, April	620#/head		$297/head

Table 15 (continued).

Alternative	Production	Mgt. Cost	Product Price
yrlg. steer, June	680#/head		$291/head
yrlg. steer, August	770#/head		$321/head
yrlg. steer, September	800#/head		$341/head
yrlg. heifer, April	590#/head		$248/head
yrlg. heifer, June	640#/head		$245/head
yrlg. heifer, August	690#/head		$259/head
yrlg. heifer, September	700#/head		$268/head
Purchase yearling steers		$18.90/head + interest	
yrlg. steer, April	590#/head		$282/head
yrlg. steer, June	660#/head		$282/head
yrlg. steer, August	730#/head		$305/head
yrlg. steer, September	750#/head		$320/head

It was assumed that no additional private lease was available during periods of low forage production.

Barley production was held constant at 77 bushels/acre while alfalfa yields were reduced by three percent. Meadow hay yield was reduced five percent and meadow forage production was reduced 10 percent. Native rangeland forage production was reduced by 34 percent and seeded rangelands forage yields were reduced by 32 percent.

Crop price levels were identical to 1977 levels to portray average unfavorable economic conditions. Calf crop percentages, weaning weights, and sale weights on yearlings were reduced to reflect lower forage availability and quality as well as reduced stock-water availability. Annual rate of death loss was four percent for the breeding herd, 11.0 percent for ranch-raised yearlings, and 13.7 percent for purchased yearlings.

COPLAN data sets derived from values shown in Tables 13, 14, and 15 and used for management strategy determinations for the small ranch are presented in Figures 7-12, Appendix A.

Optimum strategies

Optimum strategies for the large and small Utah cattle ranches were determined through linear programming optimization procedures using COPLAN (Child and Evans 1976). Optimum strategies were determined based on five assumed production and price levels: average production combined with 1977 prices and four states of nature (favorable production and favorable price levels, favorable production and unfavorable price levels, unfavorable production and favorable price levels, and unfavorable production and unfavorable price levels). Both optimum and "as is" strategies were constrained to simulate strategy performance under the four states of nature. Results of these analyses for the large Utah cattle ranch are presented first.

Large ranch strategies and estimated net returns above variable costs. Results of the linear programming analyses for the large ranch are presented in Table 16.

Large ranch strategy practiced in 1977 (L77AI). The 1977 "As is" strategy analyses were designed to simulate practice of this strategy over various states of nature. The estimated net returns above variable costs were $-6,326 in 1977, $9,029 under state of nature 1 (F/F), $3,118 under state of nature 2 (F/U), $-12,614 under state of nature 3 (U/F), and $-13,636 under state of nature 4 (U/U). Opportunity costs of feeding all ranch-raised hay

Table 16. Management strategies and estimated net returns above variable costs for the large Utah cattle ranch operating under four states of nature.

Alternatives	77AI	77AI1	77AI2	77AI3	77AI4	770	7701	7702	7703	7704	F/F0	F/F02	F/F03	F/F04	F/U0	F/U01	(Row)
BLM (AUMs)	1235	1235	1235	1112	1112	1235	1235	1235	1112	1112	1235	1235	1112	1112	1235	1235	1
F5 (AUMs)	728	728	728	677	677	728	728	728	677	677	728	728	677	677	728	728	2
Pvt Lease (AUMs)	373	373	373	347	347	—	*	*	*	*	373	257	202	197	—	*	3
Add Pvt Lease (AUMs)	*	*	*	*	*	--	*	*	*	*	93	—	—	—	—	*	4
Irr Alf 3T/Ac (Ac)	97	97	97	97	97	—	*	*	*	*	--	*	*	*	--	*	5
Irr Alf 4T/Ac (AC)	*	*	*	*	*	108	108	108	108	108	108	108	108	108	108	108	6
Irr Bar (Ac)	38	38	38	38	38	27	27	27	27	27	27	27	27	27	27	27	7
Meadow (Ac)	168	168	168	168	168	--	*	*	*	*	--	*	*	*	--	*	8
Meadowhay (Ac)	*	*	*	*	*	168	168	168	168	168	168	168	168	168	168	168	9
Foothill (Ac)	790	790	790	790	790	—	*	*	*	*	--	*	*	*	--	*	10
Fthll Brn & Seed (Ac)	*	*	*	*	*	790	790	790	790	790	--	*	*	*	790	790	11
Fthll Plow & Seed (Ac)	*	*	*	*	*	-	*	*	*	*	790	790	790	790	—	*	12
Foothill-Crested (Ac)	634	634	634	634	634	634	634	634	634	634	634	634	634	634	634	634	13
Sell Alfalfa (tons)	*	*	*	*	*	432	445	445	419	419	445	445	419	419	445	445	14
Sell Bar (Bu)	*	*	*	*	*	1856	1856	1856	1856	1856	1856	1856	1856	1856	1856	1856	15
Sell Meadowhay (tons)	*	*	*	*	*	336	346	346	319	319	346	346	319	319	346	346	16
Sell AUMs FH B&S (AUMs)	*	*	*	*	*	—	*	*	*	*	--	*	*	*	38	38	17
Sell AUMs FH P&S (AUMs)	*	*	*	*	*	—	*	*	*	*	550	550	322	322	—	*	18
Sell AUMs CW FH (Aums)	*	*	*	*	*	121	140	140	82	82	124	124	73	73	3	3	19
Feed Alfalfa (tons)	291	300	300	282	282	—	*	*	*	*	--	*	*	*	--	*	20
Feed Bar (Bu)	2608	2608	2608	2608	2608	—	*	*	*	*	--	*	*	*	—	*	21
Feed Meadowhay (tons)	*	*	*	*	*	--	*	*	*	*	--	*	*	*	--	*	22
Buy Hay (tons)	56	15	15	202	202	—	5	5	21	26	—	—	19	19	—	—	23
Cow Herd-As Is	287	287	287	287	287	—	*	*	*	*	*	*	*	*	*	*	24
Cow Herd-Oct. Weaning	*	*	*	*	*	129	129	129	129	129	—	*	*	*	--	*	25
Cow Herd-Early Weaning	*	*	*	*	*	*	*	*	*	*	125	125	125	125	126	126	26
Sell Steer Calves	72	75	75	70	70	—	--	--	--	--	--	--	--	--	--	--	27
Sell Heifer Calves	35	37	37	33	33	—	--	--	8	—	--	--	--	--	--	--	28
Sell Yearling Steers	27	27	27	26	26	52	53	53	48	48	52	52	47	47	52	52	29
Sell Yearling Heifers	29	29	29	26	26	34	35	35	24	13/20[1]	23/12	35/0	31	31	34	34	30
Purchase Yearling Steers	*	*	*	*	*	105	105	105	105	105	105	105	105	105	105	105	31
in March	*	*	*	*	*	16	105	105	24	20	105	105	51	48	105	105	32
in May	*	*	*	*	*	--	--	--	--	--	--	--	—	—	—	—	33
in June	*	*	*	*	*	89	--	--	81	85	--	--	54	57	—	—	34
Sell Purchased Steers	*	*	*	*	*	100	100	100	99	99	100	100	100	100	100	100	35
in April	*	*	*	*	*	--	--	--	24	20	—	--	47	47	—	—	36
in September	*	*	*	*	*	100	100	100	75	79	100	100	53	53	100	100	37
																	38
Contribution Margin ($s)	-6326	9029	3118	-12614	-13636	36001	71328	48017	49818	30658	71894	47153	51722	31331	47957	70998	39
Working Captl. Reqrment.($s)	36752	34477	34145	50174	45806	59469	62193	57881	67607	63525	65811	60075	67716	63176	57376	61576	40

[1] Short Yearling/Long Yearling
*Consideration not allowed
--Consideration allowed

Table 16 (continued).

(Row)	F/UO3	F/UO4	U/FO	U/FO1	U/FO2	U/FO4	U/UO	U/UO1	U/UO2	U/UO3
1	1112	1112	1112	1235	1235	1112	1112	1235	1235	1112
2	677	677	677	708	708	677	677	712	712	677
3	*	*	150	102	102	63	163	142	142	152
4	*	*	—	*	*	*	—	*	*	*
5	*	*	—	*	*	*	—	*	*	*
6	108	108	108	108	108	108	108	108	108	108
7	27	27	27	27	27	27	27	27	27	27
8	*	*	—	*	*	*	—	*	*	*
9	168	168	168	168	168	168	168	168	168	168
10	*	*	—	*	*	*	790	790	790	790
11	790	790	790	790	790	790	—	*	*	*
12	*	*	—	*	*	*	—	*	*	*
13	634	634	634	634	634	634	634	634	634	634
14	419	419	419	445	445	419	419	445	445	419
15	1856	1856	1856	1856	1856	1856	1856	1856	1856	1856
16	319	319	319	346	346	319	319	346	346	319
17	22	22	268	458	458	268	—	*	*	*
18	*	*	—	*	*	*	—	*	*	*
19	2	2	—	*	*	*	80	137	137	80
20	*	*	—	*	*	*	—	*	*	*
21	*	*	—	*	*	*	—	*	*	*
22	*	*	—	*	*	*	—	*	*	*
23	22	22	—	—	—	—	—	—	—	—
24	*	*	*	*	*	*	*	*	*	*
25	*	*	—	*	*	*	—	*	*	*
26	126	126	117	117	117	117	117	117	117	117
27	—	—	—	—	—	—	—	—	—	—
28	—	—	—	—	—	—	—	—	—	—
29	47	47	44	48	48	44	44	48	48	44
30	31	31	29	32	32	29	29	32	31	29
31	105	105	105	105	105	105	105	105	105	105
32	42	42	95	105	105	20	90	105	105	53
33	—	—	—	—	—	—	—	—	—	—
34	63	63	10	—	—	85	15	—	—	52
35	98	98	102	100	100	98	102	100	100	99
36	12	12	89	—	—	20	88	—	—	21
37	86	86	15	100	100	78	14	100	100	78
38										
39	52532	33226	56408	71890	47952	32458	35779	70383	47458	54250
40	66248	61433	61397	61875	57675	61400	56400	60650	56450	62788

and purchase of hay make maintenance of the 287 cow breeding herd under an unfavorable production situation such as drought a serious financial problem. Working capital requirement increased almost 50 percent under unfavorable production situations while ranch operation resulted in relatively large negative net returns above variable costs. It is understandable from these analyses why liquidation of the breeding her may be the best alternative available to the rancher during drought years. Although late calves could be sold at weaning or as a crisis situation becomes apparent, little flexibility was available under the 1977 "As is" management strategy.

Large ranch optimum strategy for 1977 (L770). The optimum strategy based on average production and 1977 price levels required intensively managed cow/yearling and stocker steer livestock enterprises, an intensively managed hay production enterprise, and a concentrated rangeland improvement program.

Full use of public land grazing permits was made while private leases were terminated. Alfalfa was managed for 4 T/ac yield and sale of hay and meadow was managed for hay production and sale rather than pasture. All available private foothill rangeland was burned and seeded anf forage from 202 acres of the existing crested wheatgrass seeding was sold (140 to 82 AUMs, depending on forage production).

The cow herd was reduced from 287 to 129 head and intensively managed. This reduced cow herd was based on available winter grazing and reflects the opportunity cost of a hay based commercial cow/production unit. Calves were weaned in October and retained as

yearlings. An additional 105 yearling steers were purchased in the spring. Adoption of this strategy required hay purchases of from 5 to 26 tons, depending on the year. Under adverse production but favorable price situations some (eight) heifer calves were sold at weaning. When production and price levels were unfavorable, part of the heifers (13) were sold as short-yearlings in April and the remaining heifers were sold in September.

Net returns above variable costs in 1977 dollars ranged from $71,328 for operation under state of nature 1 (F/F) to $30,658 for operation under state of nature 4 (U/U). Working capital requirement to the nearest thousand 1977 dollars varied from a low of $58,000 under state of nature 2 (F/U), to a high of $68,000 under state of nature 3 (U/F).

Large ranch optimum strategy for favorable production and favorable price levels (LF/FO). The optimum strategy based on favorable production and prices (F/F) was similar to the L770 strategy. The cow/yearling and stocker steer livestock enterprises and the crop enterprises were intensively managed. All available private foothill range was plowed and seeded.

Full use was made of public land grazing permits and capability to make use of private leases was expanded by 93 AUMs. Alfalfa was managed for 4 T/acre yield and sale of hay, and meadows were also managed for hay production and sale. Forage was sold from 969 acres of seeded rangeland for a total of 674 AUMs in favorable production periods and 395 AUMs in unfavorable production years.

Purchase of a small amount of hay (19 tons) was necessary during unfavorable production periods to meet livestock forage requirements. Livestock enterprises included a 125 head cow herd and purchased steers. Calves were weaned early (late August) and retained as yearlings. Yearling steers (105) were purchased in March and some or all yearling heifers were sold in April during favorable production years depending on livestock prices. During unfavorable production periods all yearling heifers were sold in September and 105 yearling steers were purchased and sold depending on forage availability during March through early June. All yearlings were sold by the end of September.

Net returns above variable costs in 1977 dollars varied from a high of $71,894 in state of nature 1 (F/F) to #31,331 in state of nature 4 (U/U). Working capital requirement in 1977 dollars varied from $60,000 under state of nature 2(F/U) to a high of $68,000 under state of nature 3 (U/F).

Large ranch optimum strategy for favorable production and unfavorable price levels (LF/UO). The optimum strategy for state of nature 2 (F/U) was also similar to previously discussed optimum strategies. The strategy was based on intensive management of crop and livestock enterprises and investment in rangeland improvement on private land.

Full use was made of public land grazing permits but private leases were terminated. Alfalfa was managed for 4 T/acre yield and sale of hay. Meadow was managed for hay production and sale of hay. All available private foothill range was improved by burning and

seeding and forage was sold from 70 acres of seeded range (41 AUMs in favorable production periods to 24 AUMs in unfavorable production periods).

Hay purchase of 22 tons were necessary to meet livestock requirements during unfavorable production years. The livestock enterprises were centered around an intensively managed cow herd of 126 cows, retention of calves for sale as yearlings, and purchase of yearling stocker steers. Calves were weaned in late August and 105 additional steers were purchased in the spring. This strategy, like strategies previously discussed, required commitment to a range based cow herd, range improvements, and crop production and sales. Ranch-raised and purchased yearling enterprises provided the flexibility needed to deal with production and price variability.

Net returns above variable costs in 1977 dollars varied from a high of $70,998 under state of nature 1 (F/F) to a low of $33,226 under state of nature 4 (U/U). Working capital requirement in 1977 dollars ranged from a low of $57,000 under state of nature 2 (F/U) to a high of $66,000 under state of nature 3 (U/F).

Large ranch optimum strategy for unfavorable production and favorable price levels (LU/FO). The optimum strategy for state of nature 3 (U/F) also required that crop and livestock enterprises be managed intensively and investment be made in rangeland improvement on private land.

Full use was made of BLM grazing permits but Forest Service grazing permits were not fully utilized due to seasonal inbalance of available forage. Use of private grazing leases was reduced to

40 percent or less of what was used in 1977. Alfalfa was managed for 4 T/acre yields and sale of hay. Meadow was managed for production and sale of hay. All available private foothill range was burned and seeded and all private rangeland forage was used by ranch livestock.

Hay purchases to meet livestock requirements were not necessary under this strategy. The livestock enterprises included an intensively managed cow herd of 117 cows, retention of calves for sale as yearlings, and purchase of 105 yearling stocker steers in the spring. Timing of steer purchases was determined by forage availability and steer prices from March through early June.

Net returns above variable costs in 1977 dollars ranged from a high of $71,890 under state of nature 1 (F/F) to a low of $32,458 under state of nature 4 (U/U). Working capital requirement in 1977 dollars varied from a low of $58,000 under state of nature 2 (F/U) to $62,000 under state of nature 1 (F/F).

Large ranch strategy for unfavorable production and unfavorabile price levels (LU/UO). The optimum strategy for the large ranch under state of nature 4 (U/U) depicts a more conservative approach to management than other optimum strategies previously discussed. Crop and livestock enterprises were managed intensively but no rangeland improvement practices were employed on the private foothill rangeland.

BLM grazing permits were fully utilized but Forest Service permits were not. Private leases were reduced to approximately 40 percent of the amount leased in 1977. Alfalfa was managed for 4 T/acre

yield and the hay was sold. Likewise, meadow was managed for production and sale of hay. No investment in range improvement practices was made and 80 to 137 AUMs of forage from 196 acres of the existing crested wheatgrass seeding were sold.

No hay purchases were made under this strategy. The cow herd was set at 117 cows and calves were retained as yearlings. Calves were weaned in late August and 105 yearling steers were purchased annually. Steer purchases were determined by March through mid-June forage availability and seasonal steer prices.

Net returns above variable costs in 1977 dollars varied from a high of $70,383 under state of nature 1 (F/F) to $35,779 under state of nature 4 (U/U). Working capital requirement in 1977 dollars varied from $63,000 to $56,000 under states of nature 3 and 4 (U/F and U/U), respectively.

Small ranch strategies and estimated net returns above variable costs. Results of the linear programming analyses for the small ranch are presented in Table 17.

Small ranch strategy practiced in 1977 (S77AI). The 1977 "As is" strategy analyses were designed to simulate application of this strategy over the four states of nature. The estimated net returns above variable costs in 1977 dollars were $-2,721 in 1977, $4,603 under state of nature 1 (F/F), $2,286 under state of nature 2 (F/U), $-4,681 under state of nature 3 (U/F), and $5,165 under state of nature 4 (U/U). As with the 1977 "As is" strategy practiced by the large ranch, maintenance of the 140 head cow herd with ranch-

Table 17. Management strategies and estimated net returns above variable costs for the small Utah cattle ranch operating under four states of nature.

Alternatives	77AI	77AI1	77AI2	77AI3	77AI4	770	7701	7702	7703	7704	F/F0	F/F02	F/F03	F/F04	F/U0	F/U01	(Row)
BLM (AUMs)	455	455	455	410	410	455	455	455	410	410	455	455	410	410	455	455	1
FS (AUMs)	340	340	340	316	316	340	304	308	205	212	340	330	287	285	340	292	2
Pvt Lease (AUMs)	195	195	195	181	181	55	55	55	51	51	121	84	85	84	73	73	3
Irr. Alfalfa 3.5T/Ac (Ac)	54	54	54	54	54	—	*	*	*	*	—	*	*	*	—	*	4
Irr. Alfalfa 4.5T/Ac (Ac)	*	*	*	*	*	55	55	55	55	55	55	55	55	55	55	55	5
Irr. Bar (Ac)	15	15	15	15	15	14	14	14	14	14	14	14	14	14	14	14	6
Meadow (Ac)	48	48	48	48	48	—	*	*	*	*	—	*	*	*	—	*	7
Meadowhay (Ac)	*	*	*	*	*	48	48	48	48	48	48	48	48	48	48	48	8
Foothill (Ac)	1400	1400	1400	1400	1400	—	*	*	*	*	—	*	*	*	—	*	9
Foothill-Burn & Seed (Ac)	*	*	*	*	*	1400	1400	1400	1400	1400	—	*	*	*	1361	1361	10
Foothill Plow & Seed (Ac)	*	*	*	*	*	—	*	*	*	*	1400	1400	1400	1400	39	39	11
Sell Alfalfa (tons)	*	*	*	*	*	248	255	255	239	239	255	255	239	239	255	255	12
Sell Bar (Bu)	*	*	*	*	*	1077	1077	1077	1077	1077	1077	1077	1077	1077	1077	1077	13
Sell Meadowhay (tons)	*	*	*	*	*	96	99	99	91	91	99	99	91	91	99	99	14
Sell AUMs FH Burn & Seed (AUMs)	*	*	*	*	*	546	633	633	371	371	—	*	*	*	612	612	15
Sell AUMs FH Plow & Seed (AUMs)	*	*	*	*	*	—	*	*	*	*	818	818	480	480	—	*	16
Feed Alfalfa (tons)	189	194	194	184	184	—	*	*	*	*	—	*	*	*	—	*	17
Feed Barley (Bu)	1156	1156	1156	1156	1156	—	*	*	*	*	—	*	*	*	—	*	18
Feed Meadowhay (tons)	*	*	*	*	*	—	*	*	*	*	—	*	*	*	—	*	19
Buy Hay (tons)	48	33	33	106	106	—	—	—	—	—	—	—	—	—	—	—	20
Cow Herd-As Is	140	140	140	140	140	—	*	*	*	*	*	*	*	*	*	*	21
Cow Herd-October Weaning	*	*	*	*	*	47	47	47	47	47	—	*	*	*	—	*	22
Cow Herd-Early Weaning	*	*	*	*	*	*	*	*	*	*	46	46	46	46	46	46	23
Sell Steer Calves	50	52	52	49	49	—	—	—	—	—	—	—	—	—	—	—	24
Sell Heifer Calves	31	34	34	32	32	—	2	—	12	12	—	—	11	11	—	—	25
Sell Yearling Steers	*	*	*	*	*	19	19	19	17	18	19	19	17	17	19	19	26
Sell Yearling Heifers	*	*	*	*	*	12	11	13	—	—	12	12	1	1/0[1]	12	12	27
Purchase Yearling Steers	*	*	*	*	*	49	49	49	49	49	49	49	49	49	49	49	28
in March	*	*	*	*	*	7	31	30	29	27	49	49	35	35	49	49	29
in May	*	*	*	*	*	42	18	—	—	—	—	—	—	—	—	—	30
in June	*	*	*	*	*	—	—	19	20	22	—	—	14	14	—	—	31
Sell Purchased Steers	*	*	*	*	*	47	47	47	47	47	47	47	45	45	47	47	32
in April	*	*	*	*	*	—	—	—	28	27	—	—	—	—	—	—	33
in September	*	*	*	*	*	47	47	47	19	20	47	47	45	45	47	47	34
																	35
Contribution Margin ($s)	-2721	4603	2286	-4681	-5165	18694	32337	21999	23920	15243	33427	22456	24176	15125	22704	33377	36
Working Captl. Reqrmnt.($s)	16950	16677	16029	22558	20507	28254	31728	29830	30554	28690	32426	30423	31996	30081	29020	30640	37

[1] Short Yearling/Long Yearling
*Consideration not allowed
—Consideration allowed

Table 17 (continued).

(Row)	F/U03	F/U04	U/F0	U/F01	U/F02	U/F04	U/U0	U/U01	U/U02	U/U03
1	410	410	410	435	435	410	410	437	437	410
2	205	205	316	275	275	244	295	277	277	232
3	68	68	83	7	7	74	87	25	25	81
4	*	*	--	*	*	*	--	*	*	*
5	55	55	55	55	55	55	55	55	55	55
6	14	14	14	14	14	14	14	14	14	14
7	*	*	--	**	*	*	--	*	*	*
8	48	48	48	48	48	48	48	48	48	48
9	*	*	--	*	*	*	1265	1265	1265	1265
10	1361	1361	1209	1209	1209	1209	135	135	135	135
11	39	39	191	191	191	191	--	*	*	*
12	239	239	239	255	255	239	239	255	255	239
13	1077	1077	1077	1077	1077	1077	1077	1077	1077	1077
14	91	91	91	99	99	91	99	99	99	91
15	359	359	341	582	582	341	--	*	*	*
16	*	*	--	*	*	*	--	*	*	*
17	*	*	--	*	*	*	--	*	*	*
18	*	*	--	*	*	*	--	*	*	*
19	*	*	--	*	*	*	--	*	*	*
20	--	--	--	--	--	--	--	--	--	--
21	*	*	*	*	*	*	*	*	*	*
22	*	*	--	*	*	*	--	*	*	*
23	46	46	43	43	43	43	43	43	43	43
24	--	--	--	--	--	--	--	--	--	--
25	11	11	--	--	--	1	--	--	--	--
26	17	17	16	18	18	16	16	18	18	16
27	1/0	1/0	10	12	12	10/0	11/0	12	12	11/0
28	49	49	49	49	49	49	49	49	49	49
29	42	42	49	49	49	49	49	49	49	49
30	--	--	--	--	--	--	--	--	--	--
31	7	7	--	--	--	--	--	--	--	--
32	47	47	45	47	47	45	45	47	47	46
33	26	26	--	--	--	--	--	--	--	6
34	21	21	45	47	47	45	45	47	47	40
35										
36	24907	16069	25330	32246	21842	16429	16580	29641	20416	24829
37	29997	28163	30012	30158	28443	28041	25607	27667	25952	27204

raised and purchased hay carried a high opportunity cost and resulted in relatively large losses under unfavorable production situations. Working capital requirement also increased dramatically under conditions unfavorable for production. Liquidation of the cow herd could become the only alternative available under such adverse conditions. High opportunity costs of feeding all ranch hay and lack of flexibility in the management strategy were weaknesses of the 1977 "As is" strategy for the small ranch.

Small ranch optimum strategy for 1977 (S770). The optimum strategy based on average production and 1977 price levels required intensively managed livestock and hay production enterprises and a concentrated range improvement program.

BLM grazing permits were fully utilized and Forest Service grazing permits provided an excess of forage during the summer. Private rangeland leases were reduced to approximately one-fourth of the amount leased in 1977. Alfalfa was managed for 4.5 T/acre yield and hay was sold. Meadow was also managed for hay production and sale. All available private foothill rangeland was burned and seeded. Forage sales varied from 633 to 371 AUMs from 1092 acres of burned and seeded rangeland depending on forage production.

Hay purchases were not required under this strategy and the cow herd was set at 47 head. Calves were weaned in October and were usually retained as yearlings for sale in September. Under unfavorable production conditions or favorable price levels some heifer calves were sold to allow full stocking with ranch-raised and purchased yearling steers. Forty-nine steers were purchased

annually between March and early June with time of purchase determined by forage availability and steer prices. When steer prices were favorable more steers were purchased early in the spring. The proportion of steers purchased late in the spring was greater when steer prices were unfavorable. All yearlings were sold in September under favorable production. When unfavorable production years occurred some purchased yearling steers were sold in April.

Net returns above variable costs in 1977 dollars ranged from a high of $32,337 under state of nature 1 (F/F) to a low of $15,243 under state of nature 4 (U/U). Working capital requirement in 1977 dollars varied from a high of $32,000 under state of nature 1 (F/F) to a low of $29,000 under state of nature 4 (U/U).

Small ranch optimum strategy for favorable production and favorable price levels (SF/FO). The optimum strategy based on state of nature 1 (F/F) was similar to the S770 strategy. Intensive management of crop and livestock enterprises was required and investment in range improvement was practiced.

BLM grazing permits were fully utilized while Forest Service grazing permits were fully stocked in favorable production and price level years and more lightly stocked in other years. The amount of private lease was reduced to 62 percent of levels used in 1977; however, lesser amounts were used under conditions other than favorable production and favorable price levels. Alfalfa was manged for 4.5 T/acre yield and sale of hay while meadow was also managed for production and sale of hay. All available private foothill

rangeland was plowed and seeded. Forage sales of 818 to 480 AUMs were made from 1,176 acres of plowed and seeded rangeland depending on production level for the period.

Hay purchases were not necessary for operation of this strategy. The intensively managed cow herd was set at 46 cows and calves were generally retained as yearlings. Most heifer calves not necessary for replacement of the breeding herd were sold in October during unfavorable production years. Forty-nine yearling steers were purchased in the spring and yearlings were sold in September. Time of steer purchase was dependent on forage availability from March through early June.

Net returns above variable costs in 1977 dollars varied from a high of $33,427 under state of nature 1 (F/F) to a low of $15,125 under state of nature 4 (U/U). Working capital requirement ranged from a high of $32,000 under state of nature 1 (F/F), to a low of $38,000 under state of nature 4 (U/U).

Small ranch optimum strategy for favorable production and unfavorable price levels (SF/UO). The optimum strategy based on state of nature 2 (F/U) required intensive management of crop and livestock enterprises and investment in a range improvement program.

BLM grazing permits were fully utilized and use of Forest Service permits ranged from full stocking to stocking at 65 percent of the permitted use. Private leases were reduced to approximately one-third the level used in 1977. Alfalfa was managed for 4.5 T/acre yield and sale of hay. Meadow was also managed for hay production

and sales. Private foothill range was improved by burning and seeding 1,361 acres and plowing and seeding 39 acres. Forage sales varied from 612 to 359 AUMs from 1,056 acres of burned and seeded range.

No hay purchases were required with this strategy. The cow herd was set at 46 cows and all calves were weaned in late August and retained as yearlings in favorable production years. Heifer calves were sold in October during unfavorable production periods. Forty-nine yearling steers were usually purchased in early spring and sold with ranch-raised yearlings in September. In periods of unfavorable production most (42) of the 49 steers were purchased in early March and 26 were sold in late April. Seven additional steers were purchased in June and sold with the rest of the yearling cattle in September. This "trading" occurred due to a forage deficit in May and early June during unfavorable production periods and serves as an example of the flexibility that exists in all of the optimum strategies.

Net returns above variable costs in 1977 dollars ranged from $33,377 under state of nature 1 (F/F) to $16,069 under state of nature 4 (U/U). Working capital requirement in 1977 dollars varied from $31,000 for state of nature 1 (F/F) to $28,000 for state of nature 4 (U/U).

Small ranch optimum strategy for unfavorable production and favorable price levels (SU/FO). The optimum strategy based on state of nature 3 (U/F also involved intensive management of crop and

livestock enterprises and investment in range improvement practices.

BLM grazing permits were fully utilized only in unfavorable production periods due to seasonal inbalance of available forage. During years of favorable production, BLM permits were used at 96 percent. Forest Service permits were used at the permitted level only when production conditions were unfavorable and livestock prices were favorable. Lower levels of use were made under other states of nature. Private leases were utilized to a lesser degree (43 percent or less) than in 1977. Alfalfa was managed for 4.5 T/acre yield and hay was sold. Meadow was also managed for hay production and sale. Burning and seeding was applied to 1209 acres of private foothill range and 191 acres were plowed and seeded. Forage sales from 1.004 acres of burned and seeded rangeland ranged from 341 to 582 AUMs, depending on forage production conditions.

Purchase of hay was not necessary under this strategy. The cow herd was set at 43 cows and calves were retained as yearlings. Calves were weaned in late August and under unfavorable production and unfavorable price levels, heifers were generally sold in late April (the analysis showed sale of one heifer calf in October under state of nature 4). Purchase of 49 yearling steers was made in early March and all yearlings were usually sold in September.

Net returns above variable costs ranged from $32,246 under state of nature 1 (F/F) to $16,429 under state of nature 4 (U/U). Working capital requirement varied from $30,000 for state of nature 1 (F/F) to $28,000 for state of nature 4 (U/U).

Small ranch optimum strategy for unfavorable production and unfavorable price levels (SU/UO). The optimum strategy for state of nature 4 (U/U) also required intensive management of crop and livestock enterprises but limited investment in range improvement practices.

Due to seasonal forage imbalance, use of public land grazing permits was generally less than permitted use. However, in unfavorable production situations full use was made of BLM grazing permits. Use of private leases was reduced to 45 percent of 1977 levels in unfavorable production situations. Alfalfa was managed for 4.5 T/acre yields and hay was sold. Meadow was also managed for hay production and sale. One hundred thirty-five acres of foothill range was burned and seeded and no range forage was sold.

No hay purchases were necessary under this optimum strategy. The cow herd consisted of 43 cows and was intensively managed. Calves were weaned in late August and retained as yearlings. Forty-nine yearling steers were purchased in March. In years of unfavorable production yearling steers were purchased in March. In years of unfavorable production yearling heifers were sold in April. When production was unfavorable but prices were favorable six of the purchased steers were also sold in April; otherwise, yearlings were sold in September.

Net returns above variable costs in 1977 dollars ranged from $29,641 under state of nature 1 (F/F) to $16,580 under state of nature 2 (U/U). Working capital requirement in 1977 dollars varied

from $28,000 for state of nature 1 (F/F) to $26,000 for state of nature 4 (U/U).

Decision Theory Analysis

Decision theory analyses of the large and small Utah cattle ranches were undertaken as a means of evaluating ranch management strategies over time. Estimated returns to variable costs for each strategy operating under four all inclusive states of nature were weighted by probability estimates of the occurrence of those four states of nature to obtain expected values of the strategies over time. These analyses allow comparison of strategies based on the expected ranch business environment. In addition, income variability for operating under each strategy was estimated for both Utah cattle ranches.

Decision theory analysis of large ranch strategies

Results of decision theory analysis for the large Utah cattle ranch are presented in Table 18.

Little difference was apparent among expected values of optimum strategies based on various perceptions of the ranch business environment. Expected values of these strategies ranged from a high of $58,429.75 for the optimum strategy based on unfavorable production and favorable price levels to a low of $56,210.90 for the optimum strategy based on unfavorable production and unfavorable price levels. Expected values for all optimum strategies were approximately

Table 18. Management strategy expected values for the large Utah cattle ranch.

	State of Nature				
	F/F	F/U	U/F	U/U	Expected
Strategy	(P = .61 x .69)	(P = .61 x .31)	(P = .39 x .69)	(P = .39 x .31)	Value
1977 "As is"	(.42)(9,029.04) +	(.19)(3,118.02) +	(.27)(-12,614.08) +	(.12)(-13,636.06) =	$- 657.51
1977 Optimum	(.42)(71,328.47) +	(.19)(48,016.89) +	(.27)(49,817.84) +	(.12)(30,657.61) =	$56,210.90
F/F Optimum	(.42)(71,894.28) +	(.19)(47,153.10) +	(.27)(51,721.90) +	(.12)(31,330.76) =	$56,879.29
F/U Optimum	(.42)(70,998.51) +	(.19)(47,956.69) +	(.27)(52,531.70) +	(.12)(33,226.12) =	$57,101.84
U/F Optimum	(.42)(71,889.56) +	(.19)(47,951.69) +	(.27)(56,408.58) +	(.12)(32,458.30) =	$58,429.75
U/U Optimum	(.42)(70,382.65) +	(.19)(47,458.06) +	(.27)(54,250.03) +	(.12)(35,799.26) =	$57,521.16

Where:

F/F = Favorable production and favorable price levels.
F/U = Favorable production and unfavorable price levels.
U/F = Unfavorable production and favorable price levels.
U/U = Unfavorable production and unfavorable price levels.
P = Estimated probability of occurrence.

$58,000 greater than the negative expected value of $-657.51 for the strategy practiced in 1977.

Decision theory analysis of small ranch strategies

Results of the decision theory analysis for the small Utah cattle ranch are presented in Table 19.

As is the case with optimum strategies for the large ranch, little difference among expected values of optimum strategies for the small ranch was apparent. Expected values of optimum strategies ranged from a high of $26,985.08 for the optimum strategy based on favorable production and unfavorable prices to a low of $25,021.82 for the optimum strategy based on unfavorable production and unfavorable prices. All optimum strategies resulted in expected values approximately $26,000 greater than the expected value of $483.80 for the strategy practiced in 1977.

Income variability of large ranch strategies

Probability-weighted income variance, income standard deviation, and income standard deviation expressed as a percent of management strategy expected values for large ranch strategies are presented in Table 20. Although the strategy employed in 1977 had the smallest income variance and standard deviation, the income standard deviation expressed as a percent of the expected value was approximately sixty times larger than that same expression for any of the optimum strategies. Therefore, the relative income variability was much greater under the strategy practiced in 1977 than under any of the

Table 19. Management strategy expected values for the small Utah cattle ranch.

	State of Nature				
	F/F	F/U	U/F	U/U	Expected
Strategy	(P = .61 x .69)	(P = .61 x .31)	(P = .39 x .69)	(P = .39 x .31)	Value
1977 "As is"	(.42)(4,602.87) +	(.19)(2,285.93) +	(.27)(-4,681.40) +	(.12)(-5,164.63) =	$ 483.80
1977 Optimum	(.42)(32,336.75) +	(.19)(21,999.49) +	(.27)(23,920.09) +	(.12)(15,242.88) =	$26,048.91
F/F Optimum	(.42)(33,427.47) +	(.19)(22,456.23) +	(.27)(24,175.61) +	(.12)(15,125.40) =	$26,648.68
F/U Optimum	(.42)(33,376.80) +	(.19)(22,703.52) +	(.27)(24,906.95) +	(.12)(16,068.99) =	$26,985.08
U/F Optimum	(.42)(32,246.24) +	(.19)(21,841.78) +	(.27)(25,330.14) +	(.12)(16,428.72) =	$26,503.94
U/U Optimum	(.42)(29,641.24) +	(.19)(20,415.86) +	(.27)(24,829.14) +	(.12)(16,580.14) =	$25,021.82

Where:

F/F = Favorable production and favorable price levels.
F/U = Favorable production and unfavorable price levels.
U/F = Unfavorable production and favorable price levels.
U/U = Unfavorable production and unfavorable price levels.
P = Estimated probability of occurrence.

Table 20. Income variability measures for the large ranch management strategies.

Strategy	Expected Value ($)	Probability-Weighted Income Variance[1/] ($ squared)	Probability-Weighted Standard Deviation ($)	Standard Deviation / Expected Value (%)
1977 "As is"	-657.51	100,928,878.6	10,046.34	-1,527.9
1977 Optimum	56,210.90	198,135,833.5	14,076.07	25.0
F/F Optimum	56,879.29	198,171,662.5	14,077.35	24.7
F/U Optimum	57,101.84	171,045,008.8	13,078.42	22.9
U/F Optimum	58,429.75	178,994,905.1	13,378.90	22.9
U/U Optimum	57,521.16	148,226,056.5	12,174.81	21.2

Where:

F/F = Favorable production and favorable price levels.
F/U = Favorable production and unfavorable price levels.
U/F = Unfavorable production and favorable price levels.
U/U = Unfavorable production and unfavorable price levels.

[1/] Probability based on 50 years of climatic records and 26 years of economic data.

optimum strategies. The $14,076.07 standard deviation for the 1977 optimum strategy could be easily covered by the associated $56,210.90 expected value. The $10,046.34 standard deviation under the 1977 "As is" strategy is indicative of a serious situation considering the negative strategy expected value of $-683.80.

Income variability of small ranch strategies

Probability-weighted income variance, income standard deviation, and income standard deviation expressed as a percent of management strategy expected value for small ranch strategies are presented in Table 21. The management strategy employed in 1977 had the smallest probability-weighted income variance and standard deviation; however, the income standard deviation expressed as a percent of the strategy expected value was approximately forty times as large as the same expression for any of the optimum strategies.

Estimated Percent Return on Owned Ranch Capital by Ranch Size and Management Strategy

In order to evaluate the effect that various strategies have on the total ranch business for large and small Utah cattle ranches, percent return on owned ranch capital and probability-weighted average working capital requirement were estimated for each management strategy considered. These comparisons are presented in Table 22.

Table 21. Income variability measures for the small ranch management strategies.

Strategy	Expected Value ($)	Probability-Weighted Income Variance[1/] ($ squared)	Probability-Weighted Standard Deviation ($)	Standard Deviation / Expected Value (%)
1977 "As is"	483.80	18,775,067.6	4,333.02	895.6
1977 Optimum	26,048.91	34,957,134.1	5,912.46	22.7
F/F Optimum	26,648.68	40,225,056.6	6,342.32	23.8
F/U Optimum	26,985.08	36,107,100.2	6,008.92	22.3
U/F Optimum	26,503.94	30,532,088.4	5,525.58	20.8
U/U Optimum	25,021.82	21,554,134.4	4,642.64	18.6

Where:

F/F = Favorable production and favorable price levels.
F/U = Favorable production and unfavorable price levels.
U/F = Unfavorable production and favorable price levels.
U/U = Unfavorable production and unfavorable price levels.

[1/] Probability based on 50 years of climatic records and 26 years of economic data.

Table 22. Estimated working capital requirement and percent return on owned ranch capital for two Utah cattle ranches operating under six management strategies.

Management Strategy Basis	Working Capital Required (Weighted $\bar{x}$)		Expected Percent Return on Owned Ranch Capital	
	Large (1977 $)	Small (1977 $)	Large (%)	Small (%)
1977 "As is"	40,000	19,000	1.35	1.69
1977 Optimum	63,000	31,000	10.91	9.57
F/F Optimum	65,000	32,000	11.02	9.74
F/U Optimum	61,000	29,000	11.11	9.90
U/F Optimum	60,000	29,000	11.43	9.80
U/U Optimum	58,000	26,000	11.31	9.42

Where:

F/F = Favorable production and favorable price levels.
F/U = Favorable production and unfavorable price levels.
U/F = Unfavorable production and favorable price levels.
U/U = Unfavorable production and unfavorable price levels.

Percent return on owned ranch capital for the large ranch ranged from 1.35 percent under the 1977 "As is" strategy to 11.43 percent for the optimum strategy based on unfavorable production and favorable prices. All large ranch optimum strategies produced returns on owned ranch capital of approximately 11 percent.

Percent returns on owned capital for the small ranch ranged from 1.69 percent under the 1977 "As is" strategy to 9.90 percent for the optimum strategy based on favorable production and unfavorable prices. Other optimum strategies produced returns on owned ranch capital that were slightly less than 9.90 percent.

Optimum strategies producing the largest expected percent returns on owned ranch capital for the large and small ranches were based on different ranch business environment scenarios. The "best" large ranch strategy was the SF/UO strategy. This difference may reflect relative differences in resources controlled by each ranch or management intensity. The small ranch as described by Capps (1980) obtained higher levels of production from livestock and crops. These higher levels could be due to land resources of inherently higher productivity or higher intensity of management and labor.

Higher percent returns on owned ranch capital for optimum large and small ranch strategies than for the 1977 "As is" strategies resulted from higher optimum strategy expected values and lower amounts of owned ranch capital. Lower amounts of owned ranch capital reflected the reduced investment in cow herd required by the optimum strategies.

While higher percent return on owned ranch capital and greater returns to variable costs were obtained under optimum large and small strategies, the working capital requirement associated with optimum strategies was also higher. Working capital requirement ranged from $40,000 for the large ranch 1977 "As is" strategy to $65,000 for the optimum strategy based on favorable production and favorable price levels. Working capital requirement varied from $19,000 for the small ranch 1977 "As is" strategy to $32,000 for the small ranch optimum strategy based on favorable production and favorable price levels. Some or all of the increase in working capital required for optimum strategies could be supplied by capital previously committed to the investment in breeding stock.

Modified income statement summaries for large and small Utah cattle ranches which are the bases for calculation of percent return on owned ranch capital are presented in Tables 23-34 of Appendix B.

SUMMARY AND CONCLUSIONS

Utah ranchers realize relatively little profit from ranch ownership and management. Most of this profit is derived from land appreciation rather than operation of the ranch. Frequently, ranch operation is subsidized by land appreciation. The purpose of this study was to identify optimum ranch management strategies that produce more profit over time than the strategies employed in 1977.

To identify long-term optimum management strategies, analyses of ranches under both normal and adverse ranch operation conditions were necessary to allow comparison of strategies through time. To depict these ranch business environmental conditions, production levels were estimated from available biological data and price levels were estimated by indexing 1977 ranch product prices. In addition, the variability of returns to variable costs resulting from application of various strategies over time were estimated to evaluate the risk or income stability associated with each strategy. Overall profitability comparisons among strategies were needed to evaluate strategies in the context of ranch ownership and management. Percent returns on owned ranch capital were estimated for each strategy as the basis for this comparison.

The levels of biological production and product prices relative to variable production costs are the primary influences that affect ranch net returns above variable costs or profitability of ranch

operation. In order to evaluate long-term management strategies, information regarding results of strategy application under various environmental conditions was needed. Production levels that reflect average favorable and unfavorable production conditions and prices that reflect average favorable and unfavorable price levels relative to production costs were estimated. Linear programming analyses were applied for both large and small Utah ranches and optimum management strategies were identified for all combinations of production conditions and price levels. Analyses of management strategies applied in 1977 on large and small Utah ranches were made, and, in addition, optimum strategies based on average production and 1977 price levels were identified. Thus, the six management strategies identified for each ranch size were:

1. 1977 "As is" strategy,
2. 1977 optimum strategy based on average production and 1977 prices,
3. F/F optimum strategy based on favorable production and favorable prices,
4. F/U optimum strategy based on favorable production and unfavorable prices,
5. U/F optimum strategy based on unfavorable production and favorable prices,
6. U/U optimum strategy based on unfavorable production and unfavorable prices.

For each ranch size, operation of each of the six strategies under four states of nature was simulated. The four states of nature were:

1. favorable production and favorable price levels,
2. favorable production and unfavorable price levels,
3. unfavorable production and favorable price levels,
4. unfavorable production and unfavorable price levels.

Probability estimates were made for occurrence of each of the four states of nature based on 50 years of climatic data for Utah and 26 years of indices of prices paid and received by farmers tailored to Utah ranches. Probability-weighted average net returns above variable costs (expected values) were calculated for each management strategy based on decision theory analysis techniques. Income variability estimates were made by calculating the probability-weighted variance and standard deviation of strategy net returns above variable costs across the four states of nature. In addition, strategy standard deviation was expressed as a percentage of strategy expected values to place strategy probability-weighted variance and standard deviation into perspective.

Percent return on owned ranch capital was calculated for large and small Utah cattle ranches by strategy. Strategy expected values were entered in modified income statements as net returns above variable costs and percent return on owned ranch capital was calculated based on the strategy-specific amount of owned ranch capital.

Little difference was found among optimum strategies for the large and small ranch with the exception of the degree to which

range improvement practices were applied. All optimum strategies were based on intensive production and sale of alfalfa and meadow hay. Cow numbers were reduced to levels corresponding to the winter/spring range forage constraint and cow herds were intensively managed. Intensive management of the cow herd involved reducing the cow to bull ratio, increasing herd replacement rate, improving herd health, and, where the alternative was considered, weaning calves in late August. Calves were retained for sale as yearlings and yearling stocker steers were purchased as a means of utilizing available forage that was not needed by the cow herd in the spring, summer, and fall. Imposed maximum numbers of purchased steers allowed sale of surplus summer and fall forage. It was assumed that private foothill rangeland was not available in winter months due to snow cover. However, if such areas were in reality grazable during the winter period, optimum cow herd size would increase, purchased steers would continue to be used to take advantage of seasonal forage surplus, and it is doubtful that any private range forage would be sold. In addition, it is probable that under such conditions range improvement practices would be more intensively applied. Amount and intensity of practices applied varied from plowing and seeding of forage plant species on all available private foothill rangeland under the large and small ranch optimum strategies based on favorable production and favorable price levels to application of no range improvement practices under the large ranch optimum strategy based on unfavorable production and unfavorable price

levels. The small ranch optimum strategy based on unfavorable production and unfavorable price levels did include burning and seeding of approximately 10 percent of the foothill range, however. Spraying of foothill range was not selected as a range improvement practice under any optimum strategy for the large or small ranch. Due to the plant species composition assumed for fair condition foothill rangeland expected forage response from spray release was well below expected response from seeding. Likewise, allowable use of native species was assumed to be less than allowable use for commonly seeded species such as crested wheatgrass.

Since optimum strategies were similar within the large ranch and within the small ranch, optimum strategy expected returns above variable costs (probability-weighted expected values) were comparable within both ranch sizes. Optimum strategies produced expected net returns above variable costs $58,000 and $26,000 larger than strategies applied in 1977 for the large and small ranch, respectively, and working capital requirements increased approximately 50 percent. Strategies applied in 1977 on the large and small ranches resulted in less income variance and smaller income standard deviation than optimum strategies. However, these income standard deviations expressed as percentages of the strategy expected values (relative income variabilities) were approximately sixty times greater for the "As is" strategy than for large ranch optimum strategies and forty times greater for the small ranch "As is" strategy than for optimum strategies. In addition, the expected value for the large ranch "As is" strategy was negative indicating

long-term losses. Negative net returns above variable costs were shown for both ranches during periods of unfavorable production under the strategies employed in 1977. Although net returns above variable costs for optimum strategies were decreased with unfavorable production, they were always positive and at least three times greater than the best situations under the strategies applied in 1977.

Optimum strategies for large and small ranches lowered the amount of owned ranch capital by reducing the investiment in the cow herd and herd complement. Percent returns on owned ranch capital resulting from adoption of optimum strategies were approximately eight times larger than those for the 1977 strategy for the large Utah cattle ranch and six times larger than those for the 1977 strategy for the small ranch.

In conclusion, ranch economic analyses over the range of the ranch business environment add valuable information to the decision-making process. Optimum strategies represent ways that ranch returns to variable costs can be increased. However, actual adoption of a particular optimum strategy must be based on the relative optimism or pessimism of the individual rancher. Dramatically increased levels of income from optimum strategies often bring only a relatively small increase in income variability resulting in an overall increase in ranch business stability. Optimum strategies produce returns on owned ranch capital that are considerably higher than those possible under strategies practiced in 1977.

It may be generally recommended from these analyses, that ranch management strategies for Utah cattle ranches be based on the

economic principles of marginality and opportunity cost. Intensity of crop and livestock management should be increased until added management costs are equal to the added value of the products of various enterprises. The market value of hay exceeds the value received by feeding it to beef cattle; therefore, livestock enterprises should be based on less expensive forage alternatives, primarily range forage. Livestock enterprises should be flexible so expensive maintenance of the cow herd is not necessary under adverse environmental conditions. This flexibility can be incorporated by conversion from cow/calf to cow/yearling enterprises and initiation of stocker steer enterprises. The options available on an individual ranch are determined by the resources under ranch control. In some situations, there is no alternative to feeding hay to cows in the winter. Under such conditions, a seasonal steer enterprise may be the best alternative to maximize net returns above variable costs and increase percent return on owned ranch capital.

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APPENDICES

Appendix A

Large and Small Utah Cattle Ranch Data Sets Used in COPLAN Linear Programming Optimization

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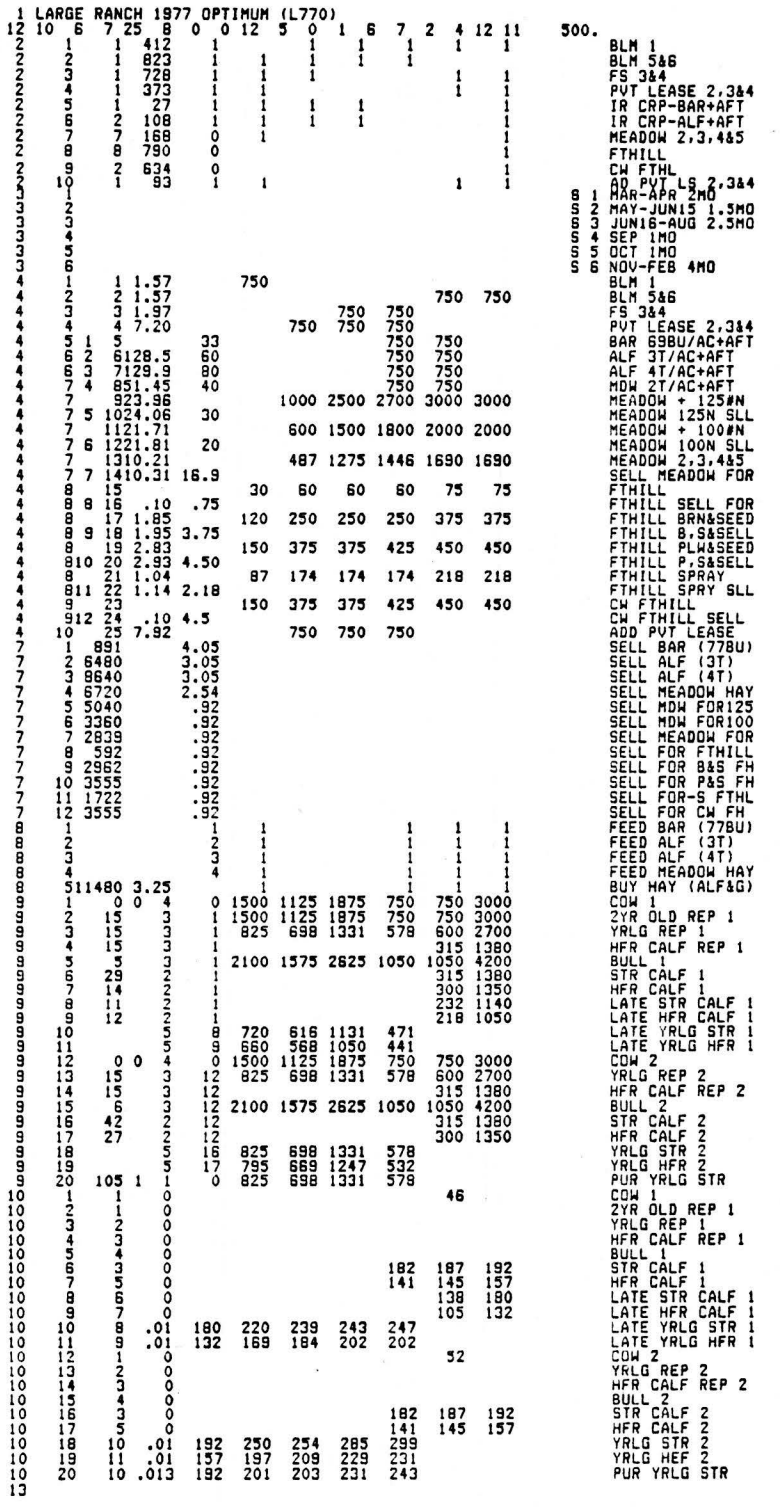
 1 LARGE RANCH 1977 AS IS (L77AI)
12  8  6  5  8  5  0  0  0  3  0  0  4  4  1  2  2 10      500.
 2     1     1 1235     1        1     1     1                    BLM 1,5&6
 2     2     1  728     1     1  1                 1     1       FS 3&4
 2     3     1  373     1     1                    1     1       PVT LEASE 2,3&4
 2     4     1   38     1     1  1     1                 1       IR CROP-BAR+AFT
 2     5     1   97     1     1  1     1                 1       IR CROP-ALF+AFT
 2     6     1  168     0     1                       1          MEADOW 2,3,4&5
 2     7     1  790     0                             1          FTHILL
 2     8     1  634     0                             1          CW FTHL
 3     1                                                  S 1   MAR-APR 2MO
 3     2                                                  S 2   MAY-JUN15 1.5MO
 3     3                                                  S 3   JUN16-AUG 2.5MO
 3     4                                                  S 4   SEP 1MO
 3     5                                                  S 5   OCT 1MO
 3     6                                                  S 6   NOV-FEB 4MO
 4     1     1 1.57        750                    750  750      BLM 1,5&6
 4     2     2 1.97                    750  750                 FS 3&4
 4     3     3 7.20              750   750  750                 PVT LEASE 2,3&4
 4     4 1   4          33                750  750              IR CROP-BAR+AFT
 4     5 2  3143.0       60                750  750              IR CROP-ALF+AFT
 4     6    610.21              487  1275 1446 1690 1690        MEADOW 2,3,4&5
 4     7     7    0          30    60   60   60   75   75       FTHILL
 4     8     8    0         150   375  375  425  450  450       CW FTHILL
 8     1                 1    1    1    1    1    1    1       BAR-RANCH
 8     2                 2    1    1    1    1    1    1       ALF-RANCH
 8     3 11480 3.25           1    1    1    1    1    1       BUY HAY (ALF&G)
 9     1   250 0   4     0 1500 1125 1875  750  750 3000       COW
 9     2    15     3     1 1500 1125 1875  750  750 3000       2YR OLD REP
 9     3    15     3     1  825  698 1331  578  600 2700       YRLG REP
 9     4    15     3     1                       315 1380       HFR CALF REP
 9     5     5     3     1 2100 1575 2625 1050 1050 4200       BULL
 9     6    29     2     1                       315           STR CALF
 9     7    14     2     1                       300           HFR CALF
 9     8    11     2     1                       232 1140      LATE CALF-STR
 9     9    12     2     1                       218 1050      LATE CALF-HFR
 9    10           5     8  720  616 1131                      LATE YRLG STR
 9    11           5     9  660  568 1050                      LATE YRLG HFR
10     1     1     0                             46           COW
10     2     1     0                                          2YR OLD REP
10     3     2     0                                          YRLG REP
10     4     3     0                                          HFR CALF REP
10     5     4     0                                          BULL
10     6     5     0                             180          STR CALF
10     7     6     0                             143          HFR CALF
10     8     7     0                                          LATE CALF-STR
10     9     8     0                                          LATE CALF-HFR
10    10     9   .01                   243                    LATE YRLG STR
10    11    10   .01                   202                    LATE YRLG HFR
13
```

Figure 1. COPLAN data set for the large ranch strategy in 1977.



```
 1 LARGE RANCH 1977 OPTIMUM (L770)
12 10  6  7 25  8  0  0 12  5  0  1  6  7  2  4 12 11    500.
 2    1    1  412     1        1    1    1    1    1          BLM 1
 2    2    1  823     1    1   1    1    1                    BLM 5&6
 2    3    1  728     1    1   1                   1    1     FS 3&4
 2    4    1  373     1    1                       1    1     PVT LEASE 2,3&4
 2    5    1   27     1    1   1    1                  1     IR CRP-BAR+AFT
 2    6    2  108     1    1   1    1                  1     IR CRP-ALF+AFT
 2    7    7  168     0    1                           1     MEADOW 2,3,4&5
 2    8    8  790     0                                1     FTHILL
 2    9    2  634     0                                1     CW FTHL
 2   10    1   93     1    1                       1    1     AD PVT LS 2,3&4
 3    1                                                  S 1 MAR-APR 2MO
 3    2                                                  S 2 MAY-JUN15 1.5MO
 3    3                                                  S 3 JUN16-AUG 2.5MO
 3    4                                                  S 4 SEP 1MO
 3    5                                                  S 5 OCT 1MO
 3    6                                                  S 6 NOV-FEB 4MO
 4    1    1 1.57        750                             BLM 1
 4    2    2 1.57                                 750  750 BLM 5&6
 4    3    3 1.97                      750  750           FS 3&4
 4    4    4 7.20                 750  750  750           PVT LEASE 2,3&4
 4    5 1  5          33                  750  750        BAR 69BU/AC+AFT
 4    6 2  6128.5     60                  750  750        ALF 3T/AC+AFT
 4    6 3  7129.9     80                  750  750        ALF 4T/AC+AFT
 4    7 4  851.45     40                  750  750        MDW 2T/AC+AFT
 4    7    923.86                1000 2500 2700 3000 3000 MEADOW + 125#N
 4    7 5 1024.06     30                                   MEADOW 125N SLL
 4    7   1121.71                 600 1500 1800 2000 2000 MEADOW + 100#N
 4    7 6 1221.81     20                                   MEADOW 100N SLL
 4    7   1310.21                 487 1275 1446 1690 1690 MEADOW 2,3,4&5
 4    7 7 1410.31 16.9                                    SELL MEADOW FOR
 4    8   15           30   60   60   60   75   75        FTHILL
 4    8 8 16  .10  .75                                    FTHILL SELL FOR
 4    8   17 1.85      120  250  250  250  375  375       FTHILL BRN&SEED
 4    8 9 18 1.95 3.75                                    FTHILL B,S&SELL
 4    8   19 2.83      150  375  375  425  450  450       FTHILL PLW&SEED
 4    810 20 2.93 4.50                                    FTHILL P,S&SELL
 4    8   21 1.04       87  174  174  174  218  218       FTHILL SPRAY
 4    811 22 1.14 2.18                                    FTHILL SPRY SLL
 4    9   23           150  375  375  425  450  450       CW FTHILL
 4    912 24  .10 4.5                                    CW FTHILL SELL
 4   10   25 7.82           750  750  750                 ADD PVT LEASE
 7    1  891        4.05                                 SELL BAR (77BU)
 7    2 6480        3.05                                 SELL ALF (3T)
 7    3 8640        3.05                                 SELL ALF (4T)
 7    4 6720        2.54                                 SELL MEADOW HAY
 7    5 5040         .92                                 SELL MDW FOR125
 7    6 3360         .92                                 SELL MDW FOR100
 7    7 2839         .92                                 SELL MEADOW FOR
 7    8  592         .92                                 SELL FOR FTHILL
 7    9 2962         .92                                 SELL FOR B&S FH
 7   10 3555         .92                                 SELL FOR P&S FH
 7   11 1722         .92                                 SELL FOR-S FTHL
 7   12 3555         .92                                 SELL FOR CW FH
 8    1                1    1                 1    1    1 FEED BAR (77BU)
 8    2                2    1                 1    1    1 FEED ALF (3T)
 8    3                3    1                 1    1    1 FEED ALF (4T)
 8    4                4    1                 1    1    1 FEED MEADOW HAY
 8    511480 3.25           1                 1    1    1 BUY HAY (ALF&G)
 9    1    0 0  4     0 1500 1125 1875  750  750 3000     COW 1
 9    2   15    3     1 1500 1125 1875  750  750 3000     2YR OLD REP 1
 9    3   15    3     1  825  698 1331  578  600 2700     YRLG REP 1
 9    4   15    3     1                       315 1380     HFR CALF REP 1
 9    5    5    3     1 2100 1575 2625 1050 1050 4200     BULL 1
 9    6   29    2     1                       315 1380     STR CALF 1
 9    7   14    2     1                       300 1350     HFR CALF 1
 9    8   11    2     1                       232 1140     LATE STR CALF 1
 9    9   12    2     1                       218 1050     LATE HFR CALF 1
 9   10         5     8  720  616 1131  471                 LATE YRLG STR 1
 9   11         5     9  660  568 1050  441                 LATE YRLG HFR 1
 9   12    0 0  4     0 1500 1125 1875  750  750 3000     COW 2
 9   13   15    3    12  825  698 1331  578  600 2700     YRLG REP 2
 9   14   15    3    12                       315 1380     HFR CALF REP 2
 9   15    6    3    12 2100 1575 2625 1050 1050 4200     BULL 2
 9   16   42    2    12                       315 1380     STR CALF 2
 9   17   27    2    12                       300 1350     HFR CALF 2
 9   18         5    16  825  698 1331  578                 YRLG STR 2
 9   19         5    17  795  669 1247  532                 YRLG HFR 2
 9   20  105 1  1     0  825  698 1331  578                 PUR YRLG STR
10    1    1    0                             46           COW 1
10    2    1    0                                          2YR OLD REP 1
10    3    2    0                                          YRLG REP 1
10    4    3    0                                          HFR CALF REP 1
10    5    4    0                                          BULL 1
10    6    3    0                        182  187  192     STR CALF 1
10    7    5    0                        141  145  157     HFR CALF 1
10    8    6    0                             138  180     LATE STR CALF 1
10    9    7    0                             105  132     LATE HFR CALF 1
10   10    8  .01  180  220  239  243  247                 LATE YRLG STR 1
10   11    9  .01  132  169  184  202  202                 LATE YRLG HFR 1
10   12    1    0                             52           COW 2
10   13    2    0                                          YRLG REP 2
10   14    3    0                                          HFR CALF REP 2
10   15    4    0                                          BULL 2
10   16    3    0                        182  187  192     STR CALF 2
10   17    5    0                        141  145  157     HFR CALF 2
10   18   10  .01  192  250  254  285  299                 YRLG STR 2
10   19   11  .01  157  197  209  229  231                 YRLG HEF 2
10   20   10 .013  192  201  203  231  243                 PUR YRLG STR
13
```

Figure 2. COPLAN data set for the large ranch optimum strategy based on average production and 1977 price levels.

```
 1 LARGE RANCH FAV/FAV OPTIMUM (LF/FO)
12 10  6  7 25  8  0  0 12  5  0  1  4  6  2  4 12 13      500.
 2    1    1  412     1          1    1    1    1    1          BLM 1
 2    2    1  823     1    1     1    1    1                    BLM 5&6
 2    3    1  728     1    1     1                   1    1     FS 3&4
 2    4    1  373     1    1                         1    1     PVT LEASE 2,3&4
 2    5    2  108     1    1     1    1                   1     IRR CROP-ALF
 2    6    1   27     1    1     1    1                   1     IRR CROP-BAR
 2    7    7  168     0    1                               1     MEADOW 2,3,4&5
 2    8    8  790     0                                    1     FTHILL
 2    9    2  634     0                                    1     CW FTHL
 2   10    1   93     1    1                         1    1     ADD PVT LEASE
 3    1                                                        S-1 MAR-APR 2MO
 3    2                                                        S-2 MAY-JUN15 1.5MO
 3    3                                                        S-3 JUN16-AUG 2.5MO
 3    4                                                        S-4 SEP 1MO
 3    5                                                        S-5 OCT 1MO
 3    6                                                        S-6 NOV-FEB 4MO
 4    1    1 1.57        750                                   BLM 1
 4    2    2 1.57                                   750  750   BLM 5&6
 4    3    3 1.97                         750  750             FS 3&4
 4    4    4 7.20              750  750  750                   PVT LEASE 2,3&4
 4    5 1  5128.5 51.8                    750  750             ALF 3T/AC
 4    5 2  6129.9 82.4                    750  750             ALF 4T/AC
 4    6 3  7         33                   750  750             BAR 69BU/AC
 4    7 4  851.45 41.2                    750  750             MEADOWHAY 2T/AC
 4    7    910.21              501 1313 1489 1740 1740        MEADOW
 4    7 5  1010.31 17.4                                       MEADOW FOR SELL
 4    7    1121.71             618 1545 1845 2060 2060        MEADOW 100#N/AC
 4    7 6  1221.81 20.6                                       MDW FOR100N SLL
 4    7    1323.96            1020 2575 2781 3090 3090        MEADOW 125#N/AC
 4    7 7  1424.06 30.9                                       MDW FOR125N SLL
 4    8   15          35   70   70   70   88   88             FTHILL
 4    8 8  16  .10  .88                                       FTHILL SELL FOR
 4    8   17  1.85       139  290  290  290  435  435        FTHILL BRN&SEED
 4    8 9  18  1.95 4.35                                      FTHILL B,S&SELL
 4    8   19  2.83       174  435  435  493  522  522        FTHILL PLW&SEED
 4  810 20  2.93 5.22                                       FTHILL P,S&SELL
 4    8   21  1.04       102  205  205  205  257  257        FTHILL SPRAY
 4  811 22  1.14 2.57                                       FTHILL SPRY&SLL
 4    9   23             174  435  435  493  522  522        CW FTHILL
 4  912 24  .10 5.22                                       CW FTHILL SELL
 4   10   25  7.92             750  750  750                 ADD PVT LEASE
 7    1 6674       4.07                                      SELL ALF(3.09T)
 7    2 8899       4.07                                      SELL ALF(4.12T)
 7    3  891       5.40                                      SELL BAR(69BU)
 7    4 8922       3.39                                      SELL MEADOWHAY
 7    5 2923       1.23                                      SELL MEADOW FOR
 7    6 3461       1.23                                      SELL MDW FOR100
 7    7 5191       1.23                                      SELL MDW FOR125
 7    8  695       1.23                                      SELL FOR FTHILL
 7    9 3436       1.23                                      SELL FOR B&S FH
 7   10 4124       1.23                                      SELL FOR P&S FH
 7   11 2030       1.23                                      SELL FOR S FH
 7   12 3309       1.23                                      SELL FOR CW FH
 8    1                  1    1                   1    1    1 FEED ALF(3.09T)
 8    2                  2    1                   1    1    1 FEED ALF(4.12T)
 8    3                  3    1                   1    1    1 FEED BAR(69BU)
 8    4                  4    1                   1    1    1 FEED MEADOWHAY
 8  511480 4.33          1                        1    1    1 BUY HAY (ALF&B)
 9    1    0 0  4       0 1500 1125 1875  750  750 3000      COW 1 (W-OCT)
 9    2   15    3       1  870  748 1388  600  622 2700      YRLG REP 1
 9    3   15    3       1                        330 1470      HFR CALF REP 1
 9    4    6    3       1 2100 1575 2625 1050 1050 4200      BULL 1
 9    5   43    2       1                        330 1470      STR CALF 1
 9    6   28    2       1                        315 1410      HFR CALF 1
 9    7         5       5  870  748 1388  600                 YRLG STR 1
 9    8         5       6  825  686 1256  532                 YRLG HFR 1
 9    9  105 1  1       0  870  748 1388  600                 PUR YRLG STR
 9   10    0 0  4       0 1500 1125 1875  541  541 3000      COW 2 (EW-AUG)
 9   11   15    3      10  900  759 1425  615  630 2700      YRLG REP 2
 9   12   15    3      10                 322  345 1530      HFR CALF REP 2
 9   13    6    3      10 2100 1575 2625 1050 1050 4200      BULL 2
 9   14   43    2      10                 322  345 1530      STR CALF 2
 9   15   28    2      10                 308  330 1470      HFR CALF 2
 9   16         5      14  900  759 1425  615                 YRLG STR 2
 9   17         5      15  855  703 1284  548                 YRLG HFR 2
10    1    1    0                                  52        COW 1 (W-OCT)
10    2    2    0                                            YRLG REP 1
10    3    3    0                                            HFR CALF REP 1
10    4    4    0                                            BULL 1
10    5    3    0                              251  257  262 STR CALF 1
10    6    5    0                              209  214  223 HFR CALF 1
10    7    6  .01  262  350  348  389  407                   YRLG STR 1
10    8    7  .01  223  258  289  310  325                   YRLG HFR 1
10    9    6 .013  262  300  295  332  348                   PUR YRLG STR
10   10    8    0                                  52        COW 2 (EW-AUG)
10   11    9    0                                            YRLG REP 2
10   12   10    0                                            HFR CALF REP 2
10   13    4    0                                            BULL 2
10   14   10    0                              251  268  271 STR CALF 2
10   15   11    0                              209  224  232 HFR CALF 2
10   16   12  .01  271  362  358  399  417                   YRLG STR 2
10   17   13  .01  232  297  293  319  334                   YRLG HFR 2
13
```

Figure 3. COPLAN data set for the large ranch optimum strategy based on favorable production and favorable price levels.

```
 1 LARGE RANCH FAV/UNFAV OPTIMUM (LF/UO)
12 10  6  7 25  8  0  0 12  5  0  1  4  6  2  4 12 13    500.
 2    1    1  412     1          1    1    1    1    1        BLM 1
 2    2    1  823     1    1     1    1    1                  BLM 5&6
 2    3    1  728     1    1     1                  1    1    FS 3&4
 2    4    1  373     1    1                        1    1    PVT LEASE 2,3&4
 2    5    2  108     1    1     1    1                  1    IRR CROP-ALF
 2    6    1   27     1    1     1    1                  1    IRR CROP-BAR
 2    7    7  168     0    1                             1    MEADOW 2,3,4&5
 2    8    8  790     0                                  1    FTHILL
 2    9    2  634     0                                  1    CW FTHL
 2   10    1   93     1    1                        1    1    ADD PVT LEASE
 3    1                                                       S-1 MAR-APR 2MO
 3    2                                                       S-2 MAY-JUN15 1.5MO
 3    3                                                       S-3 JUN16-AUG 2.5MO
 3    4                                                       S-4 SEP 1MO
 3    5                                                       S-5 OCT 1MO
 3    6                                                       S-6 NOV-FEB 4MO
 4    1    1 1.57       750                                  BLM 1
 4    2    2 1.57                                 750  750    BLM 5&6
 4    3    3 1.97                      750  750               FS 3&4
 4    4    4 7.20           750  750  750                    PVT LEASE 2,3&4
 4    5 1  5128.5 61.8                750  750               ALF 3T/AC
 4    5 2  6128.9 82.4                750  750               ALF 4T/AC
 4    6 3  7         33               750  750               BAR 69BU/AC
 4    7 4  851.45 41.2                750  750               MEADOWHAY 2T/AC
 4    7    910.21           501 1313 1489 1740 1740         MEADOW
 4    7 5 1010.31 17.4                                       MEADOW FOR SELL
 4    7   1121.71           618 1545 1845 2060 2060         MEADOW 100#N/AC
 4    7 6 1221.81 20.6                                       MDW FOR100N SLL
 4    7   1323.96          1020 2575 2781 3080 3090         MEADOW 125#N/AC
 4    7 7 1424.06 30.9                                       MDW FOR125N SLL
 4    8   15             35   70   70   70   88   88       FTHILL
 4    8 8 16   .10  .88                                     FTHILL SELL FOR
 4    8   17 1.85        139  290  290  290  435  435       FTHILL BRN&SEED
 4    8 9 18 1.95 4.35                                     FTHILL B.S&SELL
 4    8   19 2.83        174  435  435  493  522  522       FTHILL PLW&SEED
 4   810 20 2.93 5.22                                     FTHILL P.S&SELL
 4    8   21 1.04        102  205  205  205  257  257       FTHILL SPRAY
 4   811 22 1.14 2.57                                     FTHILL SPPY&SLL
 4    9   23             174  435  435  493  522  522       CW FTHILL
 4   912 24   .10 5.22                                     CW FTHILL SELL
 4   10  25 7.92             750  750  750                  ADD PVT LEASE
 7    1 6674       3.05                                     SELL ALF(3.09T)
 7    2 8899       3.05                                     SELL ALF(4.12T)
 7    3  891       4.05                                     SELL BAR(69BU)
 7    4 6922       2.54                                     SELL MEADOWHAY
 7    5 2923        .92                                     SELL MEADOW FOR
 7    6 3461        .92                                     SELL MDW FOR100
 7    7 5191        .92                                     SELL MDW FOR125
 7    8  695        .92                                     SELL FOR FTHILL
 7    9 3436        .92                                     SELL FOR B&S FH
 7   10 4124        .92                                     SELL FOR P&S FH
 7   11 2030        .92                                     SELL FOR S FH
 7   12 3309        .92                                     SELL FOR CW FH
 8    1                1    1                 1    1    1    FEED ALF(3.09T)
 8    2                2    1                 1    1    1    FEED ALF(4.12T)
 8    3                3    1                 1    1    1    FEED BAR(69BU)
 8    4                4    1                 1    1    1    FEED MEADOWHAY
 8   511480 3.25            1                 1    1    1    BUY HAY (ALF&G)
 9    1    0  0  4    0 1500 1125 1875  750  750 3000        COW 1 (W-OCT)
 9    2   15    3    1  870  748 1388  600  622 2700        YRLG REP 1
 9    3   15    3    1                       330 1470        HFR CALF REP 1
 9    4    6    3    1 2100 1575 2625 1050 1050 4200        BULL 1
 9    5   43    2    1                       330 1470        STR CALF 1
 9    6   28    2    1                       315 1410        HFR CALF 1
 9    7              5    5  870  748 1388  600              YRLG STR 1
 9    8              5    6  825  686 1256  532              YRLG HFR 1
 9    9  105 1  1    0  870  748 1388  600                   PUR YRLG STR
 9   10    0  0  4   10 1500 1125 1875  541  541 3000        COW 2 (EW-AUG)
 9   11   15    3   10  900  759 1425  615  630 2700        YRLG REP 2
 9   12   15    3   10                  322  345 1530        HFR CALF REP 2
 9   13    6    3   10 2100 1575 2625 1050 1050 4200        BULL 2
 9   14   43    2   10                  322  345 1530        STR CALF 2
 9   15   28    2   10                  308  330 1470        HFR CALF 2
 9   16              5   14  900  759 1425  615              YRLG STR 2
 9   17              5   15  855  703 1284  548              YRLG HFR 2
10    1    1    0                            52              COW 1 (W-OCT)
10    2    2    0                                            YRLG REP 1
10    3    3    0                                            HFR CALF REP 1
10    4    4    0                                            BULL 1
10    5    3    0                       213  218  222        STR CALF 1
10    6    5    0                       177  181  189        HFR CALF 1
10    7    6  .01  222  297  295  330  345                   YRLG STR 1
10    8    7  .01  189  244  245  263  276                   YRLG HFR 1
10    9    6 .013  222  248  243  274  288                   PUR YRLG STR
10   10    8    0                            52              COW 2 (EW-AUG)
10   11    9    0                                            YRLG REP 2
10   12   10    0                                            HFR CALF REP 2
10   13    4    0                                            BULL 2
10   14   10    0                       213  228  230        STR CALF 2
10   15   11    0                       177  190  196        HFR CALF 2
10   16   12  .01  230  306  304  338  354                   YRLG STR 2
10   17   13  .01  196  252  249  270  283                   YRLG HFR 2
13
```

Figure 4. COPLAN data set for the large ranch optimum strategy based on favorable production and unfavorable price levels.

```
 1 LARGE RANCH UNFAV/FAV OPTIMUM (LU/FD)
12  9  6  6 24   7  0  0 12  5  0   1   4   6   2   4 12 13    500.
 2    1    1  371     1          1     1     1     1     1          BLM 1
 2    2    1  741     1     1    1     1     1                      BLM 5&6
 2    3    1  677     1     1    1                 1     1          FS 3&4
 2    4    1  347     1     1                       1     1          PVT LEASE 2,3&4
 2    5    2  108     1     1    1     1                 1          IRR CROP-ALF
 2    6    1   27     1     1    1     1                 1          IRR CROP-BAR
 2    7    7  168     0     1                             1          MEADOW 2,3,4&5
 2    8    8  790     0                                   1          FTHILL
 2    9    2  634     0                                   1          CW FTHL
 3    1                                                             MAR-APR 2MO
 3    2                                                             MAY-JUN15 1.5MO
 3    3                                                             JUN16-AUG 2.5MO
 3    4                                                             SEP 1MO
 3    5                                                             OCT 1MO
 3    6                                                             NOV-FEB 4MO
 4    1    1 1.57      750                                        BLM 1
 4    2    2 1.57                                  750   750      BLM 5&6
 4    3    3 1.97                      750   750                  FS 3&4
 4    4    4 7.20            750   750   750                      PVT LEASE 2,3&4
 4    5 1  5128.5 58.2                  750   750                ALF 3T/AC
 4    5 2  6129.9 77.6                  750   750                ALF 4T/AC
 4    6 3  7         33                 750   750                BAR 69BU/AC
 4    7 4  851.45    38                 750   750                MEADOWHAY 2T/AC
 4    7    910.21                438 1148 1302 1521 1521          MEADOW
 4    7 5 1010.3115.21                                           MEADOW FOR SELL
 4    7    1121.71                570 1425 1702 1900 1900          MEADOW 100#N/AC
 4    7 6 1221.8119.00                                           MDW FOR100N SLL
 4    7    1323.96                941 2375 2565 2850 2850          MEADOW 125#N/AC
 4    7 7 1424.0628.50                                           MDW FOR125N SLL
 4    8   15                20   40   40   40   50   50          FTHILL
 4    8 8 16  .10  .50                                          FTHILL SELL FOR
 4    8   17 1.85           81  170  170  170  255  255          FTHILL BRN&SEED
 4    8 9 18 1.95 2.55                                          FTHILL B,S&SELL
 4    8   19 2.83          102  255  255  289  306  306          FTHILL PLW&SEED
 4   810 20 2.93 3.06                                           FTHILL P,S&SELL
 4    8   21 1.04           57  115  115  115  144  144          FTHILL SPRAY
 4   811 22 1.14 1.44                                           FTHILL SPRY&SLL
 4    9   23               102  255  255  289  306  306          CW FTHILL
 4   912 24  .10 3.06                                           CW FTHILL SELL
 7    1 6286      4.07                                          SELL ALF(2.91T)
 7    2 8381      4.07                                          SELL ALF(3.88T)
 7    3  891      5.40                                          SELL BAR(69BU)
 7    4 6384      3.39                                          SELL MEADOWHAY
 7    5 2555      1.23                                          SELL MEADOW FOR
 7    6 3192      1.23                                          SELL MDW FOR100
 7    7 4788      1.23                                          SELL MDW FOR125
 7    8  395      1.23                                          SELL FOR FTHILL
 7    9 2014      1.23                                          SELL FOR B&S FH
 7   10 2417      1.23                                          SELL FOR P&S FH
 7   11 1138      1.23                                          SELL FOR S FH
 7   12 1940      1.23                                          SELL FOR CW FH
 8    1                1     1                 1     1     1     FEED ALF(2.91T)
 8    2                2     1                 1     1     1     FEED ALF(3.88T)
 8    3                3     1                 1     1     1     FEED BAR(69BU)
 8    4                4     1                 1     1     1     FEED MEADOWHAY
 8  511480 4.33              1                 1     1     1     BUY HAY (ALF&G)
 9    1    0 0  4     0 1500 1125 1875  750   750 3000          COW 1 (W-OCT)
 9    2   15    3     1  818  686 1281  544   570 2700          YRLG REP 1
 9    3   15    3     1                       303 1395          HFR CALF REP 1
 9    4    6    3     1 2100 1575 2625 1050  1050 4200          BULL 1
 9    5   40    2     1                       303 1395          STR CALF 1
 9    6   26    2     1                       282 1311          HFR CALF 1
 9    7         5     5  818  686 1281  544                     YRLG STR 1
 9    8         5     6  771  641 1172  491                     YRLG HFR 1
 9    9  105 1  1     0  818  686 1281  544                     PUR YRLG STR
 9   10    0 0  4     0 1500 1125 1875  541   541 3000          COW 2 (EW-AUG)
 9   11   15    3    10  846  711 1350  581   600 2700          YRLG REP 2
 9   12   15    3    10                 303   314 1452          HFR CALF REP 2
 9   13    6    3    10 2100 1575 2625 1050  1050 4200          BULL 2
 9   14   40    2    10                 303   314 1452          STR CALF 2
 9   15   26    2    10                 282   293 1368          HFR CALF 2
 9   16         5    14  846  711 1350  581                     YRLG STR 2
 9   17         5    15  801  664 1222  518                     YRLG HFR 2
10    1    1    0                            52                COW 1 (W-OCT)
10    2    2    0                                              YRLG REP 1
10    3    3    0                                              HFR CALF REP 1
10    4    4    0                                              BULL 1
10    5    3    0                       236   242   250        STR CALF 1
10    6    5    0                       192   197   209        HFR CALF 1
10    7    6 .016  250  325  325  355  367                     YRLG STR 1
10    8    7 .016  209  268  271  288  298                     YRLG HFR 1
10    9    6 .020  250  275  273  298  308                     PUR YRLG STR
10   10    8    0                            52                COW 2 (EW-AUG)
10   11    9    0                                              YRLG REP 2
10   12   10    0                                              HFR CALF REP 2
10   13    4    0                                              BULL 2
10   14   10    0                       236   253   259        STR CALF 2
10   15   11    0                       192   207   217        HFR CALF 2
10   16   12 .016  259  336  338  379  392                     YRLG STR 2
10   17   13 .016  217  278  280  303  314                     YRLG HFR 2
13
```

Figure 5. COPLAN data set for the large ranch optimum strategy based on unfavorable production and favorable price levels.

```
1 LARGE RANCH UNFAV/UNFAV OPTIMUM (LU/UQ)
12  9  6  6 24  7  0  0 12  5  0  1  4  6  2  4 12 13     500.
 2     1     1  371     1        1     1     1     1     1        BLM 1
 2     2     1  741     1     1  1     1     1                    BLM 5&6
 2     3     1  677     1     1  1                 1     1        FS 3&4
 2     4     1  347     1     1                       1     1     PVT LEASE 2,3&4
 2     5     2  108     1     1  1     1                 1        IRR CROP-ALF
 2     6     1   27     1     1  1     1                 1        IRR CROP-BAR
 2     7     7  168     0     1                       1           MEADOW 2,3,4&5
 2     8     8  790     0                             1           FTHILL
 2     9     2  834     0                             1           CW FTHL
 3     1                                                    S-1 MAR-APR 2MO
 3     2                                                    S-2 MAY-JUN15 1.5MO
 3     3                                                    S-3 JUN16-AUG 2.5MO
 3     4                                                    S-4 SEP 1MO
 3     5                                                    S-5 OCT 1MO
 3     6                                                    S-6 NOV-FEB 4MO
 4     1     1 1.57        750                             BLM 1
 4     2     2 1.57                                 750  750  BLM 5&6
 4     3     3 1.97                    750  750             FS 3&4
 4     4     4 7.20              750   750  750             PVT LEASE 2,3&4
 4     5 1  5128.5 58.2                 750  750           ALF 3T/AC
 4     5 2  6129.9 77.6                 750  750           ALF 4T/AC
 4     6 3  7          33              750  750           BAR 69BU/AC
 4     7 4  851.45    38              750  750           MEADOWHAY 2T/AC
 4     7    910.21                438 1148 1302 1521 1521 MEADOW
 4     7 5 1010.3115.21                                    MEADOW FOR SELL
 4     7   1121.71                 570 1425 1702 1900 1900 MEADOW 100#N/AC
 4     7 6 1221.8119.00                                    MDW FOR100N SLL
 4     7   1323.96                 941 2375 2565 2850 2850 MEADOW 125#N/AC
 4     7 7 1424.0628.50                                    MDW FOR125N SLL
 4     8    15           20   40   40   40   50   50      FTHILL
 4     8 8 16   .10  .50                                   FTHILL SELL FOR
 4     8   17 1.85       81  170  170  170  255  255      FTHILL BRN&SEED
 4     8 9 18 1.95 2.55                                    FTHILL B,S&SELL
 4     8   19 2.83      102  255  255  289  306  306      FTHILL PLW&SEED
 4   810 20 2.93 3.06                                    FTHILL P,S&SELL
 4     8   21 1.04       57  115  115  115  144  144      FTHILL SPRAY
 4   811 22 1.14 1.44                                    FTHILL SPRY&SLL
 4     9   23          102  255  255  289  306  306      CW FTHILL
 4   912 24   .10 3.06                                    CW FTHILL SELL
 7     1 6286      3.05                                    SELL ALF(2.91T)
 7     2 8381      3.05                                    SELL ALF(3.88T)
 7     3  891      4.05                                    SELL BAR(69BU)
 7     4 6384      2.54                                    SELL MEADOWHAY
 7     5 2555       .92                                    SELL MEADOW FOR
 7     6 3192       .92                                    SELL MDW FOR100
 7     7 4788       .92                                    SELL MDW FOR125
 7     8  395       .92                                    SELL FOR FTHILL
 7     9 2014       .92                                    SELL FOR B&S FH
 7    10 2417       .92                                    SELL FOR P&S FH
 7    11 1138       .92                                    SELL FOR S FH
 7    12 1940       .92                                    SELL FOR CW FH
 8     1              1     1                 1     1     1  FEED ALF(2.91T)
 8     2              2     1                 1     1     1  FEED ALF(3.88T)
 8     3              3     1                 1     1     1  FEED BAR(69BU)
 8     4              4     1                 1     1     1  FEED MEADOWHAY
 8   511480 3.25            1                 1     1     1  BUY HAY (ALF&G)
 9     1    0 0  4     0 1500 1125 1875  750  750 3000      COW 1 (W-OCT)
 9     2   15    3     1  818  686 1281  544  570 2700      YRLG REP 1
 9     3   15    3     1                       303 1395      HFR CALF REP 1
 9     4    6    3     1 2100 1575 2625 1050 1050 4200      BULL 1
 9     5   40    2     1                       303 1395      STR CALF 1
 9     6   26    2     1                       282 1311      HFR CALF 1
 9     7         5     5  818  686 1281  544                 YRLG STR 1
 9     8         5     6  771  641 1172  491                 YRLG HFR 1
 9     9  105 1  1     0  818  686 1281  544                 PUR YRLG STR
 9    10    0 0  4     0 1500 1125 1875  541  541 3000      COW 2 (EW-AUG)
 9    11   15    3    10  846  711 1350  581  600 2700      YRLG REP 2
 9    12   15    3    10                 303  314 1452      HFR CALF REP 2
 9    13    6    3    10 2100 1575 2625 1050 1050 4200      BULL 2
 9    14   40    2    10                 303  314 1452      STR CALF 2
 9    15   26    2    10                 282  293 1368      HFR CALF 2
 9    16         5    14  846  711 1350  581                 YRLG STR 2
 9    17         5    15  801  664 1222  518                 YRLG HFR 2
10     1    1    0                            52           COW 1 (W-OCT)
10     2    2    0                                         YRLG REP 1
10     3    3    0                                         HFR CALF REP 1
10     4    4    0                                         BULL 1
10     5    3    0                       202  208  214      STR CALF 1
10     6    5    0                       164  169  179      HFR CALF 1
10     7    6 .016  214  278  279  304  315                 YRLG STR 1
10     8    7 .016  179  229  232  247  255                 YRLG HFR 1
10     9    6 .020  214  229  228  249  258                 PUR YRLG STR
10    10    8    0                            52           COW 2 (EW-AUG)
10    11    9    0                                         YRLG REP 2
10    12   10    0                                         HFR CALF REP 2
10    13    4    0                                         BULL 2
10    14   10    0                       202  217  222      STR CALF 2
10    15   11    0                       164  177  186      HFR CALF 2
10    16   12 .016  222  288  290  325  336                 YRLG STR 2
10    17   13 .016  186  238  240  260  269                 YRLG HFR 2
13
```

Figure 6. COPLAN data set for the large ranch optimum strategy based on unfavorable production and unfavorable price levels.

```
 1 SMALL RANCH 1977 AS IS (S77AI)
12  7  6  5  7  5  0  0  0  3  0  0  2  4  1  0  2  6    500.
 2     1     1   455     1        1     1     1                 BLM 1,5&6
 2     2     1   340     1     1  1                 1     1     FS 3&4
 2     3     1   195     1     1                       1     1  PVT LEASE 2,3&4
 2     4     1    54     1     1     1                       1  IR CROP-ALF+AFT
 2     5     1    15     1     1     1     1                 1  IR CROP-BAR+AFT
 2     6     1    48     0     1                             1  MEADOW
 2     7     1  1400     0                                   1  FTHILL
 3     1                                                        S 1  MAR-APR 2MO
 3     2                                                        S 2  MAY-JUN15 1.5MO
 3     3                                                        S 3  JUN16-AUG 2.5MO
 3     4                                                        S 4  SEPT 1MO
 3     5                                                        S 5  OCT 1MO
 3     6                                                        S 6  NOV-FEB 4MO
 4     1     1 1.57        750                       750   750     BLM 1,5&6
 4     2     2 1.97                    750   750                   FS 3&4
 4     3     3 7.20              750   750   750                   PVT LEASE 2,3&4
 4     4  1  4142.6    70                    750   750           IR CROP-ALF+AFT
 4     5  2  5         37                    750   750           IR CROP-BAR+AFT
 4     6     614.21                  487  1275  1446  1690  1690  MEADOW
 4     7     7     0           30    60    60    60    75    75  FTHILL
 8     1     0              1     1     1     1     1     1     1  ALFALFA-RANCH
 8     2     0              2     1     1     1     1     1     1  BARLEY-RANCH
 8     3  5600  3.25              1     1     1     1     1     1  BUY HAY (ALF&G)
 9     1   122  0  4     0  1500  1125  1875   750   750  3000     COW
 9     2    15     3     1  1500  1125  1875   750   750  3000     2 YR OLD REP
 9     3    15     3     1   862   714  1331   581   600  2700     YRLG REP
 9     4    15     3     1                             338  1530  HFR CALF REP
 9     5     4     3     1  2100  1575  2625  1050  1050  4200     BULL
 9     6    41     2     1                             338        STR CALF
 9     7    25     2     1                             315        HFR CALF
10     1     1     0                                    22        COW
10     2     1     0                                              2 YR OLD COW
10     3     2     0                                              YRLG REP
10     4     3     0                                              HFR CALF REP
10     5     4     0                                              BULL
10     6     5     0                                    193       STR CALF
10     7     8     0                                    150       HFR CALF
13
```

Figure 7. COPLAN data set for the small ranch strategy in 1977.

```
 1 SMALL RANCH 1977 OPTIMUM (8770)
12  9  6  7 23  8  0  0 11  5  0  1  4  7  2  4 11  7    500.
 2    1    1  152     1          1     1     1     1     1        BLM 1
 2    2    1  303     1     1    1     1     1                    BLM 5&6
 2    3    1  340     1     1    1                 1     1        FS 3&4
 2    4    1  195     1     1                       1     1        PVT LEASE 2,3&4
 2    5    2   55     1     1    1     1                1        IR CROP-ALF+AFT
 2    6    1   14     1     1    1     1                1        IR CROP-BAR+AFT
 2    7    7   48     0     1                             1        MEADOW 2,3,4&5
 2    8    8 1400     0                                   1        FTHILL
 2    9    1   49     1     1                             1        AD PVT LS 2,3&4
 3    1                                                          S 1 MAR-APR 2MO
 3    2                                                          S 2 MAY-JUN15 1.5MO
 3    3                                                          S 3 JUN16-AUG 2.5MO
 3    4                                                          S 4 SEP 1MO
 3    5                                                          S 5 OCT 1MO
 3    6                                                          S 6 NOV-FEB 4MO
 4    1    1 1.57        750                                     BLM 1
 4    2    2 1.57                                   750   750     BLM 5&6
 4    3    3 1.97                          750   750             FS 3&4
 4    4    4 7.20                    750   750   750             PVT LEASE 2,3&4
 4    5 1  5142.6   70                          750   750       ALF 3.5T/AC RTN
 4    5 2  6144.1   90                          750   750       ALF 4.5T/AC RTN
 4    6 3  7 0.0    37                          750   750       BAR 77BU/AC RTN
 4    7    814.21                    487  1275  1446  1690  1690 MEADOW
 4    7 4  914.31 16.9                                         SELL MEADOW FOR
 4    7 5 1072.89   40                          750   750       MEADOW 2T/AC
 4    7   1127.96                   1000  2500  2700  3000  3000 MEADOW + 125#N
 4    7 6 1228.06   30                                         MEADOW-125N SLL
 4    7   1325.71                    600  1500  1800  2000  2000 MEADOW + 100#N
 4    7 7 1425.81   20                                         MEADOW-100N SLL
 4    8   15                  30    60    60    60    75    75 FTHILL
 4    8 8 16  .10   .75                                        FTHILL SELL FOR
 4    8   17 1.85             120   250   250   250   375   375 FTHILL BRN+SEED
 4    8 9 18 1.95  3.75                                        FTHILL B+S&SELL
 4    8   19 2.83             150   375   375   425   450   450 FTHILL PLW+SEED
 4    810 20 2.93  4.5                                        FTHILL P+S&SELL
 4    8   21 1.04              87   174   174   174   218   218 FTHILL SPRAY
 4    811 22 1.14  2.18                                       FTHILL SPRY SLL
 4    9   23 7.92                    750   750   750           ADD PVT LEASE
 7    1 3850       3.05                                       SELL ALF4(3.5T)
 7    2 4950       3.05                                       SELL ALF4(4.5T)
 7    3  518       4.05                                       SELL BAR (77BU)
 7    4  811        .92                                       SELL MEADOW FOR
 7    5 1920       2.54                                       SELL MEADOW HAY
 7    6 1440        .92                                       SELL MDW FOR125
 7    7  960        .92                                       SELL MDW FOR100
 7    8 1050        .92                                       SELL FOR-FTHILL
 7    9 5250        .92                                       SELL FOR-B&S FH
 7   10 6300        .92                                       SELL FOR-P&S FH
 7   11 3052        .92                                       SELL FOR-S FTHL
 8    1                1     1                 1     1     1  FEED ALF (3.5T)
 8    2                2     1                 1     1     1  FEED ALF (4.5T)
 8    3                3     1                 1     1     1  FEED BAR (77BU)
 8    4                4     1                 1     1     1  FEED MEADOW HAY
 8    5 5600 3.25            1                 1     1     1  BUY HAY (ALF&G)
 9    1    0    4     0 1500  1125  1875   750   750  3000  COW 1
 9    2   15    3     1 1500  1125  1875   750   750  3000  2YR OLD REP 1
 9    3   15    3     1  862   714  1331   581   600  2700  YRLG REP 1
 9    4   15    3     1                          338  1530  HFR CALF REP 1
 9    5    4    3     1 2100  1575  2625  1050  1050  4200  BULL 1
 9    6   40    2     1                          338  1530  STEER CALF 1
 9    7   26    2     1                          315  1410  HFR CALF 1
 9    8         5     6  962   714  1331   581             YRLG STR 1
 9    9         5     7  810   664  1219   518             YRLG HFR 1
 9   10    0    4     0 1500  1125  1875   750   750  3000  COW 2
 9   11   15    3    10  862   714  1331   581   600  2700  YRLG REP 2
 9   12   15    3    10                          338  1530  HFR CALF REP 2
 9   13    5    3    10 2100  1575  2625  1050  1050  4200  BULL 2
 9   14   42    2    10                          338  1530  STEER CALF 2
 9   15   27    2    10                          315  1410  HFR CALF 2
 9   16         5    14  962   714  1331   581             YRLG STR 2
 9   17         5    15  810   664  1219   518             YRLG HFR 2
 9   18   49 1  1     0  862   714  1331   581             PUR YRLG STR
10    1    1    0                                22        COW 1
10    2    1    0                                          2YR OLD REP 1
10    3    2    0                                          YRLG REP 1
10    4    3    0                                          HFR CALF REP 1
10    5    4    0                                          BULL 1
10    6    3    0                          198   200   203  STEER CALF 1
10    7    3    0                          149   152   164  HFR CALF 1
10    8    6  .01   203   243   258   281   306             YRLG STR 1
10    9    7  .01   164   200   211   236   238             YRLG HFR 1
10   10    1    0                                28        COW 2
10   11    2    0                                          YRLG REP 2
10   12    3    0                                          HFR CALF REP 2
10   13    4    0                                          BULL 2
10   14    3    0                          196   200   203  STEER CALF 2
10   15    5    0                          149   152   164  HFR CALF 2
10   16    6  .01   203   243   258   281   306             YRLG STR 2
10   17    7  .01   164   200   211   236   238             YRLG HFR 2
10   18    6 .013   203   210   223   242   266             PUR YRLG STR
13
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Figure 8. COPLAN data set for the small ranch optimum strategy based on average production and 1977 price levels.

```
 1 SMALL RANCH FAV/FAV OPTIMUM (SF/FD)
12  9  6  7 23  8  0  0 11  5  0  1  4  8  2  4 11 13     500.
 2     1     1   152     1        1     1     1     1     1        BLM 1
 2     2     1   303     1     1  1     1     1     1              BLM 5&6
 2     3     1   340     1     1  1                 1     1        FS 3&4
 2     4     1   195     1     1                       1     1     PVT LEASE 2,3&4
 2     5     2    55     1     1     1     1                 1     IRR CROP-ALF
 2     6     1    14     1     1     1     1                 1     IRR CROP-BAR
 2     7     7    48     0     1                               1     MEADOW 2,3,4&5
 2     8     8  1400     0                                     1     FTHILL
 2     9     1    49     1     1                       1     1     ADD PVT LEASE
 3     1                                                           S-1 MAR-APR 2MO
 3     2                                                           S-2 MAY-JUN15 1.5MO
 3     3                                                           S-3 JUN16-AUG 2.5MO
 3     4                                                           S-4 SEP 1MO
 3     5                                                           S-5 OCT 1MO
 3     6                                                           S-6 NOV-DEC 4MO
 4     1     1 1.57        750                                     BLM 1
 4     2     2 1.57                                  750   750     BLM 5&6
 4     3     3 1.97                          750   750             FS 3&4
 4     4     4 7.20              750   750   750                   PVT LEASE 2,3&4
 4     5  1  5142.6 71.8                    750   750             ALF 3.5T/AC
 4     5  2  6144.1 92.8                    750   750             ALF 4.5T/AC
 4     6  3  7          37                  750   750             BAR 77BU/AC
 4     7  4  872.89 41.2                    750   750             MEADOWHAY 2T/AC
 4     7     914.21              502  1313  1489  1740  1740      MEADOW
 4     7  5 1014.31 17.4                    618  1545  1854  2060  2060  MEADOW SELL FOR
 4     7     1125.71                    1030  2575  2781  3090  3090  MEADOW 100#N/AC
 4     7  6 1225.81 20.6                    1030  2575  2781  3090  3090  MEADOW 100N SLL
 4     7     1327.96                    1236  3090  3337  3708  3708  MEADOW 125#N/AC
 4     7  7 1428.06 30.9                    1236  3090  3337  3708  3708  MEADOW 125N SLL
 4     8    15                    35    71    71    71    88    88     FTHILL
 4     8  8 16   .10   .88                                             FTHILL SELL FOR
 4     8    17 1.85              139   290   290   290   435   435     FTHILL BRN&SEED
 4     8  9 18 1.95  4.35                                             FTHILL B,S&SELL
 4     8    19 2.83              174   435   435   493   522   522     FTHILL PLW&SEED
 4     8 10 20 2.93  5.22                                             FTHILL P,S&SELL
 4     8    21 1.04              103   205   205   205   257   257     FTHILL SPRAY
 4     8 11 22 1.14  2.57                                             FTHILL SPRY&SLL
 4     9    23 7.92                    750   750   750               ADD PVT LEASE
 7     1  3949        3.96                                            SELL ALF(3.5T)
 7     2  5104        3.96                                            SELL ALF(4.5T)
 7     3   518        5.26                                            SELL BAR(77BU)
 7     4  1977        3.30                                            SELL MEADOWHAY
 7     5   835        1.19                                            SELL MEADOW FOR
 7     6   988        1.19                                            SELL MDW FOR100
 7     7  1483        1.19                                            SELL MDW FOR125
 7     8  1232        1.19                                            SELL FTHILL FOR
 7     9  6090        1.19                                            SELL FOR B&S FH
 7    10  7308        1.19                                            SELL FOR P&S FH
 7    11  3598        1.19                                            SELL FOR S FH
 8     1                    1     1                 1     1     1     FEED ALF(3.5T)
 8     2                    2     1                 1     1     1     FEED ALF(4.5T)
 8     3                    3     1                 1     1     1     FEED BAR(77BU)
 8     4                    4     1                 1     1     1     FEED MEADOWHAY
 8     5  3600 4.22               1                 1     1     1     BUY HAY (ALF&G)
 9     1     0    4     0 1500 1125 1875   750   750  3000           COW 1 (W.OCT)
 9     2    15    3     1  900   754 1416   608   622  2700           YRLG REP 1
 9     3    15    3     1                             352  1560      HFR CALF REP 1
 9     4     5    3     1 2100 1575 2625  1050  1050  4200           BULL 1
 9     5    43    2     1                             352  1560      STR CALF 1
 9     6    28    2     1                             330  1470      HFR CALF 1
 9     7          5     5  900   754 1416   608                     YRLG STR 1
 9     8          5     6  844   692 1290   555                     YRLG HFR 1
 9     9    49 1  1     0  900   754 1416   608                     PUR YRLG STR
 9    10     0    4     0 1500 1125 1875   541   541  3000           COW 2 (EW-AUG)
 9    11    15    3    10  930   771 1444   622   630  2700           YRLG REP 2
 9    12    15    3    10                             345   388  1620  HFR CALF REP 2
 9    13     5    3    10 2100 1575 2625  1050  1050  4200           BULL 2
 9    14    43    2    10                             345   388  1620  STR CALF 2
 9    15    28    2    10                             322   345  1530  HFR CALF 2
 9    16          5    14  930   771 1444   622                     YRLG STR 2
 9    17          5    15  885   731 1341   570                     YRLG HFR 2
10     1     1    0                                   28              COW 1 (W-OCT)
10     2     2    0                                                   YRLG REP 1
10     3     3    0                                                   HFR CALF REP 1
10     4     4    0                                                   BULL 1
10     5     3    0                             265   271   273       STR CALF 1
10     6     5    0                             213   221   229       HFR CALF 1
10     7     6  .01  273  351  354  389  407                         YRLG STR 1
10     8     7  .01  229  286  287  319  334                         YRLG HFR 1
10     9     6 .013  273  317  317  347  363                         PUR YRLG STR
10    10     8                                   28                  COW 2 (EW-AUG)
10    11     9                                                       YRLG REP 2
10    12    10                                                       HFR CALF REP 2
10    13     4                                                       BULL 2
10    14    10                             265   282   282           STR CALF 2
10    15    11                             213   231   237           HFR CALF 2
10    16    12  .01  282  362  359  398  417                         YRLG STR 2
10    17    13  .01  237  303  303  328  343                         YRLG HFR 2
13
```

Figure 9. COPLAN data set for the small ranch strategy based on favorable production and favorable price levels.

```
 1 SMALL RANCH FAV/UNFAV OPTIMUM (SF/UO)
12  9  6  7 23  8  0  0 11  5  0  1  4  6  2  4 11 13    500.
 2   1     1  152     1        1     1     1     1  1        BLM 1
 2   2     1  303     1     1  1     1     1  1              BLM 5&6
 2   3     1  340     1     1  1                 1  1        FS 3&4
 2   4     1  195     1     1                    1  1        PVT LEASE 2,3&4
 2   5     2   55     1     1     1     1                    IRR CROP-ALF
 2   6     1   14     1     1     1     1                    IRR CROP-BAR
 2   7     7   48     0     1                                MEADOW 2,3,4&5
 2   8     8 1400     0                                      FTHILL
 2   9     1   49     1     1                                ADD PVT LEASE
 3   1                                                  S-1 MAR-APR 2MO
 3   2                                                  S-2 MAY-JUN15 1.5MO
 3   3                                                  S-3 JUN16-AUG 2.5MO
 3   4                                                  S-4 SEP 1MO
 3   5                                                  S-5 OCT 1MO
 3   6                                                  S-6 NOV-FEB 4MO
 4   1     1 1.57        750                            BLM 1
 4   2     2 1.57                                 750  750 BLM 5&6
 4   3     3 1.97                       750  750          FS 3&4
 4   4     4 7.20              750  750  750             PVT LEASE 2,3&4
 4   5 1   5142.6 71.8                  750  750          ALF 3.5T/AC
 4   5 2   6144.1 92.8                  750  750          ALF 4.5T/AC
 4   6 3   7        37                  750  750          BAR 77BU/AC
 4   7 4   872.89 41.2                 750  750          MEADOWHAY 2T/AC
 4   7     914.21              502 1313 1489 1740 1740    MEADOW
 4   7 5   1014.31 17.4                                   MEADOW SELL FOR
 4   7     1125.71             618 1545 1854 2060 2060    MEADOW 100#N/AC
 4   7 6   1225.81 20.6                                   MEADOW 100N SLL
 4   7     1327.96            1030 2575 2781 3090 3090    MEADOW 125#N/AC
 4   7 7   1428.06 30.9                                   MEADOW 125N SLL
 4   8    15              35   71   71   71   88   88    FTHILL
 4   8 8  16   .10  .88                                   FTHILL SELL FOR
 4   8    17 1.85        139  290  290  290  435  435    FTHILL BRN&SEED
 4   8 9  18 1.95 4.35                                   FTHILL B,S&SELL
 4   8    19 2.83        174  435  435  493  522  522    FTHILL PLW&SEED
 4   810 20 2.93 5.22                                   FTHILL P,S&SELL
 4   8    21 1.04        103  205  205  205  257  257    FTHILL SPRAY
 4   811 22 1.14 2.57                                   FTHILL SPRY&SLL
 4   9    23 7.92              750  750  750             ADD PVT LEASE
 7   1 3949       3.05                                   SELL ALF(3.5T)
 7   2 5104       3.05                                   SELL ALF(4.5T)
 7   3  518       4.05                                   SELL BAR(77BU)
 7   4 1977       2.54                                   SELL MEADOWHAY
 7   5  835        .92                                   SELL MEADOW FOR
 7   6  988        .92                                   SELL MDW FOR100
 7   7 1483        .92                                   SELL MDW FOR125
 7   8 1232        .92                                   SELL FTHILL FOR
 7   9 6090        .92                                   SELL FOR B&S FH
 7  10 7308        .92                                   SELL FOR P&S FH
 7  11 3598        .92                                   SELL FOR S FH
 8   1                1     1                 1    1    1 FEED ALF(3.5T)
 8   2                2     1                 1    1    1 FEED ALF(4.5T)
 8   3                3     1                 1    1    1 FEED BAR(77BU)
 8   4                4     1                 1    1    1 FEED MEADOWHAY
 8   5 5600 3.25            1                 1    1    1 BUY HAY (ALF&G)
 9   1    0  0  4    0 1500 1125 1875  750  750 3000      COW 1 (W-OCT)
 9   2   15     3    1  900  754 1416  608  622 2700      YRLG REP 1
 9   3   15     3    1                       352 1560      HFR CALF REP 1
 9   4    5     3    1 2100 1575 2625 1050 1050 4200      BULL 1
 9   5   43     2    1                       352 1560      STR CALF 1
 9   6   28     2    1                       330 1470      HFR CALF 1
 9   7           5    5  900  754 1416  608                YRLG STR 1
 9   8           5    6  844  682 1290  555                YRLG HFR 1
 9   9   49  1  1    0  900  754 1416  608                PUR YRLG STR
 9  10    0  0  4    0 1500 1125 1875  541  541 3000      COW 2 (EW-AUG)
 9  11   15     3   10  930  771 1444  622  630 2700      YRLG REP 2
 9  12   15     3   10                       345  388 1820 HFR CALF REP 2
 9  13    5     3   10 2100 1575 2625 1050 1050 4200      BULL 2
 9  14   43     2   10                       345  388 1820 STR CALF 2
 9  15   28     2   10                       322  345 1530 HFR CALF 2
 9  16          5   14  930  771 1444  622                YRLG STR 2
 9  17          5   15  885  731 1341  570                YRLG HFR 2
10   1    1     0                             28          COW 1 (W-OCT)
10   2    2     0                                         YRLG REP 1
10   3    3     0                                         HFR CALF REP 1
10   4    4     0                                         BULL 1
10   5    3     0                       228  233  238     STR CALF 1
10   6    5     0                       186  190  196     HFR CALF 1
10   7    6   .01  238  302  304  334  350                YRLG STR 1
10   8    7   .01  196  247  247  274  287                YRLG HFR 1
10   9    6  .013  238  268  268  294  308                PUR YRLG STR
10  10    8     0                             28          COW 2 (EW-AUG)
10  11    9     0                                         YRLG REP 2
10  12   10     0                                         HFR CALF REP 2
10  13    4     0                                         BULL 2
10  14   10     0                       228  242  242     STR CALF 2
10  15   11     0                       186  199  204     HFR CALF 2
10  16   12   .01  242  311  318  342  358                YRLG STR 2
10  17   13   .01  204  261  260  281  295                YRLG HFR 2
13
```

Figure 10. COPLAN data set for the small ranch optimum strategy based on favorable production and unfavorable price levels.

```
 1 SMALL RANCH UNFAV/FAV OPTIMUM (SU/FO)
12  8  6  6 22  7  0  0 11  5  0  1  4  6  2  4 11 13     500.
 2  1     1  137     1        1     1     1     1  1          BLM 1
 2  2     1  273     1     1  1     1     1                   BLM 5&6
 2  3     1  316     1     1  1                 1  1          FS 3&4
 2  4     1  181     1     1                    1  1          PVT LEASE 2,3&4
 2  5     2   55     1     1  1     1                 1       IRR CROP - ALF
 2  6     1   14     1     1  1     1                 1       IRR CROP - BAR
 2  7     7   48     0     1                             1    MEADOW
 2  8     8 1400     0                                   1    FTHILL
 3  1                                                        S-1 MAR-APR 2MO
 3  2                                                        S-2 MAY-JUN15 1.5MO
 3  3                                                        S-3 JUN16-AUG 2.5MO
 3  4                                                        S-4 SEP 1MO
 3  5                                                        S-5 OCT 1MO
 3  6                                                        S-6 NOV-FEB 4MO
 4  1     1 1.57        750                                   BLM 1
 4  2     2 1.57                                 750  750    BLM 5&6
 4  3     3 1.97                    750  750                  FS 3&4
 4  4     4 7.20              750   750  750                  PVT LEASE 2,3&4
 4  5 1  5142.6   68                    750  750             ALF 3.5T/AC
 4  5 2  6144.1   87                    750  750             ALF 4.5T/AC
 4  6 3     7     37                    750  750             BAR 778U/AC
 4  7 4  872.89   38                    750  750             MEADOWHAY 2T/AC
 4  7    914.21                  438 1148 1301 1521 1521    MEADOW
 4  7 5 1014.31 15.2                                        MEADOW SELL FOR
 4  7   1125.71                  548 1433 1626 1900 1900    MEADOW 100#N/AC
 4  7 6 1225.81   19                                        MEADOW 100N SLL
 4  7   1327.96                  826 2138 2438 2850 2850    MEADOW 125#N/AC
 4  7 7 1428.06 28.5                                        MEADOW 125N SLL
 4  8    15          20   40   40   40   50   50           FTHILL
 4  8 8 16  .10  .50                                       FTHILL SELL FOR
 4  9    17 1.85        82  170  170  170  255  255        FTHILL BRN&SEED
 4  8 9 18 1.95 2.55                                       FTHILL B.S&SELL
 4  8    19 2.83       102  255  255  289  306  306        FTHILL PLW&SEED
 4 810 20 2.93 3.06                                       FTHILL P.S&SELL
 4  9    21 1.04        57  115  115  115  144  144        FTHILL SPRAY
 4 811 22 1.14 1.44                                       FTHILL SPRY&SLL
 7  1 3740       3.96                                      SELL ALF(3.4T)
 7  2 4785       3.96                                      SELL ALF(4.37T)
 7  3  518       5.26                                      SELL BAR (778U)
 7  4 1824       3.30                                      SELL MEADOWHAY
 7  5  730       1.19                                      SELL MEADOW FOR
 7  6  912       1.19                                      SELL MDW FOR100
 7  7 1368       1.19                                      SELL MDW FOR125
 7  8  700       1.19                                      SELL FTHILL FOR
 7  9 3750       1.19                                      SELL FOR B&S FH
 7 10 4284       1.19                                      SELL FOR P&S FH
 7 11 2016       1.19                                      SELL FOR S FH
 8  1                1     1                 1    1    1    FEED ALF(3.4T)
 8  2                2     1                 1    1    1    FEED ALF(4.37T)
 8  3                3     1                 1    1    1    FEED BAR (778U)
 8  4                4     1                 1    1    1    FEED MEADOWHAY
 8  5 5600 4.22      1                       1    1    1    BUY HAY (ALF&G)
 9  1    0 0  4     0 1500 1125 1875  750  750 3000         COW 1 (W-OCT)
 9  2   15    3     1  848  703 1303  555  600 2700         YRLG REP 1
 9  3   15    3     1                       330 1470         HFR CALF REP 1
 9  4    5    3     1 2100 1575 2625 1050 1050 4200         BULL 1
 9  5   40    2     1                       330 1470         STR CALF 1
 9  6   26    2     1                       308 1380         HFR CALF 1
 9  7         5     5  848  703 1303  555                    YRLG STR 1
 9  8         5     6  795  647 1181  499                    YRLG HFR 1
 9  9   49 1  1     0  848  703 1303  555                    PUR YRLG STR
 9 10    0 0  4     0 1500 1125 1875  541  541 3000         COW 2 (EW-AUG)
 9 11   15    3    10  862  714 1350  589  600 2700         YRLG REP 2
 9 12   15    3    10                 322  345 1530         HFR CALF REP 2
 9 13    5    3    10 2100 1575 2625 1050 1050 4200         BULL 2
 9 14   40    2    10                 322  345 1530         STR CALF 2
 9 15   26    2    10                 300  322 1440         HFR CALF 2
 9 16         5    14  885  731 1359  589                    YRLG STR 2
 9 17         5    15  840  692 1247  518                    YRLG HFR 2
10  1    1    0                            28               COW 1 (W-OCT)
10  2    2    0                                             YRLG REP 1
10  3    3    0                                             HFR CALF REP 1
10  4    4    0                                             BULL 1
10  5    3    0                       248  254  258         STR CALF 1
10  6    3    0                       198  206  216         HFR CALF 1
10  7    6 .018  258  329  329  355  372                    YRLG STR 1
10  8    7 .016  216  269  267  288  299                    YRLG HFR 1
10  9    6 .020  258  295  292  314  329                    PUR YRLG STR
10 10    8    0                            28               COW 2 (EW-AUG)
10 11    9    0                                             YRLG REP 2
10 12   10    0                                             HFR CALF REP 2
10 13    4    0                                             BULL 2
10 14   10    0                       248  265  288         STR CALF 2
10 15   11    0                       198  216  225         HFR CALF 2
10 16   12 .016  268  346  339  374  397                    YRLG STR 2
10 17   13 .016  225  289  285  301  312                    YRLG HFR 2
13
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Figure 11. COPLAN data set for the small ranch optimum strategy based on unfavorable production and favorable price levels.

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 1 SMALL RANCH UNFAV/UNFAV OPTIMUM (SU/UO)
12  8  6  6 22  7  0  0 11  5  0  1  4  8  2  4 11 13    500.
 2  1     1   137     1        1     1     1     1     1        BLM 1
 2  2     1   273     1     1  1     1     1     1              BLM 5&6
 2  3     1   316     1     1  1                 1     1        FS 3&4
 2  4     1   181     1     1                       1     1     PVT LEASE 2,3&4
 2  5     2    55     1     1     1     1                    1  IRR CROP - ALF
 2  6     1    14     1     1     1     1                    1  IRR CROP - BAR
 2  7     7    48     0     1                                1  MEADOW
 2  8     8  1400     0                                      1  FTHILL
 3  1                                                          S-1 MAR-APR 2MO
 3  2                                                          S-2 MAY-JUN15 1.5MO
 3  3                                                          S-3 JUN16-AUG 2.5MO
 3  4                                                          S-4 SEP 1MO
 3  5                                                          S-5 OCT 1MO
 3  6                                                          S-6 NOV-FEB 4MO
 4  1     1 1.57        750                                     BLM 1
 4  2     2 1.57                                    750   750  BLM 5&6
 4  3     3 1.97                          750   750             FS 3&4
 4  4     4 7.20                    750   750   750             PVT LEASE 2,3&4
 4  5 1   5142.6   68                          750   750       ALF 3.5T/AC
 4  5 2   6144.1   87                          750   750       ALF 4.5T/AC
 4  6 3   7        37                          750   750       BAR 77BU/AC
 4  7 4   872.89   38                          750   750       MEADOWHAY 2T/AC
 4  7     914.21                    438  1148  1301  1521  1521 MEADOW
 4  7 5 1014.31 15.2                                          MEADOW SELL FOR
 4  7     1125.71                   548  1433  1626  1900  1900 MEADOW 100+N/AC
 4  7 6 1225.81   19                                          MEADOW 100N SLL
 4  7     1327.96                   826  2138  2438  2850  2850 MEADOW 125#N/AC
 4  7 7 1428.06 28.5                                          MEADOW 125N SLL
 4  8    15              20   40    40    40    50    50      FTHILL
 4  8 8 16   .10  .50                                         FTHILL SELL FOR
 4  8    17 1.85         82  170   170   170   255   255     FTHILL BRN&SEED
 4  8 9 18 1.95 2.55                                         FTHILL B,S&SELL
 4  8    19 2.83        102  255   255   289   306   306     FTHILL PLW&SEED
 4  810 20 2.93 3.06                                         FTHILL P,S&SELL
 4  8    21 1.04         57  115   115   115   144   144     FTHILL SPRAY
 4  811 22 1.14 1.44                                         FTHILL SPRY&SLL
 7  1 3740       3.05                                        SELL ALF(3.4T)
 7  2 4785       3.05                                        SELL ALF(4.37T)
 7  3  519       4.05                                        SELL BAR (77BU)
 7  4 1824       2.54                                        SELL MEADOWHAY
 7  5  730        .92                                        SELL MEADOW FOR
 7  6  912        .92                                        SELL MDW FOR100
 7  7 1368        .92                                        SELL MDW FOR125
 7  8  700        .92                                        SELL FTHILL FOR
 7  9 3750        .92                                        SELL FOR B&S FH
 7 10 4284        .92                                        SELL FOR P&S FH
 7 11 2016        .92                                        SELL FOR S FH
 8  1                1     1                 1     1     1   FEED ALF(3.4T)
 8  2                2     1                 1     1     1   FEED ALF(4.37T)
 8  3                3     1                 1     1     1   FEED BAR (77BU)
 8  4                4     1                 1     1     1   FEED MEADOWHAY
 8  5 5600 3.25            1                 1     1     1   BUY HAY (ALF&G)
 9  1    0  0  4     0 1500 1125 1875  750   750  3000       COW 1 (W-OCT)
 9  2   15     3     1  848  703 1303  555   600  2700       YRLG REP 1
 9  3   15     3     1                       330  1470       HFR CALF REP 1
 9  4    5     3     1 2100 1575 2625 1050  1050  4200       BULL 1
 9  5   40     2     1                       330  1470       STR CALF 1
 9  6   28     2     1                       308  1380       HFR CALF 1
 9  7          5     5  848  703 1303  555                   YRLG STR 1
 9  8          5     6  795  647 1181  499                   YRLG HFR 1
 9  9   49 1  1     0  848  703 1303  555                   PUR YRLG STR
 9 10    0  0  4     0 1500 1125 1875  541   541  3000       COW 2 (EW-AUG)
 9 11   15     3    10  862  714 1350  589   600  2700       YRLG REP 2
 9 12   15     3    10                 322   345  1530       HFR CALF REP 2
 9 13    5     3    10 2100 1575 2625 1050  1050  4200       BULL 2
 9 14   40     2    10                 322   345  1530       STR CALF 2
 9 15   28     2    10                 300   322  1440       HFR CALF 2
 9 16          5    14  885  731 1359  589                   YRLG STR 2
 9 17          5    15  840  692 1247  518                   YRLG HFR 2
10  1    1     0                             28             COW 1 (W-OCT)
10  2    2     0                                            YRLG REP 1
10  3    3     0                                            HFR CALF REP 1
10  4    4     0                                            BULL 1
10  5    3     0                       213   218   222      STR CALF 1
10  6    5     0                       173   177   186      HFR CALF 1
10  7    6  .016  222  282  282  305   320                   YRLG STR 1
10  8    7  .016  186  231  230  248   256                   YRLG HFR 1
10  9    6  .020  222  249  246  265   279                   PUR YRLG STR
10 10    8     0                             28             COW 2 (EW-AUG)
10 11    9     0                                            YRLG REP 2
10 12   10     0                                            HFR CALF REP 2
10 13    4     0                                            BULL 2
10 14   10     0                       213   228   230      STR CALF 2
10 15   11     0                       173   186   193      HFR CALF 2
10 16   12  .016  230  297  291  321   341                   YRLG STR 2
10 17   13  .016  193  248  245  259   268                   YRLG HFR 2
13
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Figure 12. COPLAN data set for the small ranch optimum strategy based on unfavorable production and unfavorable price levels.

Appendix B

Modified Income Statement Summaries for Large and Small Utah Cattle Ranches Operating Under Six Management Strategies

Table 23. Modified income statement summary for a large Utah cattle ranch operating under the management strategy employed in 1977 (January 1 inventory, 1977 dollars).

EXPECTED NET RETURN ABOVE VARIABLE COSTS		$ -658
PROPERTY TAX (land, improvements, equipment)		1,891
DEPRECIATION		9,826
NET RANCH INCOME		-12,375
DEBT SERVICE COSTS		13,939
Working capital (operating and short-term debt)	$ 2,880	
Real estate	11,059	
NET RETURN FOR FAMILY LIVING EXPENSE		-26,314
LAND APPRECIATION, COMPOUND INTEREST, 1970-1979		38,531
PAYMENT TOWARD MORTGAGE PRINCIPAL		6,152
GROSS PROCEEDS TO RANCH INVESTMENT		18,369
VALUE OF OPERATOR MANAGEMENT AND LABOR		10,000
NET PROCEEDS TO OWNED RANCH CAPITAL		8,369
PERCENT RETURN ON $621,233 OWNED RANCH CAPITAL		1.35%

Table 24. Modified income statement summary for a large Utah cattle ranch operating under the optimum strategy based on average production and 1977 price levels (January 1 inventory, 1977 dollars).

EXPECTED NET RETURN ABOVE VARIABLE COSTS		$56,211
PROPERTY TAX (land, improvements, equipment)		1,891
DEPRECIATION		9,826
NET RANCH INCOME		44,494
DEBT SERVICE COSTS		15,811
Working capital (operating and short-term debt)	$ 4,752	
Real estate	11,059	
NET RETURN FOR FAMILY LIVING EXPENSE		28,683
LAND APPRECIATION, COMPOUND INTEREST, 1970-79		38,531
PAYMENT TOWARD MORTGAGE PRINCIPAL		6,152
GROSS PROCEEDS TO RANCH INVESTMENT		73,366
VALUE OF OPERATOR MANAGEMENT AND LABOR		10,000
NET PROCEEDS TO OWNED RANCH CAPITAL		63,366
PERCENT RETURN ON $580,977 OWNED RANCH CAPITAL		10.91%

Table 25. Modified income statement summary for a large Utah cattle ranch operating under the optimum strategy based on favorable production and favorable price levels (January 1 inventory, 1977 dollars).

EXPECTED NET RETURN ABOVE VARIABLE COSTS		$56,879
PROPERTY TAX (land, improvements, equipment)		1,891
DEPRECIATION		9,826
NET RANCH INCOME		45,162
DEBT SERVICE COSTS		15,955
Working capital (operating and short-term debt)	$ 4,896	
Real estate	11,059	
NET RETURN FOR FAMILY LIVING EXPENSE		29,207
LAND APPRECIATION, COMPOUND INTEREST, 1970-79		38,531
PAYMENT TOWARD MORTGAGE PRINCIPAL		6,152
GROSS PROCEEDS TO RANCH INVESTMENT		73,890
VALUE OF OPERATOR MANAGEMENT AND LABOR		10,000
NET PROCEEDS TO OWNED RANCH CAPITAL		63,890
PERCENT RETURN ON $579,847 OWNED RANCH CAPITAL		11.02%

Table 26. Modified income statement summary for a large Utah cattle ranch operating under the optimum strategy based on favorable production and unfavorable price levels (January 1 inventory, 1977 dollars).

EXPECTED NET RETURN ABOVE VARIABLE COSTS		$57,102
PROPERTY TAX (land, improvements, equipment)		1,891
DEPRECIATION		9,826
NET RANCH INCOME		45,385
DEBT SERVICE COSTS		15,595
Working capital (operating and short-term debt)	$ 4,536	
Real estate	11,059	
NET RETURN FOR FAMILY LIVING EXPENSE		29,790
LAND APPRECIATION, COMPOUND INTEREST, 1970-79		38,531
PAYMENT TOWARD MORTGAGE PRINCIPAL		6,152
GROSS PROCEEDS TO RANCH INVESTMENT		74,473
VALUE OF OPERATOR MANAGEMENT AND LABOR		10,000
NET PROCEEDS TO OWNED RANCH CAPITAL		64,473
PERCENT RETURN ON $580,081 OWNED RANCH CAPITAL		11.11%

Table 27. Modified income statement summary for a large Utah cattle ranch operating under the optimum strategy based on unfavorable production and favorable price levels (January 1 inventory, 1977 dollars).

EXPECTED NET RETURN ABOVE VARIABLE COSTS		$58,430
PROPERTY TAX (land, improvements, equipment)		1,891
DEPRECIATION		9,826
NET RANCH INCOME		46,713
DEBT SERVICE COSTS		15,739
Working capital (operating and short-term debt)	$ 4,680	
Real estate	11,059	
NET RETURN FOR FAMILY LIVING EXPENSE		30,974
LAND APPRECIATION, COMPOUND INTEREST, 1970-79		38,531
PAYMENT TOWARD MORTGAGE PRINCIPAL		6,152
GROSS PROCEEDS TO RANCH INVESTMENT		75,657
VALUE OF OPERATOR MANAGEMENT AND LABOR		10,000
NET PROCEEDS TO OWNED RANCH CAPITAL		65,657
PERCENT RETURN ON $574,436 OWNED RANCH CAPITAL		11.43%

Table 28. Modified income statement summary for a large Utah cattle ranch operating under the optimum strategy based on unfavorable production and unfavorable price levels (January 1 inventory, 1977 dollars).

EXPECTED NET RETURN ABOVE VARIABLE COSTS		$57,521
PROPERTY TAX (land, improvements, equipment)		1,891
DEPRECIATION		9,826
NET RANCH INCOME		45,804
DEBT SERVICE COSTS		15,523
Working capital (operating and short-term debt)	$ 4,464	
Real estate	11,059	
NET RETURN FOR FAMILY LIVING EXPENSE		30,281
LAND APPRECIATION, COMPOUND INTEREST, 1970-79		38,531
PAYMENT TOWARD MORTGAGE PRINCIPAL		6,152
GROSS PROCEEDS TO RANCH INVESTMENT		74,964
VALUE OF OPERATOR MANAGEMENT AND LABOR		10,000
NET PROCEEDS TO OWNED RANCH CAPITAL		64,964
PERCENT RETURN ON $574,436 OWNED RANCH CAPITAL		11.31%

Table 29. Modified income statement summary for a small Utah cattle ranch operating under the management strategy employed in 1977 (January 1 inventory, 1977 dollars).

EXPECTED NET RETURN ABOVE VARIABLE COSTS		$ 484
PROPERTY TAX (land, improvements, equipment)		1,141
DEPRECIATION		4,191
NET RANCH INCOME		-4,848
DEBT SERVICE COSTS		9,825
Working capital (operating and short-term debt)	$1,368	
Real estate	8,457	
NET RETURN FOR FAMILY LIVING EXPENSE		-14,673
LAND APPRECIATION, COMPOUND INTEREST, 1970-79		25,466
PAYMENT TOWARD MORTGAGE PRINCIPAL		4,945
GROSS PROCEEDS TO RANCH INVESTMENT		15,738
VALUE OF OPERATOR MANAGEMENT AND LABOR		10,000
NET PROCEEDS TO OWNED RANCH CAPITAL		5,738
PERCENT RETURN ON $339,821 OWNED RANCH CAPITAL		1.69%

Table 30. Modified income statement summary for a small Utah cattle ranch operating under the optimum strategy based on average production and 1977 price levels (January 1 inventory, 1977 dollars).

EXPECTED NET RETURN ABOVE VARIABLE COSTS		$26,049
PROPERTY TAX (land, improvements, equipment)		1,141
DEPRECIATION		4,191
NET RANCH INCOME		20,717
DEBT SERVICE COSTS		10,833
Working capital (operating and short-term debt)	$2,376	
Real estate	8,457	
NET RETURN FOR FAMILY LIVING EXPENSE		9,884
LAND APPRECIATION, COMPOUND INTEREST, 1970-1979		25,466
PAYMENT TOWARD MORTGAGE PRINCIPAL		4,945
GROSS PROCEEDS TO RANCH INVESTMENT		40,295
VALUE OF OPERATOR MANAGEMENT AND LABOR		10,000
NET PROCEEDS TO OWNED RANCH CAPITAL		30,295
PERCENT RETURN ON $316,541 OWNED RANCH CAPITAL		9.57%

Table 31. Modified income statement summary for a small Utah cattle ranch operating under the optimum strategy based on favorable production and favorable price levels (January 1 inventory, 1977 dollars).

EXPECTED NET RETURN ABOVE VARIABLE COSTS		$26,649
PROPERTY TAX (land, improvements, equipment)		1,141
DEPRECIATION		4,191
NET RANCH INCOME		21,217
DEBT SERVICE COSTS		10,905
Working capital (operating and short-term debt)	$2,448	
Real estate	8,457	
NET RETURN FOR FAMILY LIVING EXPENSE		10,412
LAND APPRECIATION, COMPOUND INTEREST, 1970-79		25,466
PAYMENT TOWARD MORTGAGE PRINCIPAL		4,945
GROSS PROCEEDS TO RANCH INVESTMENT		40,823
VALUE OF OPERATOR MANAGEMENT AND LABOR		10,000
NET PROCEEDS TO OWNED RANCH CAPITAL		30,823
PERCENT RETURN ON $316,307 OWNED RANCH CAPITAL		9.74%

Table 32. Modified income statement summary for a small Utah cattle ranch operating under the optimum strategy based on favorable production and unfavorable price levels (January 1 inventory, 1977 dollars).

EXPECTED NET RETURN ABOVE VARIABLE COSTS		$26,985
PROPERTY TAX (land, improvements, equipment)		1,141
DEPRECIATION		4,191
NET RANCH INCOME		21,653
DEBT SERVICE COSTS		10,761
Working capital (operating and short-term debt)	$2,304	
Real estate	8,457	
NET RETURN FOR FAMILY LIVING EXPENSE		10,892
LAND APPRECIATION, COMPOUND INTEREST, 1970-79		25,466
PAYMENT TOWARD MORTGAGE PRINCIPAL		4,945
GROSS PROCEEDS TO RANCH INVESTMENT		41,303
VALUE OF OPERATOR MANAGEMENT AND LABOR		10,000
NET PROCEEDS TO OWNED RANCH CAPITAL		31,303
PERCENT RETURN ON $316,307 OWNED RANCH CAPITAL		9.90%

Table 33. Modified income statement summary for a small Utah cattle ranch operating under the optimum strategy based on unfavorable production and favorable price levels (January 1 inventory, 1977 dollars).

EXPECTED NET RETURN ABOVE VARIABLE COSTS		$26,504
PROPERTY TAX (land, improvements, equipment)		1,141
DEPRECIATION		4,191
NET RANCH INCOME		21,172
DEBT SERVICE COSTS		10,761
Working capital (operating and short-term debt)	$2,403	
Real estate	8,457	
NET RETURN FOR FAMILY LIVING EXPENSE		10,411
LAND APPRECIATION, COMPOUND INTEREST, 1970-79		25,466
PAYMENT TOWARD MORTGAGE PRINCIPAL		4,945
GROSS PROCEEDS TO RANCH INVESTMENT		40,822
VALUE OF OPERATOR MANAGEMENT AND LABOR		10,000
NET PROCEEDS TO OWNED RANCH CAPITAL		30,822
PERCENT RETURN ON $314,633 OWNED RANCH CAPITAL		9.80%

Table 34. Modified income statement summary for a small Utah cattle ranch operating under the optimum strategy based on unfavorable production and unfavorable price levels (January 1 inventory, 1977 dollars).

EXPECTED NET RETURN ABOVE VARIABLE COSTS		$25,022
PROPERTY TAX (land, improvements, equipment)		1,141
DEPRECIATION		4,191
NET RANCH INCOME		19,690
DEBT SERVICE COSTS		10,473
Working capital (operating and short-term debt)	$2,016	
Real estate	8,457	
NET RETURN FOR FAMILY LIVING EXPENSE		9,217
LAND APPRECIATION, COMPOUND INTEREST, 1970-79		25,466
PAYMENT TOWARD MORTGAGE PRINCIPAL		4,945
GROSS PROCEEDS TO RANCH INVESTMENT		39,628
VALUE OF OPERATOR MANAGEMENT AND LABOR		10,000
NET PROCEEDS TO OWNED RANCH CAPITAL		29,628
PERCENT RETURN ON #314,633 OWNED RANCH CAPITAL		9.42%

VITA

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Doctor of Philosophy

Dissertation: Economic Analysis of Long-Term Management Strategies for Two Sizes of Utah Cattle Ranches

Major Field: Range Science

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