THE ORGANIZATION OF COMMERCIAL CATTLE RANCHES IN SOUTH CENTRAL OKLAHOMA FOR PROFIT AND STABILITY: STATIC AND DYNAMIC ANALYSIS

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PREFACE

More often than not an investigation raises more questions than it answers. Yet there is a time when even intermediate results must be summarized and presented to the scrutiny of collegues and, when the work is in the area of management, to the acid test of practical usefulness.

This is a theoretical study of a practical problem. The author is aware that he often used language that is not the language of the practitioner, and dwelt on questions that might have been settled on the basis of experience. Still he found it gratifying that the results obtained by a "theoretical" approach could be compatible with the recommendations of practicioners (88). If this study has added little that is new to the knowledge of ranching, it should be encouraging to see that both experience and analysis can arrive at common conclusions from widely separated initial positions. This study can contribute toward the improvement of the systematic analysis of ranch operations, and the subsequent development of dynamic management in this field.

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Lastly it was my wife who made this possible through her willingness to take upon her the risks and hardships of setting out upon an uncertain future, who held the family together while my mind wandered, and who typed and retyped this dissertation. To her I dedicate it.

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CHAPTER I

THE PROBLEM AND THE PLAN OF THIS STUDY

A. The Study Area

A four-county area in South-Central Oklahoma (Pontotoc, Johnston, Murray, and Carter Counties) is commonly designated "Hereford Heaven" (fig. 1). Shallow limestone soils, rich in organic matter and calcium, provide excellent cattle pasture yet limited possibilities for crop production. This area is the home of many well-known cattle breeders, but the mainstay of the agriculture of this region is commercial calf production. Topography and soils have been described by Gray and Galloway (1).

In 1958 a field survey of the area was initiated by the Department of Agricultural Economics, Oklahoma State University, in order to obtain the basic information for a detailed study of the management practices and alternatives for the region. This study is part of a systematic investigation of management problems, adjustment opportunities and income potentials of various types of farms in Oklahoma.

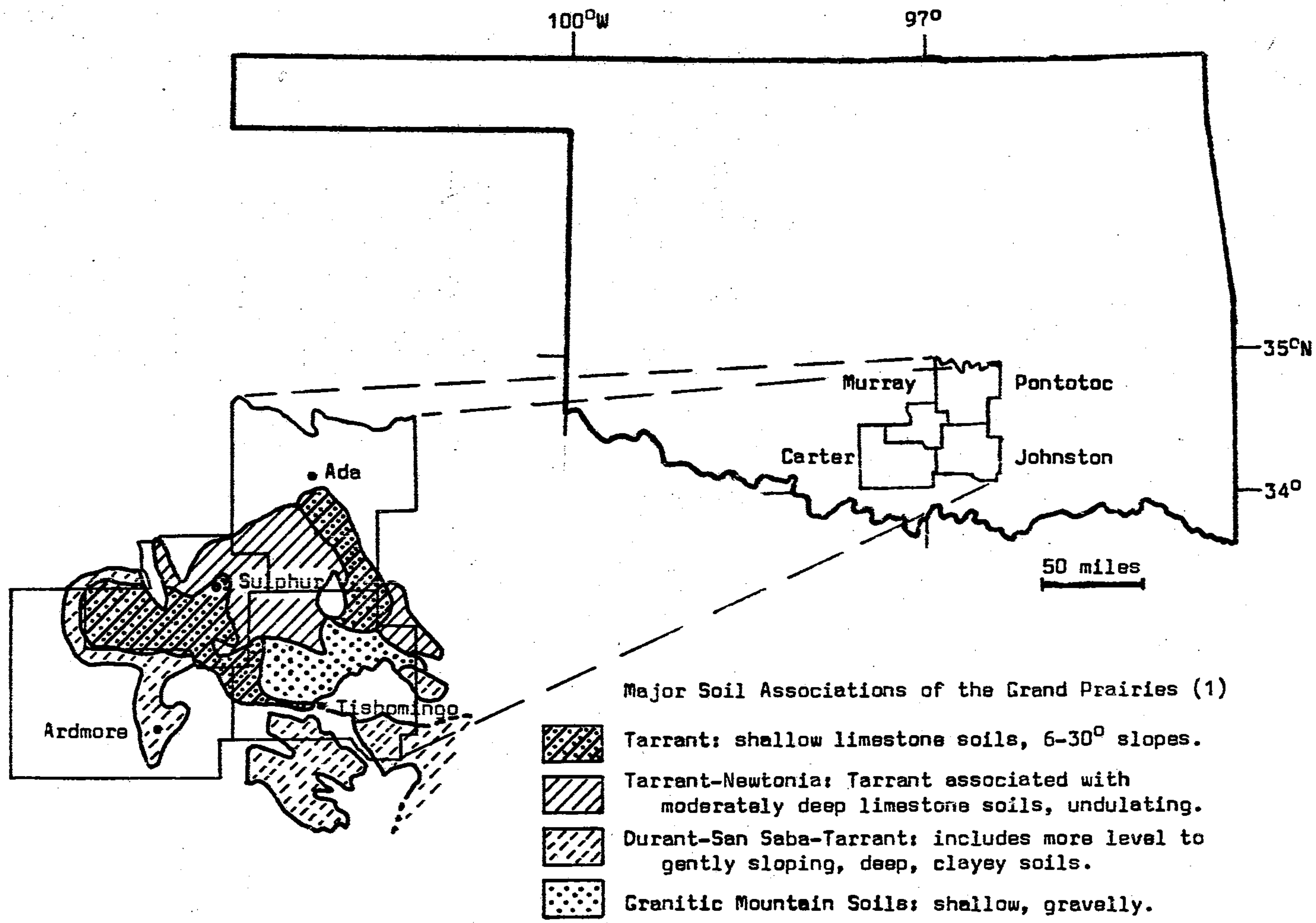

Fig. 1. Location and Soil Resources of the Study Area

B. Management Concepts

A farm or a ranch[1] generally is understood to be a production unit, i.e. the array of land, buildings, chattel, and other physical and non-physical assets set up and operated under one management. The function of management is to organize and operate the farm so as to maximize a desired objective. The manager of a farm usually sets the objective, and on the great majority of the farms and ranches the manager also supplies the labor.

The operation of a business, or a farm, is the sum of all day-to-day dispositions. From the viewpoint of the farm management scientist operation includes all those decisions and actions which can be done without much delay, without change in the asset structure, and which can be altered on short notice (3, p. 8).

The organization of a business, by contrast, includes all long-run dispositions; dispositions that take time to implement, that change the asset structure, and are difficult or impossible to reverse. Organization includes intangibles too, namely the general framework for action in a contingency, the strategy of management.

Strategy, a term borrowed from the military, is the plan of a campaign or war. It is concerned with the long-run course of action. The associated term, tactics, describes the plan of action in the battlefield,

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[1]For statistical purposes the U.S. Bureau of the Census defines a farm as a "Livestock Ranch" if "sales of livestock, wool, and mohair represented 50 per cent or more of the total value of farm products sold and if pastureland or grazing land amounted to 100 or more acres and was 10 or more times the acreage of cropland harvested" (2, p. xxiv). However, in popular parlance a ranch is often thought of as simply a large or "important" farm.

the short-run plan, the disposition on short notice. Usually any formulated strategy includes a list of alternative tactics that may be employed in certain anticipated situations (which does not prepare for the unexpected, though).

A strategy frequently employed in farming is to take no positive action, in the hope that difficulties will run their course before reserves are exhausted. Another strategy is to anticipate turns of the market, and perhaps of nature, and prepare ahead as far as possible. This strategy requires (a) some notion of the course of events that influence farming, (b) advance knowledge of outcomes of alternative plans under various circumstances, (c) operational skill to do well under a variety of organizations, (d) a willingness to make organizational changes where indicated.[2] Here we will be concerned with both approaches to the organization of a ranch.

A third approach is the truly "dynamic" strategy which considers each decision as one step in a long succession of moves (6 χ7). Dynamic planning requires that all decisions be based on long-run plans. Yet long-run plans are frequently modified as new information changes the outlook (chapter VI).

Production economics and farm management science often appear to be preoccupied with organization at the neglect of the daily operation of a

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[2]Many people act as if they hold the -- fallacious -- belief that if there is a choice of actions, one to uphold the status quo, the other to make some kind of change, staying put is ipso facto the better alternative. The only reason not to make a change, if analysis shows change to be favorable, is unfamiliarity with the new. Good management requires that the "instinctive" fear of change be taken account of explicitly in two ways: The cost of changeover must be calculated and included in a cost-benefit analysis (4, p. 48), and the manager must habitually "ponder.... the unthinkable" (Herman Kahn, 5) to be familiar with an alternative course of action if it should become necessary to follow it.

farm. This is partly due to the fact that the ever changing needs of operation are hard to categorize. Furthermore, farm and ranch "operators" appear to be heavily preoccupied with the problems of daily operation, rarely stopping to concern themselves with the often much more consequential problems of how to organize their business and adapt to changing circumstances.

The reason farmers tend to concentrate on problems of operation rather than problems of organization are not hard to see:

(i) Haynes (8, p. 528) says it aptly:

The owner-managers of small firms often appear to be so involved in day-to-day affairs ... that they have little time to think about the larger decisions. When routine activities compete with the nonprogrammed, imaginative search for investments, the routines take priorities - a sort of 'Gresham's Law' of management that most of us observe in our daily lives.

Haynes and Solomon noted this attitude in small commercial firms. There can be little doubt that it holds true for farmers and ranchers who spend a great deal of their time with the daily chores. Habituation makes routine matters appear most important.

(ii) The knowledge and skills of running a farm are often acquired within a given organization. Most farmers are familiar only with a limited range of farming setups. Rightly or wrongly they are afraid to fail under a changed organization. Even more important, alternative forms of organization are not widely known and farmers find it difficult to judge alternative organizations on their merits alone.

(iii) Once established, an organization is by itself an obstacle to change. A given plan represents a certain investment, part or all of which may be lost if the plan is changed. The operator of a small farm who sells and moves to town may not get the capitalized value of benefits he derives from it in its current state. Potential buyers may not have any use for the farm buildings. Their offers are determined by what the farm is worth to them in <u>their</u> organization. Asset specialization and asset fixity make some organizational changes costly (9),(10, p. 78),(11).

While the third cause is inherent in the given state of the arts, factors (i) and (ii) can be influenced by providing information on organizational change and its consequences by stimulating debate on and preoccupation with organizational change. This thesis contributes to the pool of information. It is to be hoped that it may stimulate some debate on and preoccupation with organizational change.

C. Cattle Price Ratios

The forces that shape the market for agricultural products in this country favor the beef industry. Increased per capita income continues to raise the demand for beef relative to other farm products.[3] If there is no corresponding shift in supply, the increased demand is generally met by increases in output as well as price. Fig. 2 demonstrates how the market price for slaughter steers has improved its position relative to the price received by farmers for all farm products. In spite of wide cyclical swings the gain has averaged 3/4 of a percentage point per year.

In addition to a generally favorable development for the beef industry as a whole, the price of stocker and feeder steers and calves has gained relative to slaughter beef prices, as illustrated in fig. 3 and appendix A. While cyclical price variation is evident, particularly

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[3]See for instance G.E. Brandow (12).

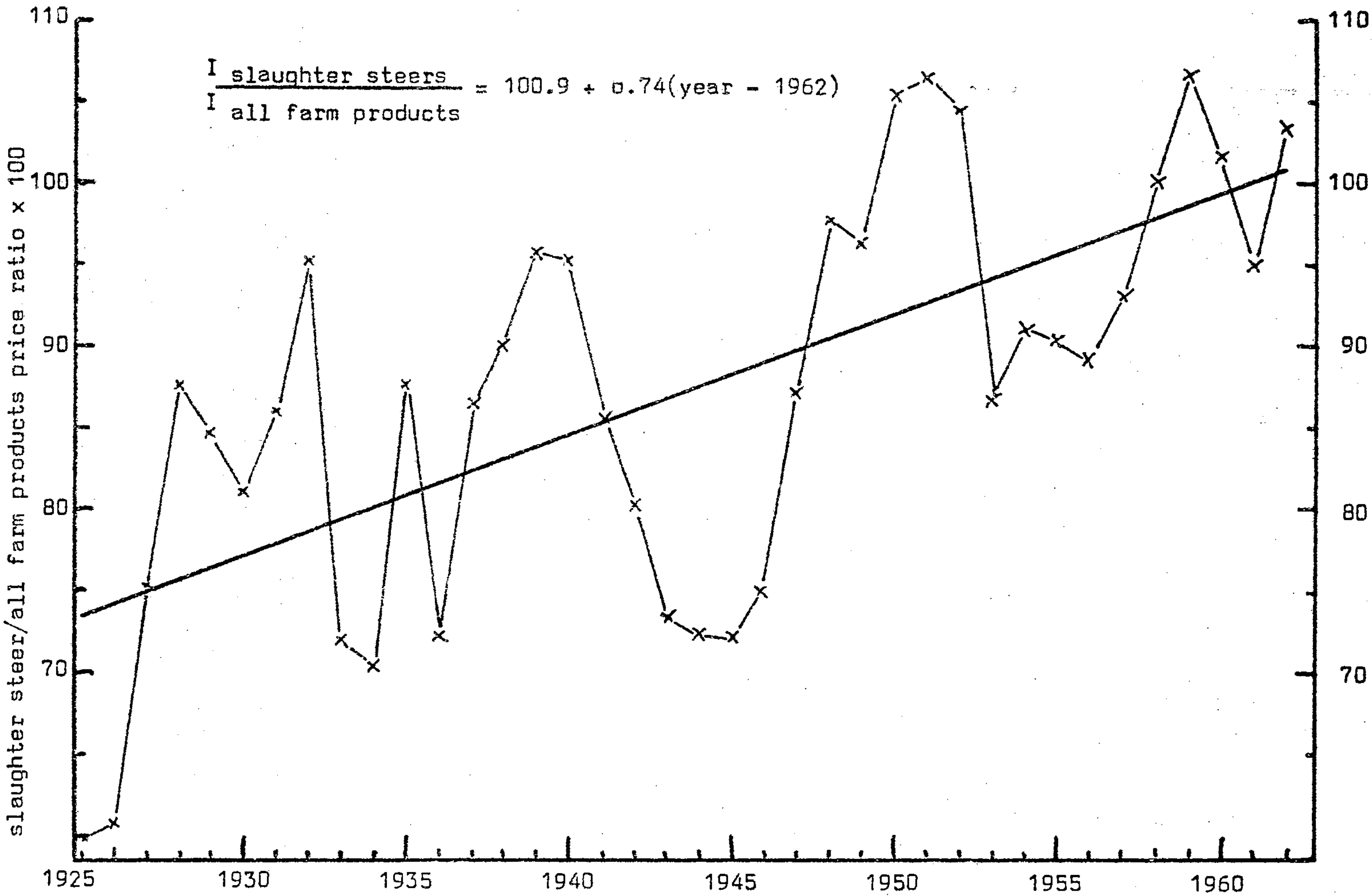

Fig. 2. The Relation of the Price Index of Slaughter Steers, Chicago, and the Price Index of All Farm Products, U. S. A., 1925-62. Data from (61)(86).

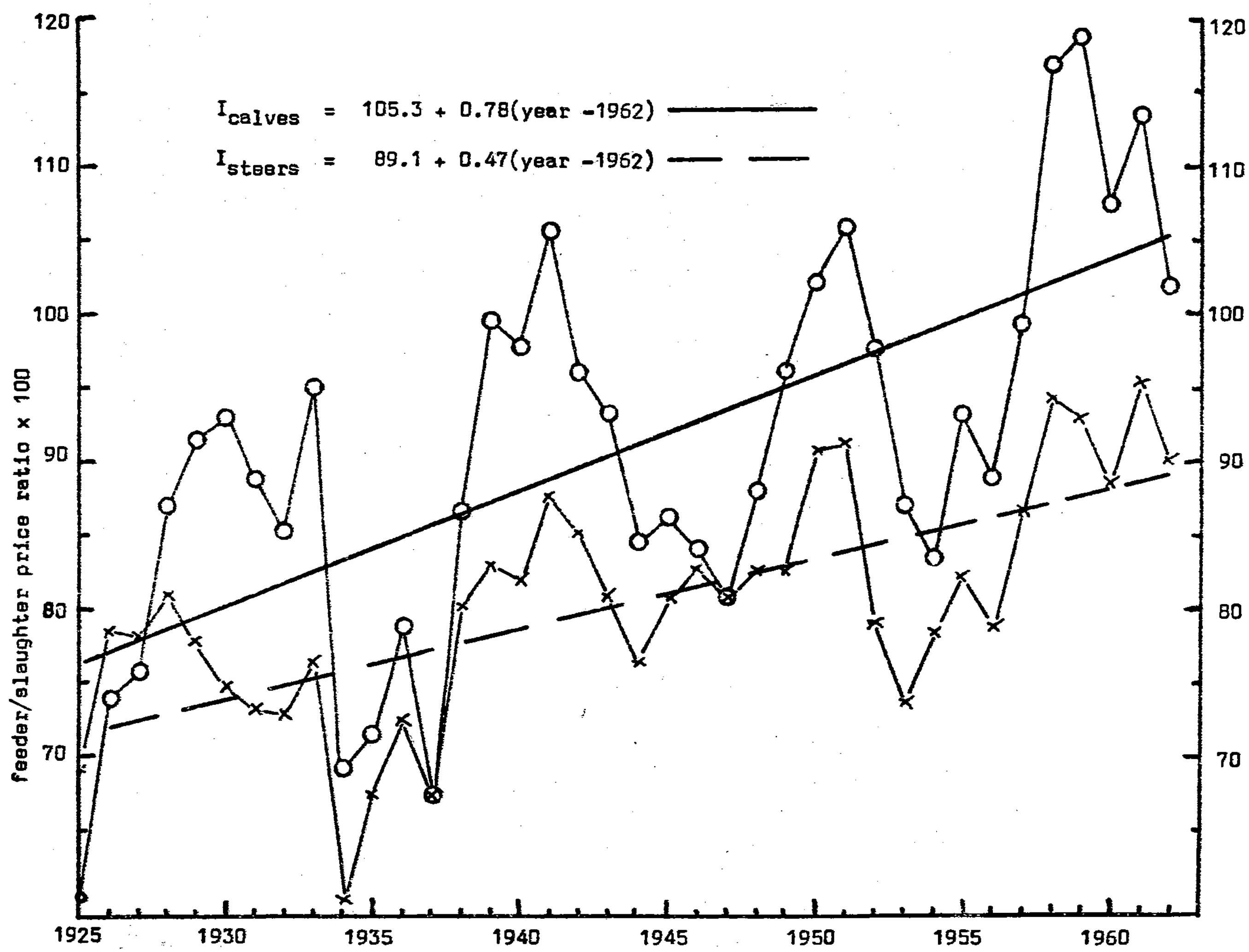

Fig. 3. The Relation Between Stocker-Feeder and Slaughter Cattle Prices, 1925-62. The Price of Stocker and Feeder Calves, and Stocker and Feeder Steers in Kansas City, Expressed as a Percentage of the Price of Slaughter Steers, all Grades, in Chicago. See Appendix A for source of data and method of computation.

in feeder calf prices, the trends are consistent, and there are no signs of a slowdown. The calf price is now normally higher than the slaughter steer price. It tends to gain 3/4 of a percentage point per year, while the stocker and feeder steer price gains almost $\frac{1}{2}$ per cent per year, relative to the slaughter steer price.

Higher prices for calves and stocker and feeder steers narrow the profit margin for the cattlemen who stock steers. Increased competition from an expanding cattle feeding industry probably accounts for the long-term rise in feeder prices. Since it is more attractive to sell feeder calves, many have shifted to cow-calf herds. The trend toward cow-and-calf operations has been evident in Oklahoma and other Plain States for many years.

The changing feeder/slaughter price ratio has had an effect in the traditional feeding and traditional dairy areas as well. Thus the marginal feeders and the marginal dairymen may gradually find a beef herd more attractive than their traditional operation.

D. Objectives of the Study

This study was undertaken to deduce general principles and specific recommendations of management of ranches in the Southern Plains from a formal, but empirically rooted model ranch seen, in turn, in a static, stochastic-static, and dynamic conceptual framework.

The effect of changes in the cost of capital is investigated in static models reflecting a variety of circumstances and extraneous conditions. The static model is further evaluated by applying a historical frequency distribution of beef prices to alternate ranch plans. This narrows down the choices to be recommended. Finally ranch operating plans for several consecutive years are selected, given certain assumptions about the course of prices and production in future years. Repeated use of such plans based on explicit forward planning constitutes "dynamic management."

While attention is paid to the premisses - empirical data, objectives, constraints of the model - and to the consistency of the deductions, the ultimate proof of any social science research which suggests action must await the outcome of the action taken as the ultimate proof of its correctness.

E. Analytical Methods Used in the Static Analysis

The planning objective usually assumed for the farm or ranch is to find the organizational forms that maximize the returns to the operator with a limited number of production processes, limited by the quantity of resources on hand. For many years, farm planning and farm budgeting were virtually synonymous words (3, p. 606 ff), (13, p. 328). This is no longer the case, owing to the advance of "mathematical programming," especially linear programming.[4]

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[4]The literature on linear and other mathematical programming is legion. George Dantzig is generally credited with the development of linear programming as a calculatory method. The first generally available accounts of linear programming were published in 1949 (14).

Subsequent developments can be followed in a series of symposia volumes, the last of which (15) contains further references.

"Linear Programming and Economic Analysis" by R. Dorfman, P. Samuelson and R.M. Solow, has long been considered the standard work on the application of linear programming in economics (16).

E.O. Heady and W. Candler have written a widely used explanation of linear programming with special reference to farm management and agricultural economics (17).

Linear programming is a method of maximizing a functional or an objective, (a) which is in itself a function of a number of interdependent processes or activities, linked to the objective by means of 'value transforms,' each of which is in turn dependent upon the availability of other variables, and (b) the value of which may ultimately be limited by constraints on the sum of the values of the constraining variables. It is natural that agricultural economists soon turned to this tool as a means of improving farm planning over the tried and proven if somewhat inelegant and inexact tool of budgeting. In fact agricultural problems were the first ones tackled by those economists who had "popularized" linear programming as a tool of economic analysis.[5]

Linear programming has advantages over budgeting (33, p. 28):

(a) there is a unique optimal solution;

(b) it forces the user to state explicitly his assumptions (this quality it shares with other formal and rigorous methods!);

(c) it is a tool for simulating real life decisions before their actual commission; specifically it allows analysis of the involved cause-and-effect relations of real farms.

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[5]The earliest applications to agriculture were published in 1951 by Dorfman (18), C. Hildreth and Reiter (19), Waugh (20), followed by publications in 1953: Fisher and Schruben (21), Fox (22), Freund and King (23), Judge and Fellows (24), and 1954: Heady (25), McCorkle and Boles (26). After 1954 the agricultural studies using linear and other mathematical programming have become too numerous to mention. The first theses using linear programming were those by Babbar (27), Bowlen (28); 1955 Kottke (29), Freund (30), and Dixon (31). See privately circulated bibliography by Reisch and Eisgruber (32).

1. Linear Programming Principles

In this paper the "objective" to be maximized is called "contribution to profit and overhead" or "contribution" for short, to signify that this objective is neither a strict net revenue figure nor just gross revenue. It is a concept similar to what Woermann (34) calls "gross revenue adjusted for specific costs."

a. The Basic Model

The general profit function of any firm may be stated

(1.1) $\Pi = F\ (x_{m+1}, \ldots x_{m+n}) - H$

where Π is the total net profit of the firm, x_{m+1} to x_{m+n} are the output quantities in individual production ventures, and H the overhead cost, not affected by the volume of $x_{m+1} \ldots x_{m+n}$. It is convenient to bring H to the left side, and rename the sum $\Pi + H = P$ (= contribution to profit and overhead). The total value P of (1.2) is to be maximized.

(1.2) $P = F\ (x_{m+1}, \ldots, x_{m+n})$

In linear programming it must be assumed for formal reasons that each x is independent of all other x'es. Therefore, (1.2) in this case is simply a summation of n subfunctions $f_{m+1}\ (x_{m+1}), \ldots f_{m+n}\ (x_{m+1})$. Each of these functions is a production function. It must be further assumed that these individual functions $f_j\ (x_j)$ are homogeneous and linear in x_j : a doubling of x_j doubles the value of $f_j\ (x_j)$ etc. (35, p. 315). A venture thus defined is called a "process."

The objective function of a linear programming model can now be written in specific form:

(1.3) $P = \sum_{j=m+1}^{m+n} c_j x_j = \max$

or, in matrix notation:

(1.3a) $P = CX = \max$

where the weighing factors ("value transforms") c_j are the contributions to profit and overhead of individual processes, x_j are any quantities of output (or input) chosen as the enumerator of the j^{th} process. In any situation the quantities, x_j, are likely to be limited, because the resources needed in their production are limited.[6] To facilitate resource allocation it is necessary to specify (a) the input requirements per unit of output in each process, (b) the quantities of each resource available and (c) a system of inequalities or equations relating available resources to requirements of all potential processes (constraints).

Resource requirements of process j for resources 1 ... m are specified by an array of input coefficients

(1.4) $a_{1j}, a_{2j}, \ldots a_{ij} \ldots a_{mj}$.

Because the production function of the process is homogeneous, the input coefficiente--the transformation or productivity rates in marginal analysis--thus specified are independent of the level of x_j, and completely specify the production process.

Coefficients $x_i \ldots x_m$ specify the quantity of each resource available.

The m constraints are of the form

(1.5) $x_i \geq \sum_{j = m+1}^{m+n} a_{ij}x_j \; (i = 1,2 \ldots m)$

---

[6]If some value of x turns out to be infinite, this usually indicates an economically trivial solution. The existence of such an "unbounded" x-value calls for reexamination of the model specifications.

or, in matrix notation:

(1.5a) $X^1 = AX^2$

where x_i are given, x_j unknown. While the total amount of resource x_i is limited, it may be allocated in any way desirable to each of the n processes.

The problem of maximizing P may now be restated as the problem of determining the "levels" of process variables x_j in such a way that the value of the objective function (1.3) is maximized, subject to constraints (1.5) or (1.5a). Because production processes are directed processes, the process variables may not be negative: calves may be produced with certain amounts of land, breeding stock etc. But it is impossible to make land, breeding stock etc. from calves. Therefore, another set of conditions specifies

(1.6) $x_j \geqslant 0.$ $(j = m+1 \ldots m+n).$

$x_i \geqslant 0.$ $(i = 1, \ldots m).$

Any allocation plan or solution which violates any equation of (1.5) or (1.6) is called "infeasible".

Equations (1.3), (1.5), (1.6) together specify the linear programming model. The combination of x-values in the optimal solution is achieved in an iterative process, applying essentially economic and accounting principles. The commonly used selection method is called the "Dantzig algorithm" or simplex algorithm.

While the system of equations (1.3, 1.5, 1.6) is solved for a maximum value of the functional, simultaneously a solution is obtained for a "dual" or orthogonal set of equations:

(1.7) $K = \sum_{i=1}^{m} b_i y_i = \min$

subject to n constraints

$$(1.8)\quad y_i = c_j \sum_{i=1}^{m} a_{ij}y_i \qquad (j = m+1 \ldots m+n)$$

and

$$(1.9)\quad y \geqq o$$

The b_i equal the initial x_i. The system utilizes the same coefficient matrix (B, A, C) as the original program. Yet they are joined by "vertical" equations.

In economic terms the y's are values of either outputs ($y_j = c_j$) already given, or values of inputs (y_i) which have to be imputed. They are called variously "shadow prices," "calculatory prices," "accounting prices," "imputed values," "use values." They should not be negative (1.9). The resources should be fully imputed. Hence the aggregate value of the resources employed in any process should not be less than the market price c_j of the process product (1.8). On the other hand, the aggregate value of all resources, K, must be equal to the maximum contribution P, in (1.3).

Linear programming theory proves that a maximum solution for (1.3) is also a solution to (1.7) satisfying all constraints (36)(14)(16). The solution which maximized P is also the only one which imputes the value of output completely to the resources. The maximum contribution solution is also the least-cost solution if the resources were priced near their imputed values.

b. Parametric Programming

Graves (37) has succinctly stated the effect of varying the contributions factor of an activity. In a linear programming problem and its dual, "(a) there exists a finite connected set of closed intervals

/̲ of the cost factor varied_7 (some of which may be points) on which the problem has a solution. The set of intervals may include /̲ the range of cost factor values from $-\infty$ to ∞ _7. Outside the set of intervals, the problem has no solution.

(b) On each interval the /̲ values of the variables x_i in the primal solution_7 are constants.

(c) On each interval the /̲ accounting prices_7 are linear functions of /̲ the varying cost factor_7.

(d) On each interval /̲ the functional value of the primal solution_7 is a linear function of x /̲ the varying cost factor_7.

(e) The /̲ objective_7 function is convex."[7]

In parametric programming an interval of a cost factor is determined within which one optimum solution obtains, then the value of the cost factor is changed so that it falls into a new interval with a new optimum solution, and the process repeated until the value of the cost factor reaches a stated limit (17, chapter 8). This method can be very useful "in cash budgeting where the amounts of funds available as well as the cost coefficients depend on the interest rate." The method of parametric contribution factors "permits a sophisticated sensitivity analysis (37)."

It is well known that economic plans for the firm are not drawn up with just a market rate of interest. Firms are generally operated as if their interest rate were considerably higher than the market rate of interest. In allocating capital, managers appear to discount for the

[7]If a constraint instead of a cost factor is varied, the statement above is correct if "value of the variables in the primal solution" is substituted for "accounting price," and "negative functional value" for "functional value (37, p. 201-2)."

varying degree of uncertainty[8] in the operation by adding a risk discount rate to capital. Further modifications are more subjective in nature, only partly accountable for by such objective factors as net worth and measures of "reaction to uncertainty." knowledge of credit sources, attitude towards using credit (42).

Programming over a range of capital costs presents a number of significant advantages over point estimates of optimum solutions:

(1) Statements can be made on what constitutes an efficient organization over a range of market rates of interest plus risk discounting rates. This presupposes that estimates of actual risk rates are available independently.

(2) By comparing the outcomes with various capital costs, statements may be made on the opportunity cost to the manager of erring in the "target rate of interest" which effectively governs his organization.

(3) An interesting use of this technique has been little explored:

By seeking out the model organization that comes closest to the organization found in real life, it should be possible to arrive at an

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[8]"Uncertainty" not in the Knight (38) sense, but as used in its original meaning (39). Mehr and Hedges (40) consciously avoid the antinomy of Knight's "risk and uncertainty." To them (p. 15) "risk is defined as uncertainty regarding a loss." Instead they make a distinction between "static risk." always a cost to both individuals and society (fire!), where statistical analysis and thus pooling is more applicable, and "dynamic risk." which involves questions of both size of risk and profit and loss (management, political, innovative risks!), which may be losses to the individual while a gain to society and vice versa. Furthermore "the growth and development of the economy depend upon the existence of an adequate number ... willing and able to undertake the dynamic risks." Fellner (41) apparently has a similar distinction in mind when he defines "business risk" as "a risk not capable of being eliminated through pooling (p. 48)."

estimate of the target rates of interest that actually govern the farm, be it the representative farm of an aggregate, or a single farm for which organizational improvements are sought.

Of course, uses (1) and (3) are mutually exclusive, because jointly they lead to circular reasoning.

(4) With a parametric series of solutions, a 'normative demand' function for operating capital can be constructed as with a series of variable capital constraints.

(5) The capital demand curve permits the analysis of optimum solutions for the effect of (a) interest rates, and (b) the amount of capital available to a firm. The steeper (less elastic) the capital demand curve, the less will the firm respond to changes in the -market or subjective- interest rate, or to changes in the supply of money available. The more horizontal the curve, the sooner do we expect expansion as more capital or cheaper capital becomes available. This kind of comparison is called sensitivity or stability analysis in operations research publications.

CHAPTER II

SPECIFICATIONS OF THE STATIC RANCH MODEL

Plans for farm (and ranch) organizations are commonly drawn up as budgets for a year. The practice is, however, to consider a budget the managerial blueprint over a period of years.[1] The budget commonly describes the "stationary state" of the farm, the farm as a "homeostatic process (44)." The usual budgeting approach makes a number of implicit assumptions: that the environment, the resources available, and the objectives of the planning unit remain essentially the same. Because of this assumption we tend to conclude that it is desirable to keep the organization of the farm constant as well. This is, of course, circular reasoning. The "normalcy" assumptions are, at best, first approximations. Therefore, the "normalcy" plan of a farm or ranch too, is a first approximation.

In spite of this limitation the static approach to farm planning is useful as long as it is understood that the "normal" results of the plans obtained are approximations, tools of analysis and demonstration . The method has the advantage of simplicity and is widely understood.

The method of linear programming has been described in the preceeding chapter. This chapter will deal with

A. the production processes or activities considered as alternatives, including the partial budgets for each, price levels, and related assumptions,

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[1]Tinbergen's "planning horizon (43)."

B. the structure of the decision system implied by the model,

C. the limited quantities of classes of land, labor, capital, which together form the resource bundle of the model ranches and serve as the constraints in the computing models.

A. A Description of the Production Processes in the Static Ranch Models

1. Partial Budgets and the Input-Output Matrix

Since the processes or activities in linear programming are by assumption linearly homogeneous they may be readily defined by partial budgets expressed on a per unit basis (per cow, per acre). Requirements are expressed in terms of the constraining inputs as well as in monetary costs, and the "contribution," the difference between direct costs (of all but the constrained - fixed - inputs) and gross revenue per unit is calculated.

No two ranches will have exactly the same production situation and the same productive potential. The budgets presented here should be considered estimates for a representative firm, managed with just above average efficiency; productivity and price data being an average over recent years. The budgets have been published in detail elsewhere (45), and are briefly described here and in appendix B.

a. Cow-and-Calf Activities

This study considers only commercial cow-and-calf operations, not specialized breeding.

Of the major alternative cow-and-calf systems, one based on considerable silage feeding was left out, because in preliminary budgets it had scored considerably below others. This left for consideration primarily

(a) the choice of a calving date - spring, fall, or both, with a saving on the costs of bulls, (b) the choice of wintering supplements, - protein concentrate, alfalfa hay, or more extensive winter feeding, either in the form of hay, or winter pasture, (c) a choice to creep feed or not to creep feed. To accomodate all these alternatives would have required 24 activities. Since the computing facilities were limited, only the ten combinations of table I were selected.

Differences in gross returns between the ten alternative cow-and-calf activities result from differences in physical productivity as well as seasonal price differences, as indicated in table II. Information on weaning weights, number of animals sold, and sales values per animal are to be found in appendix B, table III. It is worth noting that among the activities listed physical production varies more widely, thus influencing gross returns more, than seasonal sales price.

Table III summarizes direct cash outlay, contribution to overhead and profit, capital, pasture and other requirements that may be satisfied with resources or intermediate products of the ranch. Note that sales costs are included in direct costs, but not in operating capital requirements. A comparison of tables II and III shows that high gross revenues of the creep-feed systems are more than compensated for by higher cash outlays. Their contribution per cow is lower than for any other system. This apparent inefficiency is not compensated for by savings in any other requirements. They were included in the comparisons only to demonstrate their opportunity costs under various alternatives.

Profit contributions per cow as presented in table III cannot be compared directly between activities. The profit contributions are not comparable at this point because no charge has been made for the physical

TABLE I

CHARACTERISTICS OF BUDGETED COW-CALF OPERATIONS

Budget Number	Calving Season Oct.-Dec.	Calving Season Feb.-Apr.	Average Marketing Date	Calves Creep Fed?	Winter Feed Supplements (lbs. per animal unit per day)	
1.1		yes	Oct.10	no	Cottonseed cake	1.5
1.2		yes	Oct.10	no	Alfalfa hay	6.0
1.3		yes	Oct.10	yes[a]	Cottonseed cake	1.5
1.4	yes		Jul.20	no	Cottonseed cake	2.5
1.5	yes		Jul.20	no	Alfalfa hay	8.0
1.6	yes		Jul.20	yes[b]	Cottonseed cake	2.5
1.7	yes		Jul.20	no	Prairie hay	12.0
					Cottonseed cake	1.5
1.8	yes		May 31	no	Oats-vetch grazing;[c]	4 A.U.M.
					Prairie hay	4.0
					Cottonseed cake	0.5
1.9	yes	yes	Jul.20			
			Oct.10	no	Cottonseed cake	2.0
1.10	yes	yes	Jul.20			
			Oct.10	no	Alfalfa hay	7.0

[a] 4.2 cwt. of creep feed per calf to provide for 35 lbs. of extra grain.

[b] 8.4 cwt. of creep feed per calf to provide for 70 lbs. of extra grain.

[c] Hay and cottonseed cake substituted for failing oats-vetch pasture one third of the time.

TABLE II

VOLUME OF BEEF SALES, AVERAGE PRICES OBTAINED, AND GROSS RETURNS PER COW IN BUDGETED COW-CALF OPERATIONS

Act./ Budget Number	Activity	Salable Beef per Cow (Cwt.)	Average Sales Price ($ per Cwt.)	Gross Return per Cow ($)
1.01 1.02	Spring calves, not creep-fed	4.61	21.72	100.15
1.03	Spring calves, creep-fed	4.86	21.86	106.25
1.04 1.05	Fall calves, not creep-fed	4.40	22.31	98.15
1.06	Fall calves, creep-fed	4.88	22.53	109.95
1.07	Fall calves, not creep-fed; high winter feed rations	4.47	22.34	99.84
1.08	Fall calves, not creep-fed; wintered on small grain pasture	4.23	22.95	97.09
1.09 1.10	Fall and spring calves, not creep-fed	4.51	21.99	99.15

TABLE III

DIRECT COSTS, CONTRIBUTION TO PROFIT AND OVERHEAD, AND INPUT REQUIREMENTS: BUDGETED COW-AND-CALF ACTIVITIES, PER COW

Activity or Budget No.	Direct Costs ($/Cow)	Contribution to Overhead and Profit ($/Cow)	Operating Capital Livestock ($/Cow)	Operating Capital Operating ($/Cow)	Range A.U.M. per Animal Unit	Other Requirements[a]
1.01	18.77	81.38	192.00	15.06	12.0	-
1.02	9.45	90.70	192.00	5.74	11.5	Alfalfa hay
1.03	28.25	78.00	192.00	24.42	12.0	-
1.04	24.88	73.27	192.00	21.28	12.5[b]	
1.05	9.35	88.80	192.00	5.74	11.5	Alfalfa hay
1.06	42.97	66.98	192.00	39.13	12.5[b]	
1.07	18.70	81.14	192.00	15.06	10.5	Prairie hay
1.08[c]	12.36	84.74	192.00	8.85	8.0	Oats-vetch grazing Prairie hay
1.09	21.25	77.90	177.50	18.12	12.25[b]	-
1.10	8.97	90.18	177.50	5.86	11.5	Alfalfa hay

[a]The exact quantities required are listed in appendix C table IV.
[b]Includes browse for older calves.
[c]Excludes the establishment costs of pasture.

input requirements listed in subsequent columns of the table.

Spring and fall calving operations differ little in their total labor requirements. They differ, however, in the seasonal distribution of their labor needs. The labor peaks occur during the calving season. Balancing the labor requirements with available labor is one of the problems of managing the cattle ranch. This has been recognized in the model by specifying labor requirements for three periods. Table IV contains the total and seasonal labor requirements of the cow-and-calf systems.

TABLE IV

TOTAL AND SEASONAL LABOR REQUIREMENTS FOR BUDGETED COW-CALF OPERATIONS[a]

Budget Number	Labor Requirements (man hours per cow) Oct-Dec.	Jan-Apr.	May-Sept.	Total
1.01	0.79	4.05	0.74	5.58
1.02	1.00	4.76	0.74	6.50
1.03	0.89	4.05	1.74	6.68
1.04	2.67	1.74	1.02	5.43
1.05/7/8	2.89	2.47	1.02	6.38
1.06	2.67	2.54	1.52	6.73
1.09	1.73	2.89	0.88	5.50
1.10	1.94	3.62	0.88	6.44

[a]Based on survey results.

b. Stocker Cattle Activities

It is fairly well recognized that young stock cattle make particularly good use of lush, young pasture, rich in protein and short in raw fibers. This feed produces rapid gains without excessive fat production. Range pasture in Oklahoma and in most of the plains states remains in this condition normally only for a few spring and early summer months. One of the consequences is that feeder calf and feeder steer prices rise in the spring and continue high until signs of pasture deterioration caution prospective buyers. Later in the year, the bulk of weanling calves, whether born in the fall or in the spring, hits the market causing prices to drop sharply and to remain low until after Christmas. If calves are to be retained to stock the ranges the next spring, the price differential between fall and spring prices must be such that an incentive remains for either the calf producer, or the stock cattle operator, or a third party to winter the calves through the cool season, approximately from October 1 to April 1.

Nine calf wintering and stocker cattle activities were selected for comparison. Budgets 2.01 and 2.04 cover the wintering of weanling calves and determine the price differential necessary to provide an incentive to retain the calf crop on the ranges. The first provides for the "roughing" of the calves on range with a protein concentrate, the other entails wintering in a small pasture or trap with free choice prairie hay plus protein supplement.

A third wintering alternative exists under the climatic conditions of wide areas of Oklahoma. Calves allowed to graze a small grains pasture will gain rapidly and are ready for market as stocker feeder or lightweight slaughter cattle early in May (budget 2.07). Because small grain pastures do fail occasionally, budget 2.07 includes an ample feed allowance for trap wintering in one out of three years.

The level of wintering of cattle influences the gains that can be obtained during summer grazing (48). Budgets 2.02 and 2.03, covering the summer phase of yearling production, have been developed around roughed yearlings. Budgets 2.05 and 2.06, covering the same period, make use of trap wintered cattle which in the summer phase gain somewhat less rapidly than do the roughed ones. A further distinction was made between cattle sold off range pasture in August (budgets 2.02 and 2.05) and cattle which, after grazing heavily on native range in the spring, are transferred to a sudan grass pasture. These are to be marketed around the first of September (budgets 2.03 and 2.06).

The last two stocker budgets concern the wintering and subsequent summer grazing of 18 month-old cattle to be sold one year later. The only distinction between these budgets lies in the kind of winter feed: Budget 2.08 assumes a cottonseed cake supplement, budget 2.09 alfalfa hay.

The stocker cattle budgets cover subsequent stages from weanling to long two-year olds. At each stage a choice is open to either sell the cattle produced in the previous stage, carry them on through the next stage, or buy additional animals for the next stage. Marketing charges have to be paid whenever cattle are sold or bought, but not when cattle are merely transferred from one production period to another.

No specifications were set for the type of animal produced. It has been assumed that the operator has sufficient freedom and oversight to market cattle either as slaughter or as stocker-feeder cattle, whichever returns the better prices. Prices used have been reported in tables I and II, appendix B.

TABLE V

CHARACTERISTICS OF BUDGETED STOCKER CATTLE OPERATIONS

Budget Number (1)	Ave. Date to Buy (2)	Ave. Date to Sell[a] (3)	Weight Buy (4)	Weight Sell[a] (5)	Components of Ration Winter (6)	Components of Ration Summer (7)
2.01	Oct. 10	April 1	475	525	C.S.C., Range	-
2.02	April 1	Aug. 10	525	750	-	Range
2.03	April 1	Sept. 1	525	790	-	Range, Sudan
2.04	Oct. 10	April 1	475	575	C.S.C., Hay	-
2.05	April 1	Aug. 10	575	785	-	Range
2.06	April 1	Sept. 1	575	815	-	Range, Sudan
2.07[b]	Oct. 10	May 10	475	740	Oats-Vetch Pasture, Hay	-
2.08	Aug. 10	Aug. 10	750	1,025	C.S.C., Range	Range
2.09	Aug. 10	Aug. 10	750	1,025	Alfalfa Hay Range	Range

[a] May be sold as feeder or slaughter cattle depending on market price situation.

[b] Trap feeding in one year out of three.

Gains and gross revenue of the stocker cattle operations may be found in table VI. Both gains in weight and seasonal price difference affect gross returns. The price margin may be positive as for the wintering operations, or negative as for the summer period, or neutral, as for the small-grain wintered yearlings and the older steers kept for a full year. (See appendix B, table II). The gross returns listed in table VI are not comparable unless differences in the time periods covered and in their nonpriced requirements are taken into account.

On a per year basis, a combination of 2.04 and 2.06 yields the highest gross returns of all combinations with $66.83 per steer, while 2.01 and 2.02 combined yield lowest with $54.25 per steer. The small

TABLE VI

GAINS, PURCHASE VALUE, SALES VALUE, AND GROSS REVENUE PER STEER; BUDGETED STOCKER STEER OPERATIONS, PER STEER

Activity or Budget No.	Activity	Total Gain[a] (Cwt)	Purchase Value ($)	Sales Value ($)	Gross Returns ($)
2.01	Weanling calves roughed X-10 to IX-1	0.45	115.24	136.43	21.19
2.02	Roughed yearlings on range IV-1 to VIII-10	2.21	137.81	166.05	28.24
2.03	Roughed yearlings on range and sudan, IV-1 to IX-1	2.61	137.81	172.53	34.72
2.04	Weanling calves trap wintered X-10 to IV-1	0.94	115.24	150.94	35.70
2.05	Trap wintered yearlings on range, IV-1 to VIII-10	2.06	150.94	173.79	22.85
2.06	Trap wintered yearlings on range and sudan, IV-1 to IX-1	2.36	150.94	178.40	27.46
2.07	Weanling steers wintered on oats-vetch, X-10 to V-10	2.58	115.24	177.66	62.42
2.08/9	Long yearlings wintered and grazed, VIII-10 to VIII-10	2.65	166.88	225.78	58.90

[a]Final weight less initial weight less death loss.

grain wintering operation is attractive since it takes only seven months to achieve this result.

Table VII lists direct costs, contribution to profit and overhead, and nonpriced requirements like operating capital and range A.U.M.. Specified costs include marketing charges for both the purchase and sale of the animal. A death loss of from one-half per cent (summer grazing) to one per cent of the sales value (all other stocker steer budgets) is included in the cost totals. The livestock capital required equals the purchase value of the stocker (see table VI). Table VII lists the requirements for other working capital. The capital for stocker operations often is not required for the full year. Depending on the credit arrangements this may result in a saving of interest payments, or, if the capital is owned by the operator, the capital may be used to finance other operations part of the time.

Stocker steer operations require less labor than cow-calf operations on the range, while considerable labor is required for winter feeding (table VIII).

c. Forage Production

Table IX lists the budgeted forage enterprises. Alfalfa hay may be sold or fed. For simplicity it has been assumed that the entire hay crop is harvested by custom operators. A breakdown of costs and seasonal labor requirements may be found in appendix B, tables V and VI.

TABLE VII

DIRECT CASH COSTS, CONTRIBUTION TO OVERHEAD AND PROFIT, AND NON-CASH REQUIREMENTS, BUDGETED STOCKER STEER OPERATIONS PER STEER

Budget or Activity Number	Priced Specific Costs[a] ($)	Contribution to Profit + Overhead ($)	Operating Capital[a] ($)	Range A.U.M.	Other
2.01	17.86	4.64	14.01	3.0	-
2.02	7.90	23.61	3.44	3.0	-
2.03	8.14	30.53	3.44	1.2	Sudan grazing 2.0 A.U.M.
2.04	16.73	19.27	12.00	0.5	Prairie hay 1.0 ton
2.05	8.37	17.94	3.69	3.0	-
2.06	8.55	22.29	3.69	1.2	Sudan grazing 2.0 A.U.M.
2.07	12.81	43.52	6.80	0.5	Oats-vetch pasture 2.8 A.U.M., Prairie hay .33 tons
2.08	26.42	37.83	21.13	12.0	-
2.09	12.16	52.08	6.88	10.0	Alfalfa hay 0.67 tons

[a]Excludes value of purchased animal.

TABLE VIII

TOTAL LABOR REQUIREMENT AND SEASONAL DISTRIBUTION, BUDGETED STOCKER STEER OPERATIONS, MAN-HOURS PER STEER

Activity	Labor Requirements (man-hours per steer)			
	Oct.-Dec.	Jan.-Apr.	May-Sept.	Total
2.01	0.58	0.75	-	1.33
2.02/5	-	0.28	0.48	0.76
2.03/6	6	0.28	0.62	0.90
2.04	1.00	1.23	-	2.23
2.07	0.38	0.50	0.44	1.22
2.08	0.60	0.73	0.98	2.31
2.09	1.00	1.43	0.98	3.41

d. Accounting Activities

Two activities are included in the model to account for quantity and value of production accrued in the production activities. These are the row vector (23) - marketable livestock production in tons liveweight, and (24) - gross revenue accrued by the end of the production period. They have been included to have these two measures of production automatically summarized as the model data are computed (see "Production" charts in chapter III).

TABLE IX

FORAGE BUDGETS.

Act./ Budget Number	Crop	Land Requirements	Yiels per Acre		Costs[a]		Labor (Man-Hour)[b]	
			Unit	Amount	$/Acre	$/Yield Unit	per Acre	per Yield Unit
3.1	Alfalfa Hay	Class A	Ton	2.75	30.45	11.07	4.65	1.69
3.2	Prairie Hay	Meadow	Ton	1.10	9.92	9.02	0.0	0.0
3.3	Oats Hay	Upland	Ton	1.45	16.86	11.63	4.42	3.05
3.4	Sudan Hay	Upland	Ton	1.25	13.92	11.14	2.92	2.34
3.5	Oats-Vetch Grazing	Upland	A.U.M.	3.20	11.89	3.72	2.28	0.71
3.6	Sudan Grazing	Upland	A.U.M.	2.66	2.92	1.10	2.70	1.02

[a]Does not include a land change. For details see Appendix C, Table VI.

[b]Harvest labor is provided by custom operators.

e. General Management Activities

A number of general management activities are needed to complete the economic ranch model: renting, borrowing, purchasing feed, purchasing cattle, and selling cattle.

All classes of land may be rented out at rental rates five per cent below the rates for renting in. Capital may be borrowed against collateral. Capital borrowed against real estate at a variable rate may be used to finance cattle purchase; capital borrowed against more liquid forms of assets, such as cattle and cash, at a rate of three per cent above the rate for livestock loans may be used to finance any capital needs, including operating expenses.

Feed may be purchased and some choice has been provided in the marketing of cattle. Though the marketing dates are specified by the particular method of production,separating the production and marketing activities permits keeping young animals for further production.

2. The Matrix of Input, Output, and Contributions Coefficients

Once the enterprise budget has been formulated, it is an easy matter to establish the equations that relate activities, constraints, and contributions to the operating objective in a formal system for linear programming. The relations are expressed in input-output, and contributions coefficients attached to the unknown activity variables. The coefficient matrix is presented in appendix C. Further explanation is provided in the next section.

B. A Qualitative Description of Management Decisions Simulated by the Models

In order to simplify the presentation of farm organizational models obtained by linear programming the following decision tree presentation has been devised. It should be helpful also when setting up linear programming tableaus: Each alternative to be decided upon is represented by an arrow to indicate the directions a decision may turn.[2] This illustrates well the qualitative aspect of decisions that may be taken, the choice between one activity rather than another. The quantitative specification - how many units of each - will be represented in the conventional way by means of tables and charts.

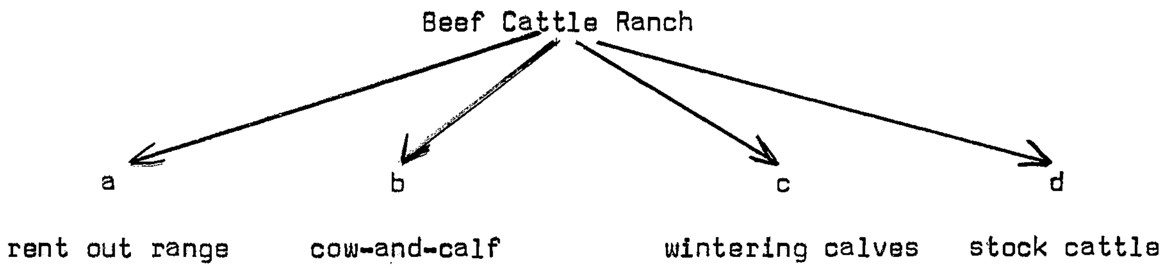
Decisions to be taken may be grouped into primary, secondary, and subsidiary decisions. Primary decisions are those that determine the general direction of the farm organization - beef breeding herd versus stocker steers, calf wintering, and expansion decisions. Secondary decisions involve a choice between alternative modes of operation, like fall or spring calving, calf pasturage on small grain pasture, or roughing etc. Subsidiary decisions are those that follow from primary and secondary decisions. Here belong such questions as choice of roughages, hiring of labor, and land use.

Choices described by pairs or bundles of arrows are not necessarily exclusive choices. Whether it is an 'either - or' or an 'as well as' is determined by the shadow price and constraint relations of the model

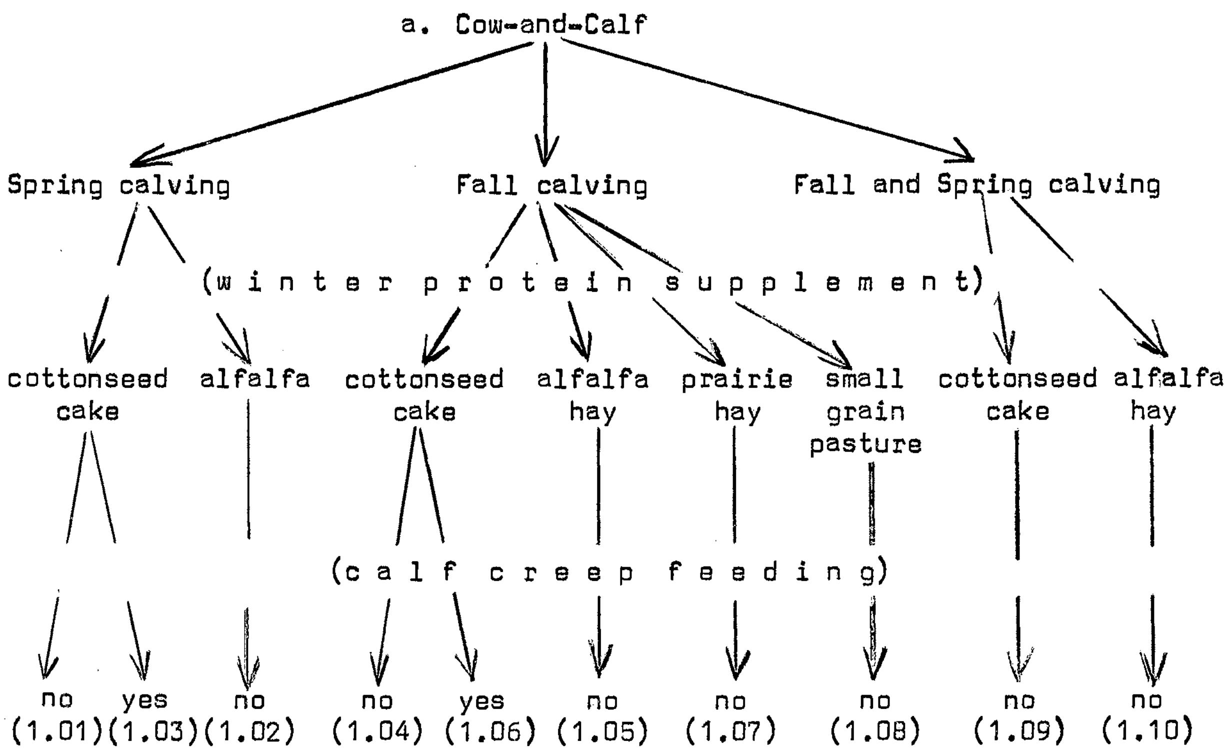
[2]This arrow scheme should not be confused with the rather well known arrow scheme by Tinbergen (43) where arrows are used to indicate the intertemporal causative relationships.

only. Numbers in parentheses are the identification numbers of activities in the static model.

1. Primary Decisions

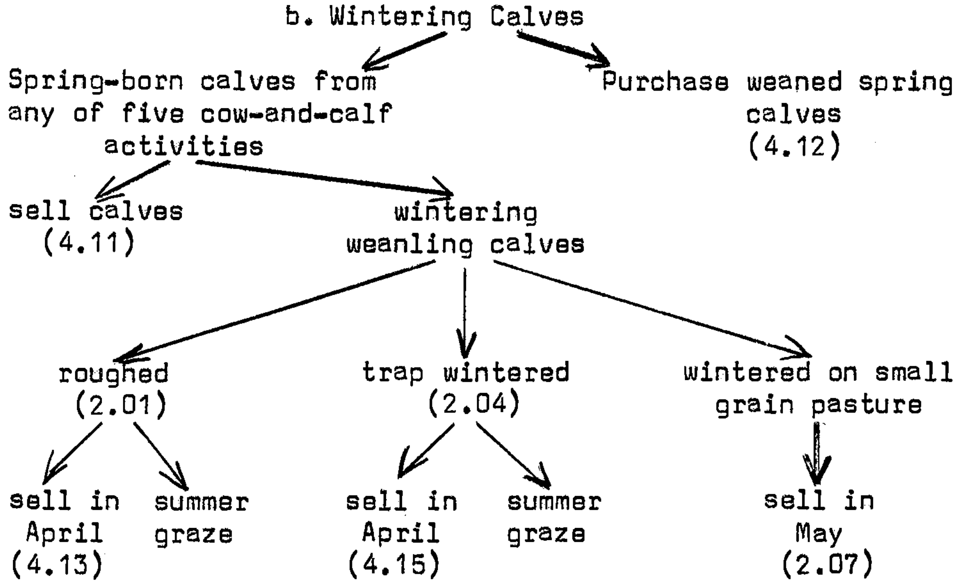


2. Secondary Decisions

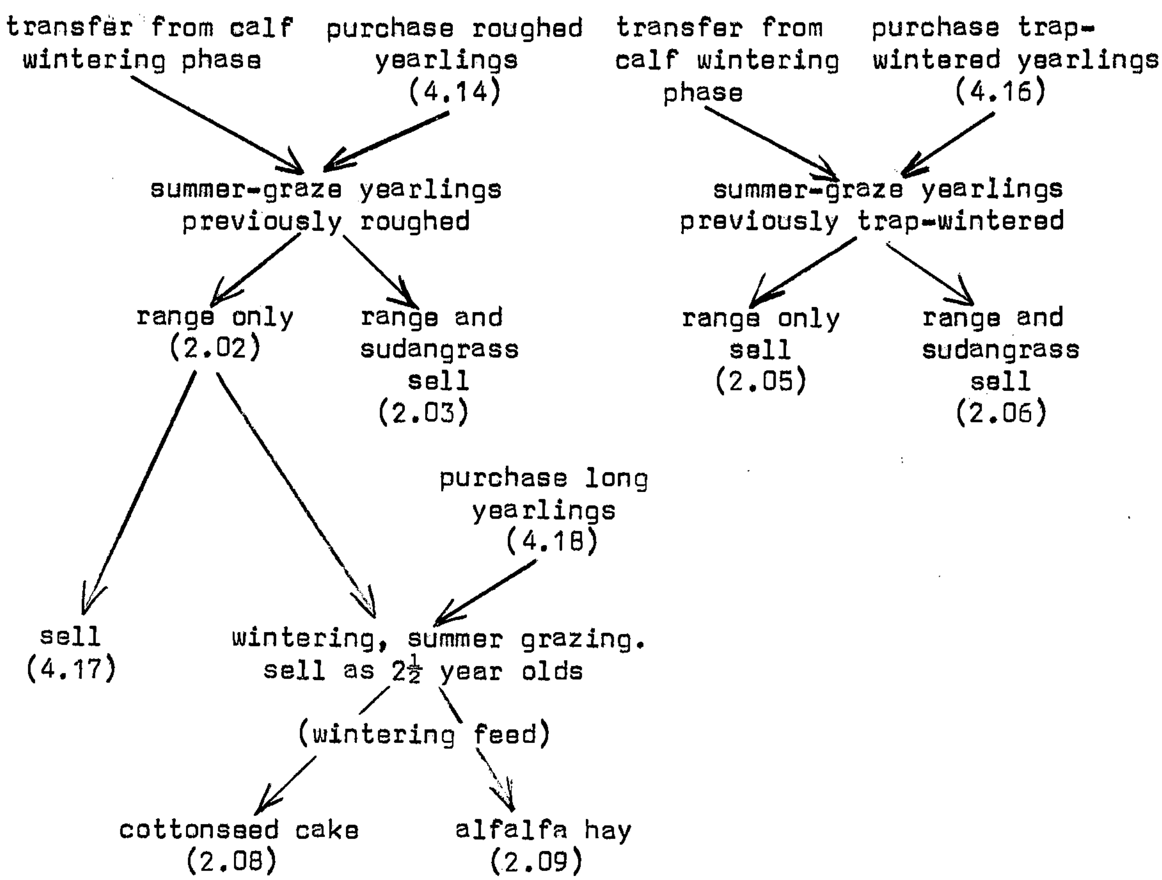


Note: All fall calves to be sold at weaning; spring calves may be either sold at weaning or transferred to wintering phase. See (c) below.

b. Wintering Calves

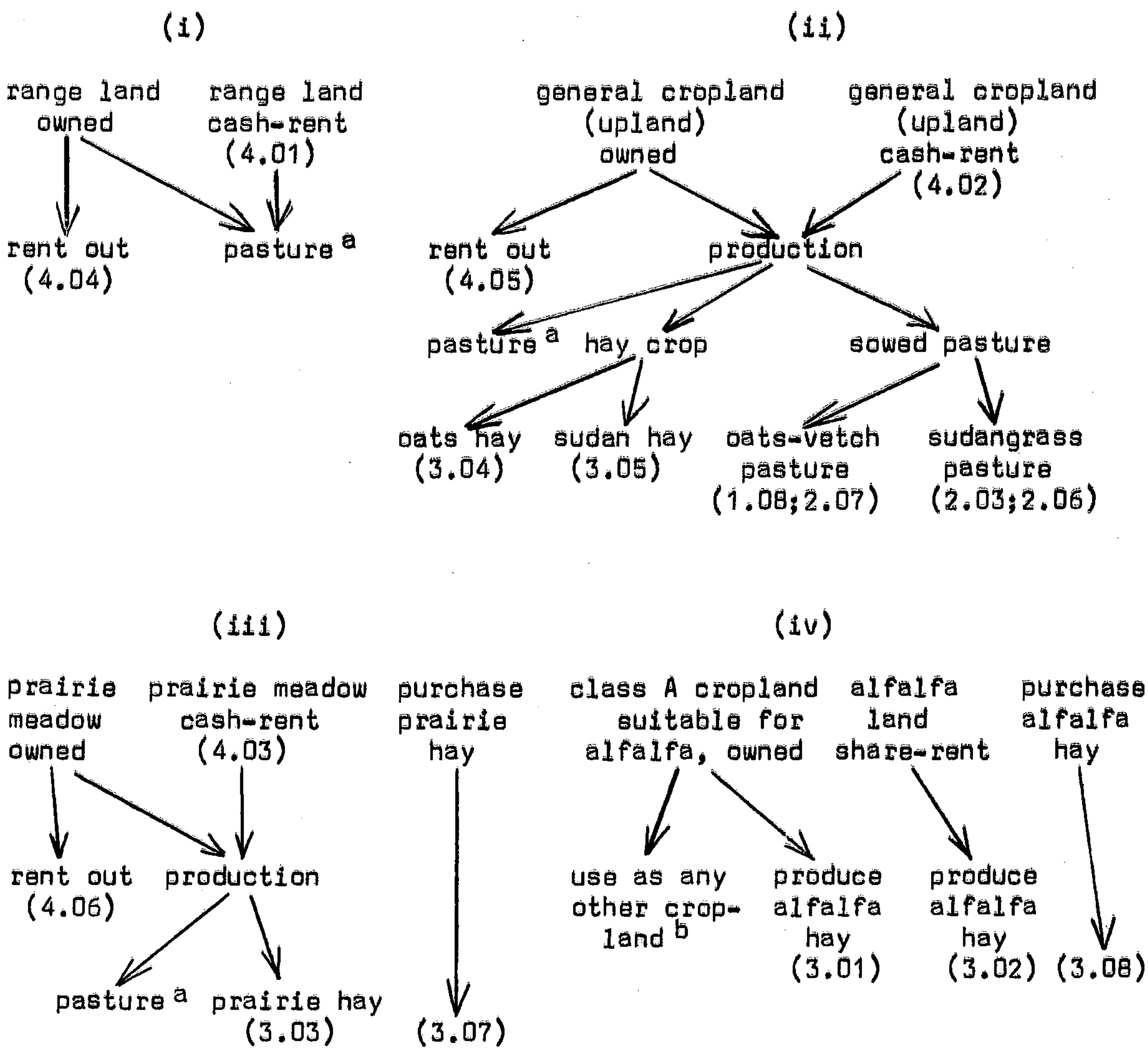


c. Stock Cattle



3. Subsidiary Decisions

a. Land Use and Roughage Purchase



Note: Alfalfa hay is required for activities 1.02, 1.05, 1.10, and 2.09; alfalfa may be substituted freely for prairie hay in all other uses.

[a] Used in cattle activities as indicated.

[b] Class A cropland may be selected for any use permissible for general cropland.

b. Labor Disposition

(i) Operator's Working Time[3]

overhead labor not restricted to any particular season

discretionary working time, available for production activities (original constraint)

(ii) operator's discretionary working time, Fall (original constraint)

hired labor, Fall (4.22)

Fall work load of all activities

Note: Spring and Summer seasonal work loads may be performed in like manner by either operator or hired labor (activities 4.23 and 4.24).

c. Capital Use and Credit Disposition

(i) Livestock Capital

operator's capital (original constraint)

livestock capital borrowed (4.20)

for purchase of livestock only

(ii) All Other Operating Capital

operator's operating capital

transfer from livestock capital stock at additional 3 % interest charge (4.21)

all operating expenses prior to sale with the exception of livestock purchase

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[3]See appendix B, table VII.

C. The Resources Allocated to the Model Ranches

The resources of the firm ultimately limit its productive capacity and its ability to generate income for the owne.. The major resources of a farm or ranch are the operator, the land he controls, and capital, in its physical form - breeding stock, buildings, equipment - as well as in the form of operating capital, either owned or as a line of credit.

To fully define the resources of a firm, it is necessary to state the quantity as well as the quality of the resources available. Some of the qualitative aspects of resources to be used have already been discussed. Land quality was specified by defining the carrying capacity of range, labor quality by the man hours needed for the various enterprises, and managerial ability by the total of the requirements specified.

It remains to define the quantity of resources which together complete the description of a particular ranch situation. Since the results are considered primarily for the use of managers of individual ranches, it was not necessary to define resources for "average" or "representative" units. The choice of the resource bundles selected for the computational phase was based on three considerations believed important: they should(a) reflect the variety of ranch units as they exist now, and as they are likely to develop in the future,(b) be modular, i.e. they should be given in multiples of quarter sections, family labor should be defined in full-time persons etc. and(c) demonstrate the principles that govern the relations between changes in resources and management results.

The typical or "normal" situation selected is a four-section ranch with ninety-three per cent of the acreage native pasture, one per cent prairie hay, five per cent suitable for cropland, one per cent of which could be used for alfalfa hay production (irrigated or bottom land). The operator may work as many as 2700 hours annually. One third of the operator's labor is reserved for overhead work and the remainder is available for work directly related to the various enterprises (49). The maximum time available per month is 240 hours, of which 40 hours again had to be reserved for non-deferrable overhead jobs[4] (see appendix B, table VII).

Operating capital to finance the purchase of livestock and other current expenditures was available freely. The quantity of operating capital used was determined by parametric programming, the price of operating capital being the parameter to be varied. By varying the price of operating capital ("target rate of return"), a series of organizational plans was generated.

The computing facilities permitted calculating of the range of interest rates for which a particular program would remain optimal.[5] This procedure has the advantage that it generates results for any capital and credit situation. The reader of the following chapter merely needs to form an estimate of the amount of owned or borrowed capital he is able to or wishes to commit (in addition to the real estate already specified), enter the diagrams presented in the following chapter at

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[4]This arrangement allows the operator more flexibility than if the total of 1800 hours had been prorated strictly to each month. It is assumed that he works more in high-load periods, but makes up for it at other times.

[5]A supplementary program had to be written to step into the next range of interest rates that would require a change in organization, and recompute the new situation. This modification of the customary 'variable price programming' routine provided a continuous series of optimum solutions, which in turn defined the demand curves for operating capital as presented in the following chapter.

the appropriate value on the horizontal axis, read off the description of the optimum setup, the rate of return to the operating capital committed, and the amount of contribution generated to pay for overhead and profits (which also must cover service on additional real estate loans).

The resource situation has been modified in several ways (table X): In addition to the "normal" situation, resembling an operator owned four-section ranch (A), an alternative was a tenant-operated ranch of like size (B), an option to rent an additional section to the four already operated (H and I), and a "small" ranch limited to six quaters of land (C). Another series of modifications was designed to demonstrate the effect of other land capabilities. For example by eliminating land suitable for forage crops the choice of productive activities available becomes more limited. Valuation and rental rates used in this study are given in table XI. The remaining constraints of the model facilitate the transfer of physical quantities of resources or products between activities (table XII).

TABLE X

RESOURCE SITUATIONS OF MODEL RANCHES

Line	Resource	Unit	A S1-10	B S11	C S-12	D S13 S17-19,21	E S14 S20	F S15	G S16	H S20-24	I S25-27
1	Operator labor, all year[a]	man-hr	1800	*	*	*	*	*	*	*	*
2	of which Oct.-Dec.	man-hr	600	*	*	*	*	*	*	*	*
3	Jan.-Apr.	man-hr	800	*	*	*	*	*	*	*	*
4	June-Sept.	man-hr	1000	*	*	*	*	*	*	*	*
5	Land owned[b]	acre	2550	0	950	2550	2550	2550	2550	2550	2550
6	of which cropland	acre	125	0	60	0	0	125	125	125	0
7	class A cropland	acre	25	0	10	0	0	0	0	25	0
8	prairie hay	acre	25	0	10	0	25	0	25	25	0
9	Rent option, range	acre	0	2400	0	0	0	0	0	640	640
10	Rent option, cropland[c]	acre	0	100	0	0	0	0	0	0	0
11	Rent option, class A cropland	acre	0	25	0	0	0	0	0	0	0
12	Rent option, prairie hay	acre	0	25	0	0	0	0	0	0	0
-	Capital value of real estate owned	$	221350	0	83250	217600	217975	219475	219800	221350	217600

*Same value as in preceeding column.

[a]Plus 900 hours for overhead labor. The sum of hours available per season exceeds by one third the total man hours available per year. Thus a heavier than normal workload can be performed if necessary, provided this is compensated by a lighter workload during another season.

[b]Four sections, less 10 acres for homestead. The total acreage may be grazed. Lines 6,7 and 8 specify the parts which are suitable for other uses.

TABLE XI

LAND VALUATIONS AND RENTAL RATES

ASSUMED

Class of Land	Valuation $ per acre	Rental Rate $ per acre rent in	Rental Rate $ per acre rent out
Range	85.00	2.50	2.38
Cropland	100.00	6.50	6.50
Class A cropland	160.00	½ share	6.50
Prairie hay meadow	100.00	6.50	6.50

TABLE XII

CONSTRAINTS SET INITIALLY TO ZERO

Row No.	Name of Constraint	Unit
	Capital Control	
09	Livestock Capital, annual or fall[a]	$
10	Other working capital, annual or fall[a]	$
11	Livestock capital, spring[b]	$
12	Other working capital, spring[b]	$
	Feed Transfer	
17	Prairie hay (or equivalent)	ton
18	Alfalfa hay (high protein roughage)	ton
	Cattle Transfer	
19	Weaned spring calves, October 10	head
20	Roughed yearlings, April 1	head
21	Trap wintered yearlings, April 1	head
22	Long yearlings, October 10	head
	Output Accounting	
23	Marketable Production - liveweight	ton
24	Sales Volume	$

[a]Fall requirements in static models no. 1, 2, 3, 5 - 10 and 17 - 24. Annual requirements in other models.

[b] This constraint is waived in those static models which have an annual requirement in rows 09 and 10.

CHAPTER III

RESULTS: THE STATIC MODEL

A. Notes on the Interpretation of the Data

The results of the various models (table XIII) may be compared directly in a series of graphs and tables. The charts show, as calculated, (a) the contribution to profit and overhead;[1] (b) production volume and organization: quantity and value of beef sales, acres of range used, number of head of cows and other cattle; (c) the demand function for operating capital; (d) the accounting prices or marginal productivity values of land; (e) the accounting prices or opportunity costs of the non-basis beef production activities. The data have been plotted against a scale of working capital required to achieve the desired results.[2]

The tables of appendix D contain information on critical points of the capital cost - amount curve; namely (1) the O-point, characterized by the highest rate of interest which would justify beef production, i.e. the highest marginal productivity of capital to be achieved by the ranching activities compared; (2) point G, where the cost of capital is low enough to permit the use of all owned grazing land allotted the

[1]as defined on page 12.

[2]Even though the computations themselves were based on a variation of the cost of borrowing capital.

TABLE XIII

CHARACTERISTICS OF VARIANTS OF STATIC RANCH MODEL

No.		Resource Mix	Choice of activities	Capital charged	Hay price
S 1	A[a]	basic 4-section ranch	all	full year	normal
S 2	A	ditto	ditto	ditto	up 20%
S 3	A	ditto	ditto	ditto	up 40%
S 4	A	capital charge formula relaxed	all	for months in use	normal
S 5	A	raised cattle only	raised cattle	full year	normal
S 6	A	ditto	ditto	ditto	up 20%
S 7	A	ditto	ditto	ditto	up 40%
S 8	A	breeding herd only	breeding herd	full year	normal
S 9	A	ditto	ditto	ditto	up 20%
S 10	A	ditto	ditto	ditto	up 40%
S 11	B	tenant-operated 4-section ranch	all	for months in use	normal
S 12	C	small owner-operated ranch[b]	all	for months in use	normal
S 13	D	land mix: range only (I)	all	for months in use	normal
S 14	E	land mix: range and prairie hay (I)	all	for months in use	normal
S 15	F	land mix: range and cropland (I)	all	for months in use	normal
S 16	G	land mix: all but class A cropland	all	for months in use	normal
S 17	D	land mix: range only (II)	raised cattle	full year	normal
S 18	D	ditto	ditto	ditto	up 20%
S 19	D	ditto	ditto	ditto	up 40%
S 20	E	land mix: range and prairie hay (II)	raised cattle	full year	normal
S 21	D	land mix: range only (III)	breeding herd	full year	normal
S 22	H	rent option, basic land mix	raised cattle	full year	normal
S 23	H	ditto	ditto	ditto	up 20%
S 24	H	ditto	ditto	ditto	
S 25	I	rent option: rangeland only	raised cattle	full year	normal
S 26	I	ditto	ditto	ditto	up 20%
S 27	I	ditto	ditto	ditto	up 40%

[a]letters refer to columns of table X.

[b]960 acres ($1\frac{1}{2}$ section)

model ranch; (3) point C, indicating the limit of efficient use of operating capital with associated resources and activities, i.e. the capital input where marginal productivity of capital falls to zero; and, for models which make provision for renting in some land, (4) point R, where full use is made of the allotted rented land.

Figures 4 and 5, and table I in appendix D exhibit the traits of the basic model for a four section ranch, consisting primarily of range land, with some cropland, prairie hay and alfalfa acreage (static model 1). Interest is charged for a full year. However, two activities which use capital at different seasons may use the same capital.

The effect of adding operating capital to the existing four section unit may be read off the charts from left to right. The characteristics of one and the same organization lie on a single vertical across all diagrams. In the interest of legibility most curves have been drawn continuous, rather than as step functions.[3]

In addition to the true "lean" objective function obtained by calculating optima for the capital cost that are in equilibrium with the amount of capital used (top diagram), contributions curves have also been drawn for capital costs or "external rates of interest" of zero, 10 and 20 per cent.

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[3]If the amount of capital is allowed to vary, resource use and objective function curves will be smooth (even though their direction may change) while the dual accounting prices have discontinuous change-over points, which leads to step functions. If the price of capital is allowed to vary, the accounting prices will vary continously, while resource use and objective function will change at vertex or breakeven prices, resulting in step functions for the basis variables.

B. The Basic Situation (Static Model 1)

The first ranching activity has a marginal productivity of capital in excess of 39 per cent. Thus, as long as the internal interest rate exceeds 39 per cent, land will be rented out. Naturally no operating capital is needed. Rental income is $6600 (zero solution).

Up to $11,000 working capital ($\alpha$ in fig. 4,5) will be employed at a cost of 34 to 39 per cent, principally to utilize the cropland by wintering 80 calves on a small grain pasture (2.07), and 69 yearlings grazed through the summer (2.02). The stand of prairie hay is used, plus 83 acres of range. Beef sales (not adjusted for the cost of the livestock purchased) amount to nearly $27,000.

The contribution to profit and overhead (i.e. the value of the objective function) for this organization depends on the assumed magnitude of the external interest rate. If the full target rate of interest (here 39 per cent) were charged off, the contribution would be only slightly better than the zero solution - $6,600. If a charge of 10 per cent on all working capital is made, the contribution available to meet overhead costs and operation profit (residual) jumps to $9,800, and to $11,000 if no charge for working capital is made. The latter figure may represent the earnings and overhead to the operator who owns all the working capital himself. Prairie hay is used throughout. Fall-and-spring cows with an alfalfa hay supplement are the next best alternative, though they reduce income by $7 per cow.

Below the 34 per cent internal rate of interest, a cow herd is profitable (fig. 4), the combination of spring and fall calving with alfalfa hay as the principal supplement (activity 1.10). However, because

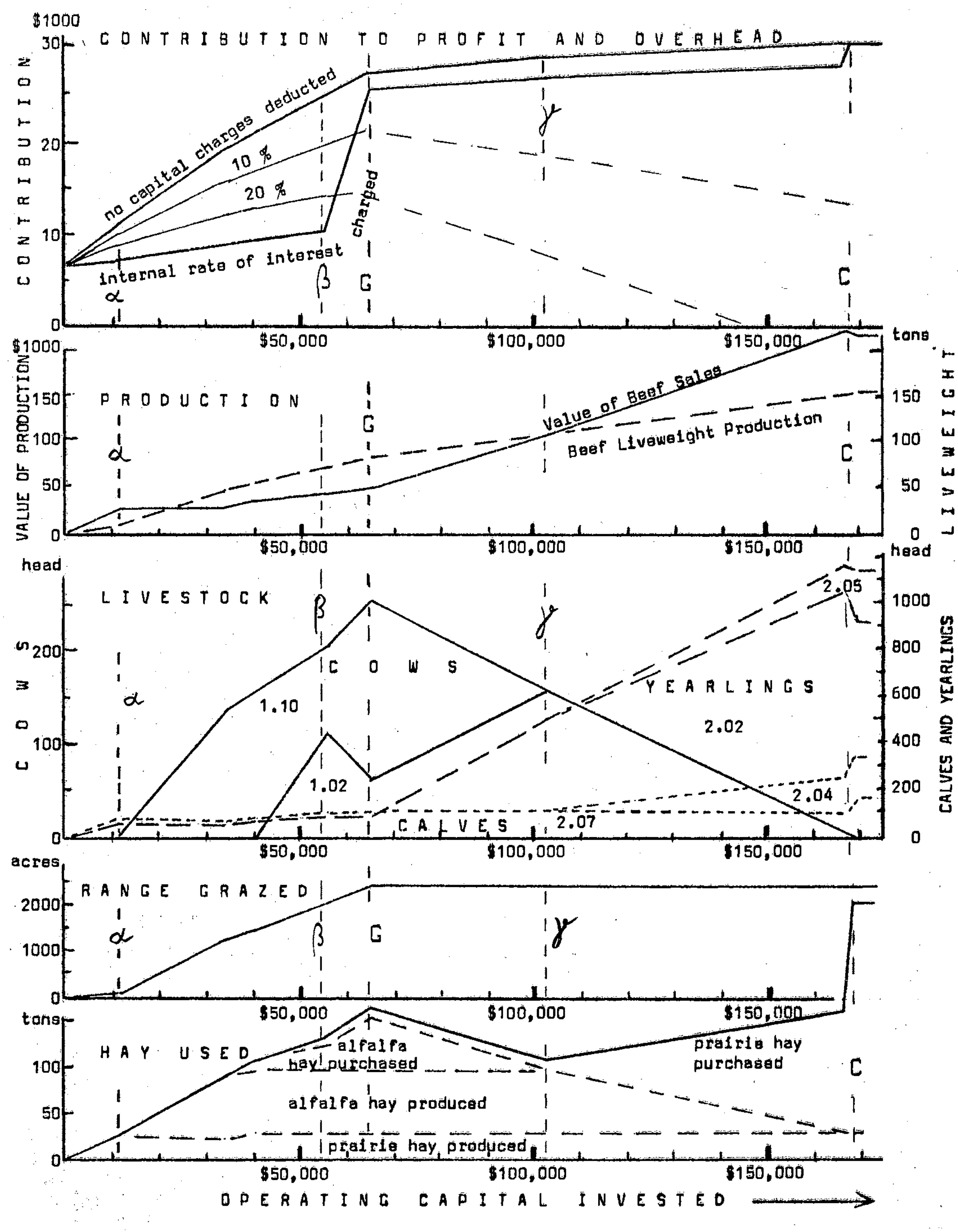

Fig. 4. Contribution to Profit and Overhead and Organizational Characteristics, Basic Four Section Ranch Model (Model No. 51). Explanatory letters refer to the text, p. 49 ff.

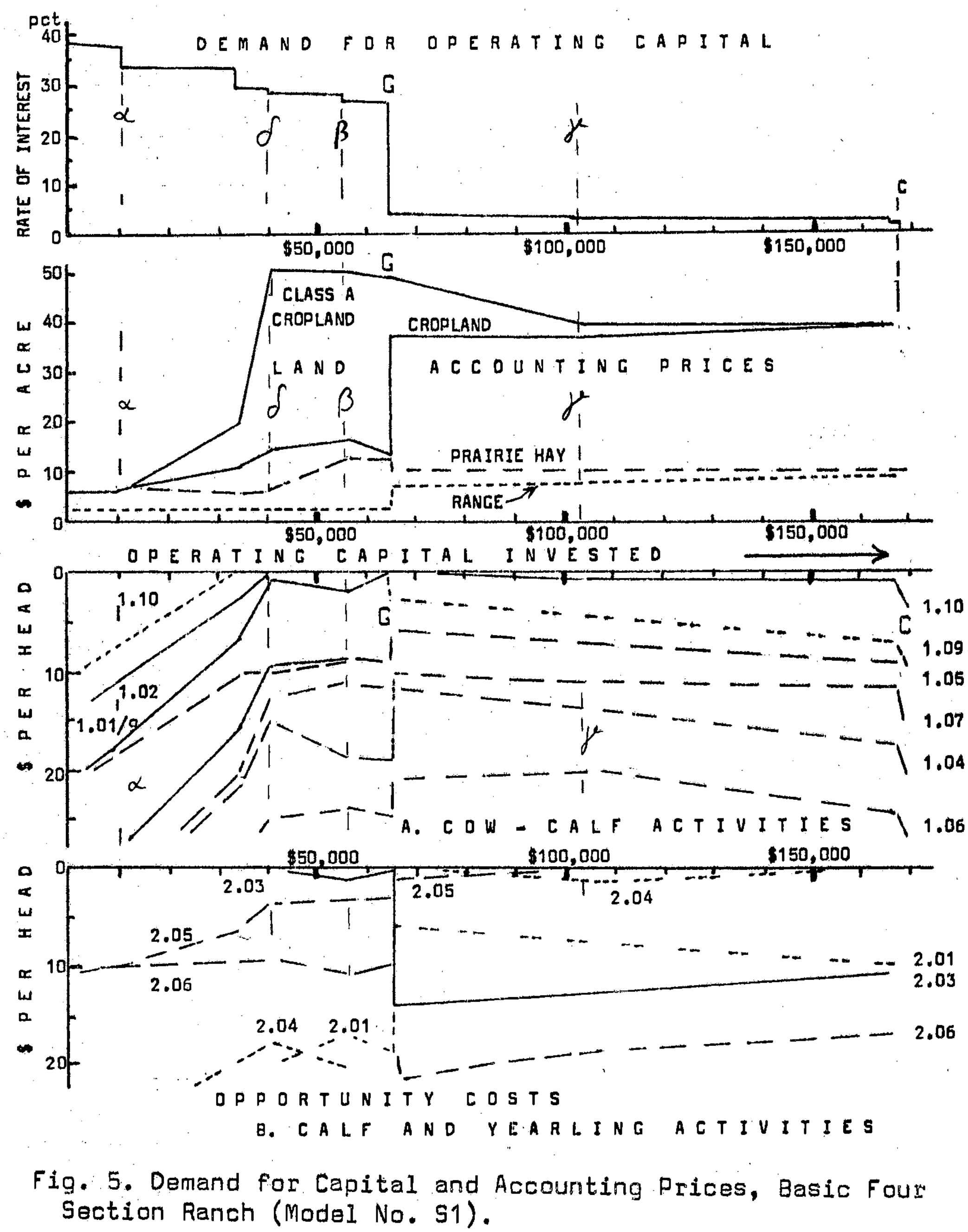

Fig. 5. Demand for Capital and Accounting Prices, Basic Four Section Ranch (Model No. S1).

additional labor and alfalfa hay must be purchased, there is a tendency to increase the proportion of spring-calvers (activity 1.02) beyond the 50 per cent ratio (β).

As more capital is made available and more cows are kept, more range is brought into production. The full complement is reached at G with 255 cows, 96 grazing yearlings, 114 calves wintered on small grains, and $65,000 invested in livestock and operating expenses ($26 per acre). At this point some labor is hired, primarily in the fall. Prairie and alfalfa hay are produced to the limit of the land capacities. In addition 165 tons are bought (priced at $25 per ton).

Beef production stands at 83 tons or 86 pounds per acre. Sales value is $49,000 or $19 per acre. Contribution to profit and overhead at a 10 per cent market rate of interest amounts to $20,800. The <u>average</u> rate of return to <u>operating</u> capital, disregarding all capital costs, is about 42 per cent. The average rate of return to <u>total</u> capital is almost 10 per cent before capital, operator labor, and other overhead is charged. Only small opportunity costs are associated with the competing cow-and-calf activities 1.01 and 1.09 (which differ from the selected activities 1.02 and 1.10 only in that protein concentrates are used instead of alfalfa). If alfalfa hay must be bought, there is little difference between the two sources of winter protein.

Enough calves to utilize small grain pasture are kept over winter. It is assumed that calves for summer grazing may be bought each spring. If that is not possible, wintering the calves on the range or lot (activities 2.01 and 2.04) will cost an additional $25 per calf. Another way of looking at this is to say that, other things being equal, one may pay up to $25 more per calf than was budgeted here, and still do as well as or better than if calves were wintered at the ranch.

Stocking long yearlings for sale as two year olds would reduce income by as much as $60 per head (activities 2.08, concentrate feed wintering), or $50, if alfalfa hay is used as the winter feed. Provided the enterprise budgets are approximately correct, one could hardly afford to stock this type of cattle.

In general the basic cow-and-calf activity coupled with some further cattle grazing is very stable. Once the range capacity has been reached, a shift of the internal interest rate from 26 per cent to less than five per cent is required before any organizational changes will take place.

For most operators, a five per cent marginal rate of return would not justify additional investments. There may be instances, though, where no other suitable outlet for investments exists, or where tax considerations make investment in beef production more attractive than other opportunities. If marginal rates of return of under 5 per cent appear justified, additional operating capital may be invested by gradually replacing cows with yearling stocker steers. Simultaneously as many calves as possible are wintered on small grain. With $103,000 invested (point γ), cows are reduced to 159, making room for 500 yearling steers. This reduces the need for purchased hay and for hired labor. Operating capital per acre for this organization now is raised to $48, beef output is 83 pounds per acre, value of beef sales $42 per acre, net revenues $10 per acre, and an <u>average</u> return of 28 per cent on operating capital is obtained.

Further expansion within the realm of the activities specified may be achieved by buying up to 255 tons of hay, with 350 calves wintered, and 1140 yearling summer stockers (point C). No more than $1\frac{1}{2}$ per cent return on investment may be expected on the additional $66,000 that are needed to finance this final expansion step. This brings operating capital to nearly $67 per acre. Since additional feed is being purchased, 119 pounds of beef are produced per acre. Total contribution to profit and overhead amounts to $30,000 with near zero capital cost, still 18 per cent average return on operating capital.

Even at this point the opportunity cost of the next best cow-and-calf activities (using alfalfa hay supplement) is only about $4 per cow. Not much is gained by a full conversion to a stock cattle operation.

Such narrow profit margins are actually too low. A $1 price change in the sales or purchase price will more than wipe out the profit of the additional $100,000 capital required. Similarly, only a small change in summer gain will have the same effect. The problem of changing price and productivity will be investigated in chapter V.

C. Land Productivity and Valuation

There is a close relationship between the amount of capital available (the internal rate of interest), and the accounting price or marginal productivity value of land. When land is not completely used - the range is used up when $26 per acre of operating capital are invested - the accounting price will be just equal to the next best alternative, namely renting out.[4]

Class A cropland, used primarily to produce alfalfa hay, becomes a very valuable asset: at the $40,000 capital mark ($\delta$) its accounting price exceeds $50 per acre (per year). Compared to the alternative of buying hay it pays to rent alfalfa land, even on a half share. Under low capital/high interest rate conditions regular cropland and meadow rate accounting prices between $10 and $16 per acre. That is enough to make renting at the going rate attractive even if compared with the alternative uses of operating capital in the model, which at this point returns from 30 to 26 per cent. It is quite clear, however, that under such conditions it would not be advantageous to buy land. The highest price justified is given by the ratio $\frac{\text{marginal productivity value per year}}{\text{rate of return on alternative investment}}$.[5] Here it amounts to $16/0.26 = $61.50. This certainly is lower than the going market price for land in the area, even after due allowance is made for the value of mineral rights.

As soon as the range capacity is reached, however, the accounting price of cropland goes up rapidly, to reflect the additional earning capacities available if lower returns to operating capital are required. Assuming an internal interest rate of 9 per cent on operating capital,

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[4]The model presumes a perfectly elastic demand for land: the operator may rent out all the land he wants at the same price. This holds if only a few operators wish to rent out. Obviously, this assumption breaks down if there were a general slump in the cattle market and more people wanted to rent out than rent in. There may be willing renters for quite a while, but only at lower prices! - This emphasizes the fact that these models are useful now for individual operators, but not as a blueprint for action for the industry, or all ranchers in the area as a whole.

[5]The formula for capitalizing a perpetual rent over an infinite period of time.

the marginal productivity value of regular cropland is $31.50, the capitalized value as much as $350 per acre. This is more than the market prices for land of this kind. We may conclude, therefore, that a rancher with a land mix as in our model, i.e. with a very low proportion of crop and hay land, is likely to be a strong contender in the market for crop and hay land.

The pressure to expand by buying land becomes stronger as more capital is available. The preceeding applies, of course, only if additional land will not add appreciably to overhead costs; and if the price level assumed in the model holds over the long run.

The accounting price of rangeland rises above the floor provided by rental rates. With certain internal rates of interest annual and capitalized marginal productivity values of rangeland are as follows:

internal rate of interest	23%	9%	5%	3%
operating capital per acre	$26	$26	$26	$40
annual accounting price	$ 3.05	$ 6.22	$ 7.20	$ 7.87
capitalized value[6]	$13	$57	$90	$117

The current market price for rangeland in the area (after allowing for the value of mineral rights) lies in the range of $60 to $90, the price range corresponding to a 9 - 5 per cent discount factor in the model. This would indicate that the assumptions in the model seem to agree closely with the judgement of ranchers in the area who buy rangeland.

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[6]Present value of annual accounting price accumulated over 20 years; discounted at internal rate of interest according to the formula

$$C = \frac{A}{I}\left(1 - \frac{1}{(1-i)^{20}}\right). \quad (50, \text{ p. } 466)$$

The preceding indicates that it is more advantageous to buy range land at prices up to $100 than using the available land more intensively.

The accounting prices for land apply for an increment of 380 acres to the four section ranch. Beyond that point additional labor must be hired and the residual economic rent left for land decreases.

D. Hay Price Sensitivity of the Basic Situation (S2, 3)

Increases of 20 to 40 per cent in the hay price were simulated in model S1. A 20 per cent increase eliminated alfalfa purchases, and some changes in the kind of cow-and-calf activities selected occurred. Protein concentrates replace alfalfa hay (activities 1.01, 1.09). Where hay must be purchased the corner points are shifted to the left almost imperceptably. The capital demand curve is shifted upward by less than one percentage point, if the hay price increasee by 20 per cent. A hay price increase of 40% still did not require organizational changes, though it did impinge upon the profit and overhead contribution. The 40% variant (S3) is reproduced in appendix D, fig. 1 and 2.

Up to a point, we may expect a highly elastic demand for hay because of the ready substitute of concentrate (several times unity). However, a residual amount of hay will be needed, virtually unaffected by price. The residual amount must be covered, even if own hay sources are insufficient. The incentive to buy hay and use the own land for grazing steers and calves becomes greater as the internal interest rate decreases.

The graph of opportunity costs (appendix D, fig. 2) presents a patchwork even more diverse than in the basic model. Generally, the distance between the best choice and other alternatives has shrunk, but there are no systematic changes in relative profitability.

As expected, higher prices of hay tend to raise the value of land, especially hay land. With a cow herd to utilize the grazing capacity the accounting price of hay land is about $5 higher per acre than in the basic model; in the 40 per cent hay price variation the accounting price of hay land increases even more.

E. Effect of an Alternative Way of Computing Capital Charges (S4)

Many lending institutions offer credit with interest payable only for the time in which credit is actually used. If owned capital is used, the owner may have alternate uses for his capital in slack capital price periods. Thus, interest need only be charged for the period that cattle are actually in the possession of the rancher. This does not change the capital cost of a breeding herd, but it cuts the capital cost of stocker cattle in half.

The effect of such a change in capital costs is clearly seen by comparing figures 4 and 6. Enough calves are retained to utilize small grain pasture. The cow herd will be a straight 50-50 combination of spring and fall calvers (activity 1.10). No labor need be hired. The most conspicuous change, perhaps, is the modification found in the demand curve for capital. There is no longer a sharp break at the point where the capacity of the range has been reached with a cow-and-calf activity. Substitution of stocker steers for cows may now take place gradually. A drop of only three percentage points in the internal interest rate of capital suffices to set in motion the process of substituting steers for cows. Even with the highest capital intensity - $69 per acre - there

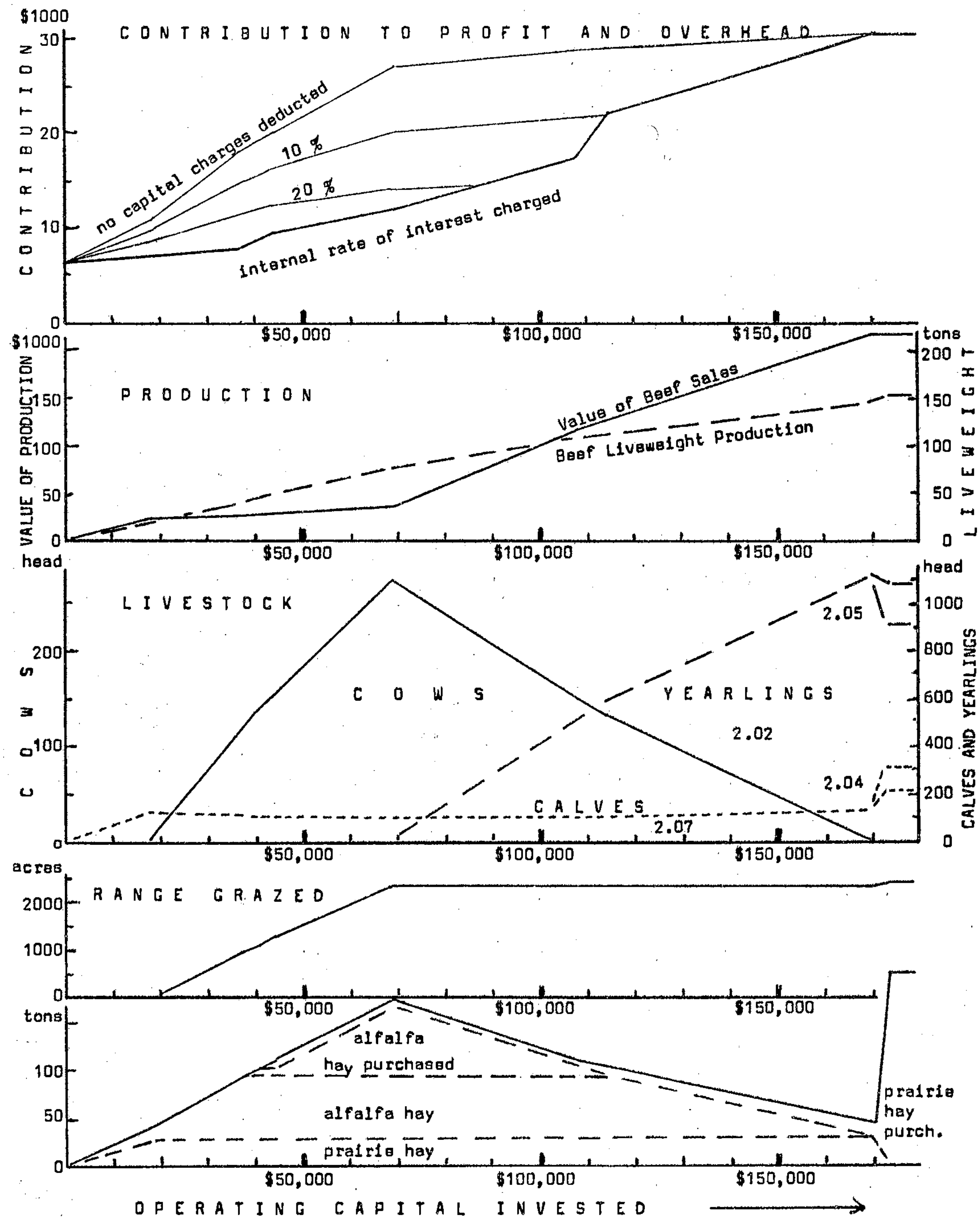

Fig. 6. Contribution to Profit and Overhead and Organizational Characteristics, Four Section Ranch. Capital Charged for Months of Use Only (Model No. S4).

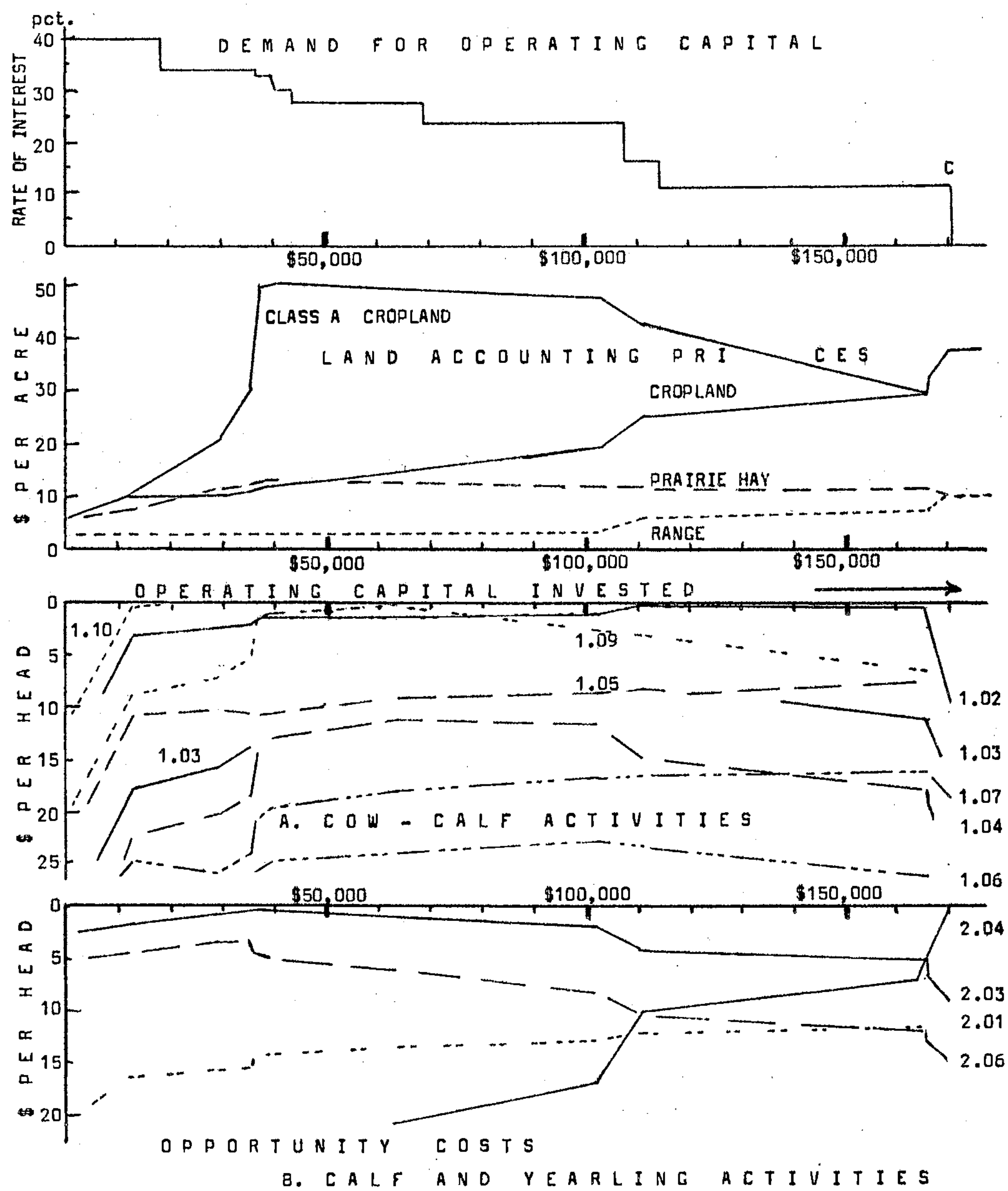

Fig. 7. Demand for Capital and Accounting Prices, Four Section Ranch. Capital Charged for Months of Use Only (Model No. S4).

is a return on operating capital of eleven per cent.

As more liberal credit conditions reduce costs, we observe an upward shift of the demand curve for capital. Land is brought into production now at a rate of 40 per cent; at a given rate of return now \$3-5000 more are being invested in livestock; the most conspicuous shift taking place at high capital intensities.[7] In spite of the liberalization of capital conditions the contribution to profit, overhead and capital service remains essentially the same as in the basic model.

The more liberal credit conditions of this model variant make stockers appear a practical alternative to a cow herd. Yet, unless we change our assumptions, total beef production will not expand beyond the maximum of S1.

In the schematic of figure 8 no production is possible beyond the efficiency frontier GHIC, regardless of the incentive which is provided by any of the iso-revenue curves (g, h etc.). G and C are the grazing capacity and capital limit points as defined on page 46. H and I are some intermediate points. The efficiency frontier is defined by all resources available save operating capital. A change in the cost of capital will not change the location of GHIC. A fall in the effective price of capital will, however, decrease the slope of the iso-revenue curves in figure 8 (from g to g', h to h'). A fall in the effective cost of borrowing for money borrowed for less than a year will favor the short-term enterprises, grazing steers or wintering calves, without affecting the profitability

[7]The abscissa in all charts is the greatest sum of operating capital invested, whereas interest is paid only for the fractional period of a year for which the capital is used.

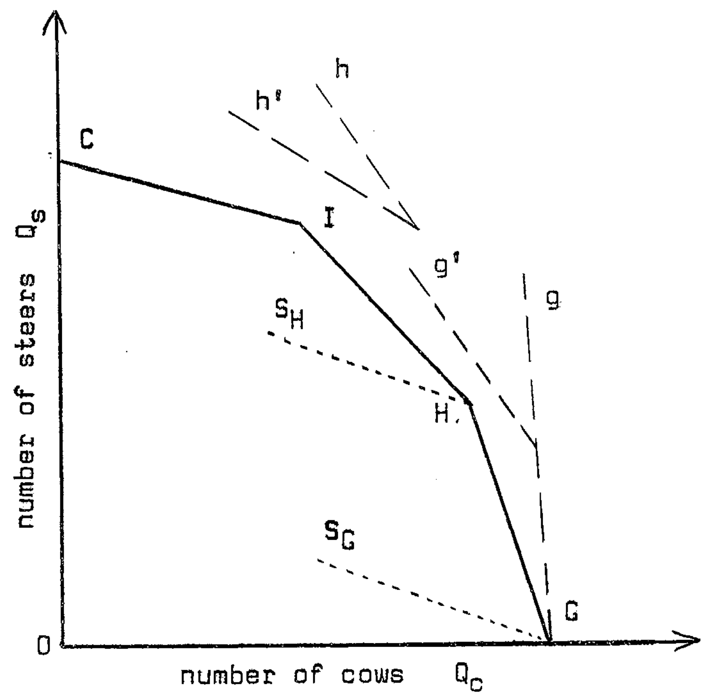

Fig. 8. The Effect of Methods of Capital Procurement on the Relative Profitability of Cows and Steers.

of the cow-and-calf herd, thus shifting the equilibrium away from the latter. Yet in no case will the equilibrium be shifted beyond C. The distance OC still determines the maximum production level of beef steers.

S_G etc. are dual capital restrictions which produce the same activity combination as the associated interest rates embodied in the slopes of the iso-revenue lines.

The accounting prices and valuation of land in S4 are as follows:

internal rate of interest	23%	11%	8%
operating capital per acre	$45	$67	$67
accounting price of range, per acre	$ 3.60	$ 7.24	$ 7.89
capitalized value, per acre	$15	$58	$77

Land accounting prices are somewhat higher at the same rate of interest than in the basic model (cf. page 56). Now it is profitable to use more operating capital per acre (by shifting from cows to steers) before the purchase of land becomes an equally or more profitable alternative at present land prices. Under conditions prevailing in this model there will be a tendency to substitute more capital for land. More liberal credit conditions do not tend to be capitalized in higher land prices because of higher derived demand for land.

F. Optimal Solutions if Choice of Activities is Restricted

1. Stocker Cattle Purchases Eliminated (S5,6,7)

Calves and stocker cattle are now limited by the number of calves reared by stock cows (fig. 9 and 10). Expansion finds an end, therefore, at a much lower level than in the models discussed previously, with $78,000 ($31 per acre) operating capital. This amount is invested in a maximum of 256 stock cows, 114 calves wintered essentially on small grain pasture, 70 wintered on prairie hay in the feedlot, and 69 grazing yearlings. All the prairie and alfalfa hay that can be produced at home will be produced. Purchased prairie hay brings the total hay supply to 220 tons. There is a deficit in the labor budget in the summer, requiring 460 hours of hired help. Beef production is 84 tons (66 pounds to the acre), gross receipts $36,000 ($14 per acre), contribution to profit, overhead and capital $27,500 ($11.80 per acre).

Marginal return to capital (internal interest rate), now obtainable only with cows, reaches a maximum of only 33 per cent. From its maximum the capital demand curve slopes gently to a point representing 26.5 per cent interest, a $27 per acre investment, and full use of grassland.

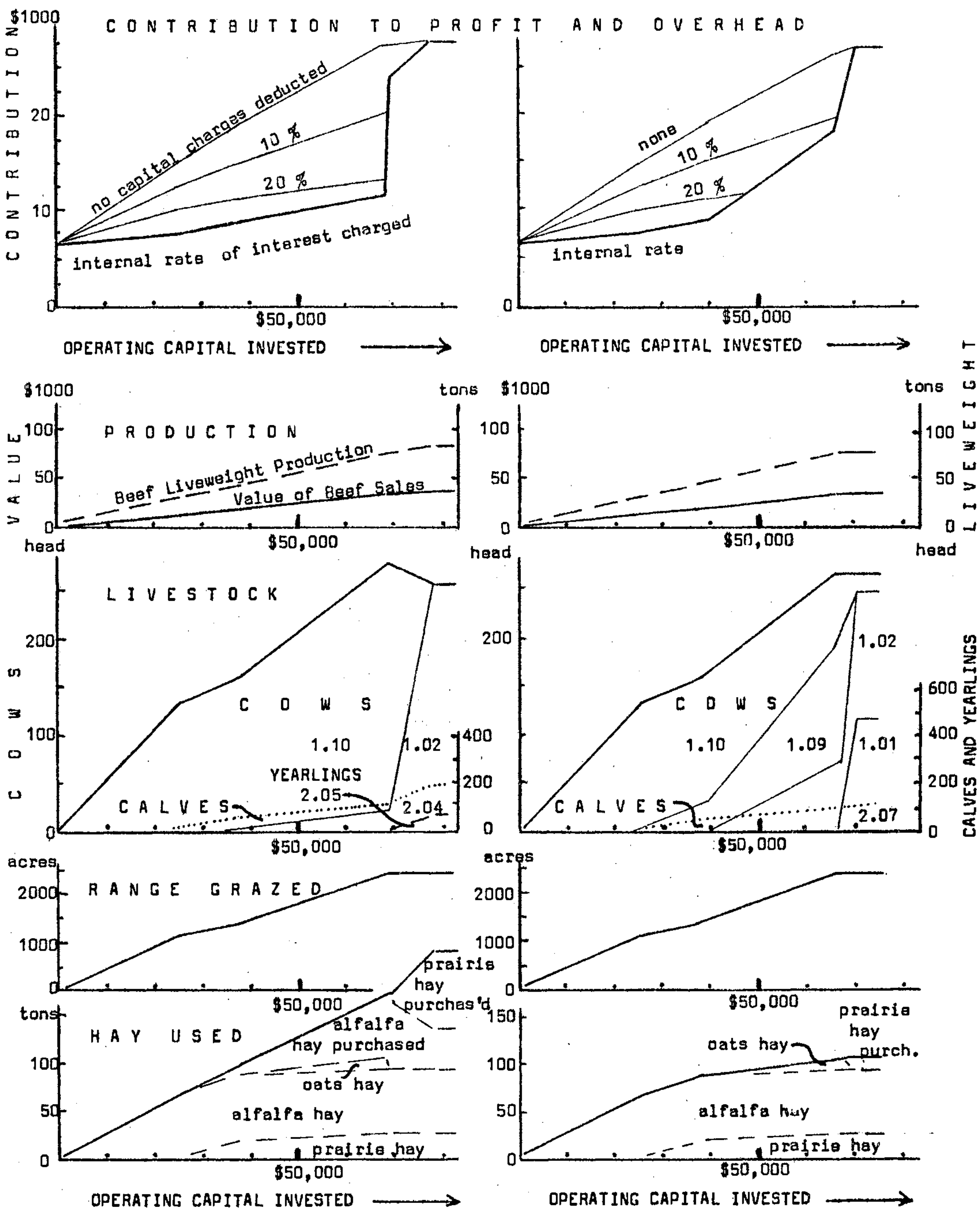

Fig. 9. Contribution to Profit and Overhead and Organizational Characteristics, Four Section Ranch. Raised Cattle Only.
Left: Normal Hay Price (Model No. S5).
Right: Hay Price up 40 per cent (Model No. S7).

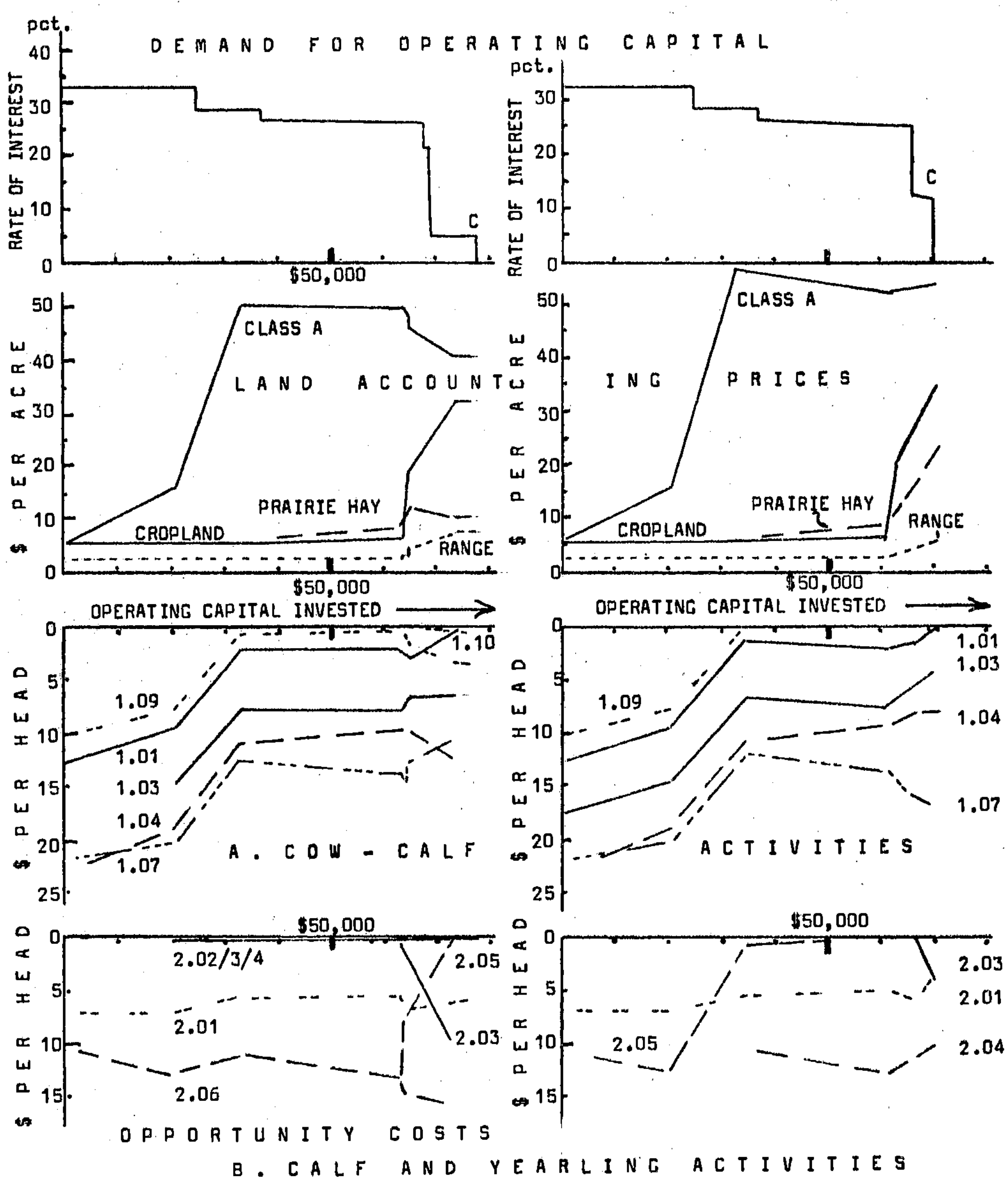

Fig. 10. Demand for Capital and Accounting Prices, Four Section Ranch. Raised Cattle Only.
Left: Normal Hay Price (Model No. S5).
Right: Hay Price up 40 per cent (Model No. S7).

Some calves are wintered to utilize available small grain pasture.

Once the grazing capacity has been exhausted (G), a sharp drop occurs in the capital demand curve down to the 5 per cent level. In order to bring in stocker cattle, enough calves must first be wintered (previously raised calves were sold, then grazing steers bought back in the spring). No return would be expected from investments exceeding $31 per acre.

Alternative cow-and-calf enterprises rank in nearly the same order as in the basic model. Again there is little difference between the alfalfa and protein concentrate versions; creep feeding reduces income contribution $8 per cow; fall calving alone is not very promising. A change occurs in the calf-wintering enterprises (2.01, 2.04). Because wintering has become the necessary prerequisite to summer grazing, and no longer competes with the purchase of yearlings, the opportunity costs of wintering are drastically reduced. "Rough" wintering of calves plus summer grazing costs about $5 per calf in income foregone in comparison to the combination of trap-wintering with summer grazing, even though the summer gains of the well-fed calves stay a little below those of the roughed calves. Two-year stock cattle continue to rate rather poorly ($24 - 30 per head opportunity costs).

Limiting profitable income opportunities reduces the marginal value of other resources, including land. With land fully utilized, the marginal productivity values and capitalized present values are as given in table XIV.

The calf-wintering activity requires a large amount of hay. Nevertheless, it is still advantageous to buy hay after a 20% rise in price.

TABLE XIV

ACCOUNTING PRICE AND CAPITALIZED VALUE[a] OF CLASSES OF LAND, VARIOUS INTEREST RATES AND CORRESPONDING OPTIMAL LEVELS OF OPERATING CAPITAL, NO STOCKER CATTLE PURCHASES, FULL CAPITAL CHARGES

Description	Unit	Internal Rate of Interest		
		21%	8%	4%
Operating capital	$ per acre	--- 27 ---		31
Range				
Accounting price	$ per acre	3.66	4.39	7.46
Capitalized value[a]	$ per acre	17	43	101
Cropland				
Accounting price	$ per acre	13.40	19.05	32.40
Capitalized value[a]	$ per acre	62	187	440
Class A cropland				
Accounting price	$ per acre	47.90	46.70	40.75
Capitalized value[a]	$ per acre	224	460	550
Prairie hay land				
Accounting price	$ per acre	12.37	12.04	10.68
Capitalized value[a]	$ per acre	58	118	145

[a]Accounting price compounded over a period of 20 years at a discount rate which corresponds to internal rate of interest.

A 20 per cent rise in the price of purchased hay has much the same effects on ranch organization as in the basic model (S1). Where possible, hay-using activities will be replaced by protein concentrate activities (1.09 for 1.10; 1.01 for 1.02). A 40 per cent rise in the price of hay (figure 10, S7) reduces the maximum level of operating capital to $71,000. Calf-wintering, and thus range steers are eliminated. The organization at the highest profitable investment level now consists of 270 cows, and 114 calves on small grain pasture. The income contribution is reduced.

2. Choices Restricted to Cow-and-Calf Activities (S8,10)

Eliminating the option to buy stocker cattle reduces the total contribution only moderately, while saving a great deal of operating capital (fig. 3,4, appendix D). The contribution to profit, overhead, and capital tops out at $23,400 ($9.10 per acre). $58,000 operating capital ($23 per acre) are required to bring about this operating income. Annual beef production is 67 tons (52 pounds per acre), valued at $29,500 ($11.50 per acre). It is necessary to hire 480 man-hours of labor in the fall season.

Because of the restricted choice of activities, the organization of the model ranch is now highly specialized. Over the entire range of internal rates of interest and associated amounts of operating capital there is always the same activity, a combination of spring- and fall-calving, with alfalfa hay as the protein supplement (1.10). Cow numbers are increased to 298 by converting all but class A cropland into grazing land. Additional alfalfa hay is bought (at $25 per ton) to bring total hay consumption to 151 tons.

The productivity value of rangeland is $5.94 per year. Capitalized at 5.5% this adds up to $71 per acre. This is less than the best that could be made from grazing land with a combination of cows and stock cattle. The productivity value of class A cropland is maintained at $44 per year, or capitalized at 5.5% over 20 years, $525.

A 40 per cent increase in the price of hay (S10) eliminates hay purchases. There will be some native hay cut instead, and the number of cows drops to 289 spring-calvers fed with protein concentrate supplements (1.01, 1.09). Contribution to income drops by about two per cent from the level of the previous model.

G. Effect of Changes in Tenure and Size of Operation

Up to now variations of the basic model always started with the premisse that the operator owns four sections of land. We shall now see what suggestions for organizing the ranch will follow from a change of the original premisse.

1. Tenant-Operated Ranch Model (S11)

No land is assumed owned. The operator may rent the same amount of land that was available to the owner-operator in the basic model. The income floor that was present in previous models because the land owned could always be rented out, is absent here.

The resultant organization (fig. 11,12) is comparable to S4. Differences are: the maximum demand for operating capital exceeds the demand of the owner-operated ranch under otherwise identical circumstances (S4); because rent payments must be made, the contribution to profit, overhead, and capital for a given amount of operating capital is reduced; the largest number of beef cows kept is 150, thus avoiding hiring any labor and reducing the quantity of hay to be purchased. Profitable operation starts at a lower rate of interest.

The following characteristics are similar to model S4: a relatively smooth demand curve for capital; use of small grain pasture for wintering calves even before it pays to buy cows (2.07); substitution of stocker cattle for cows as the internal rate of interest is lowered and land is in limited supply; similarities in the relative advantage of alternate activities.

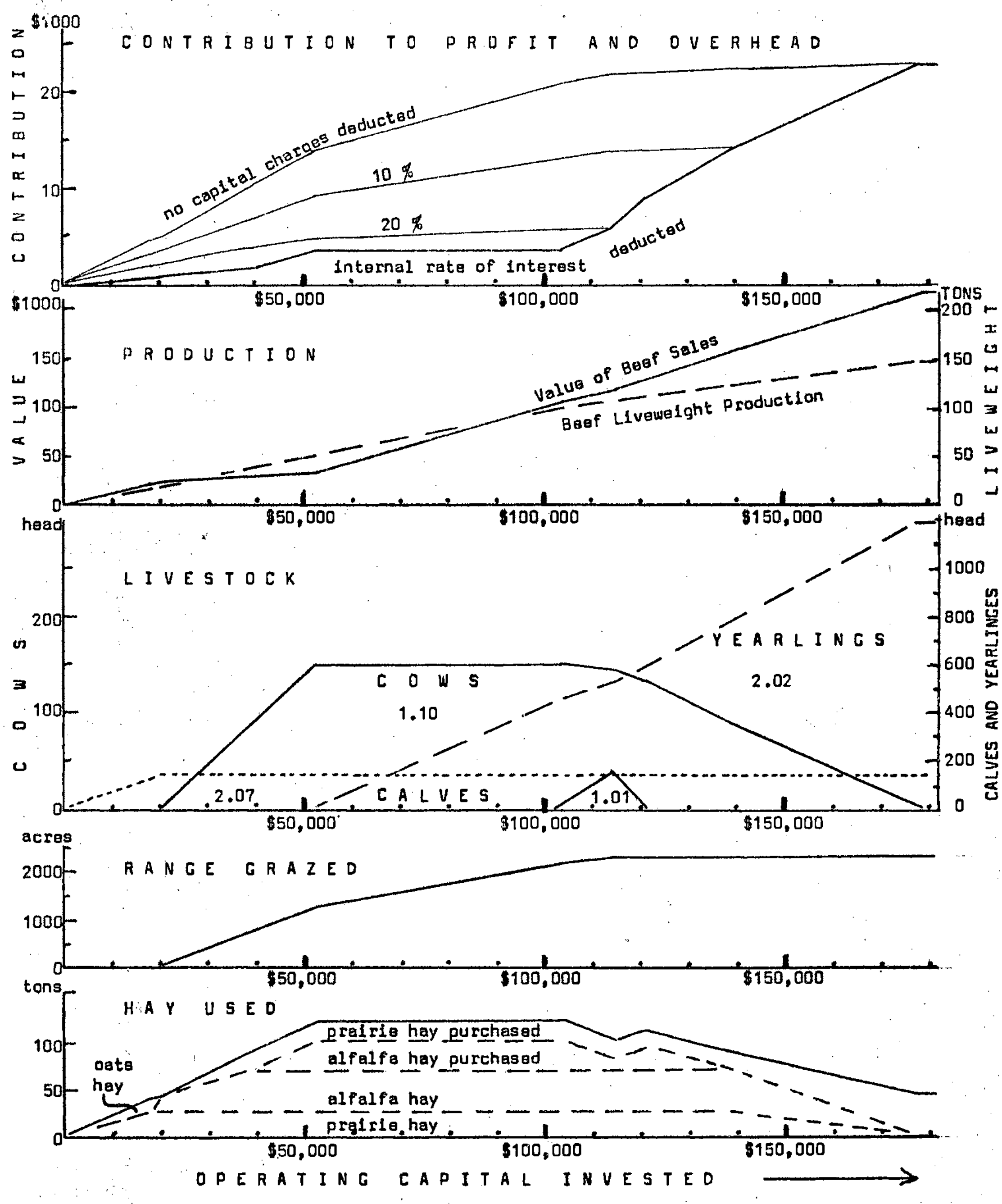

Fig. 11. Contribution to Profit and Overhead and Organizational Characteristics, Tenant-Operated Four Section Ranch. Capital Charged for Months of Use Only (Model S11).

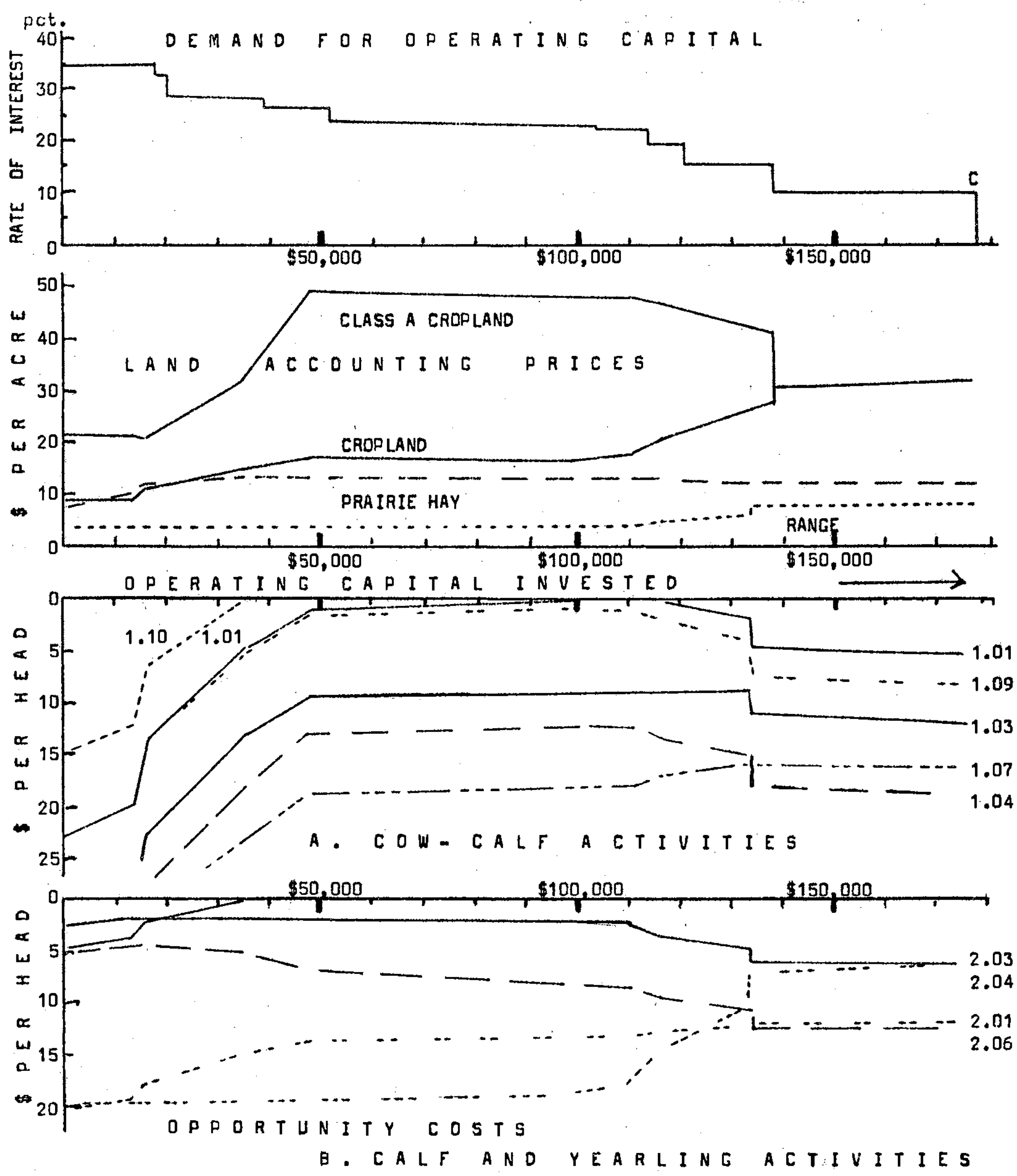

Fig. 12. Demand for Capital and Accounting Prices, Tenant-Operated Four Section Ranch. Capital Charged for Months of Use Only (Model No. S11).

2. Small Owner-Operated Ranch (S12)

This model (fig. 13) is a scaled-down version of S4, but the amount of operator labor was left unchanged. In spite of this change in the ratio of available land and labor, the small ranch model shows the same pattern of production as S4: The O-point is located at the 39 per cent rate of interest, production commences at high capital costs with a small-grain wintering operation, complemented by a breeding herd with fall as well as spring calving, replaced gradually by purchased stocker steers if all land is fully utilized and capital is available.

There are a few differences: The target rate of interest must fall below 16 per cent before stocker steers will be substituted, and there is a tendency for higher accounting prices of land. This is consistent with theoretical considerations. Under more rigid capital cost regimens stocker steers may be eliminated entirely from the program of small ranch units, since no saved wages compensate for the high capital costs. This question has not been answered here.

H. Land Mix Variants

1. Four Land Mix Variants, all Production Activities Permitted

The following variants of the basic Four Section Ranch are presented to demonstrate the effects of eliminating some or all of the more productive classes of land. It will be seen that a loss of flexibility is the principal change. This series (S13 to S16) is comparable to S4: Operating capital is charged only for the months in which it is actually invested in cattle and all activities are permitted. Numerical data are presented in appendix D, tables IV and V.

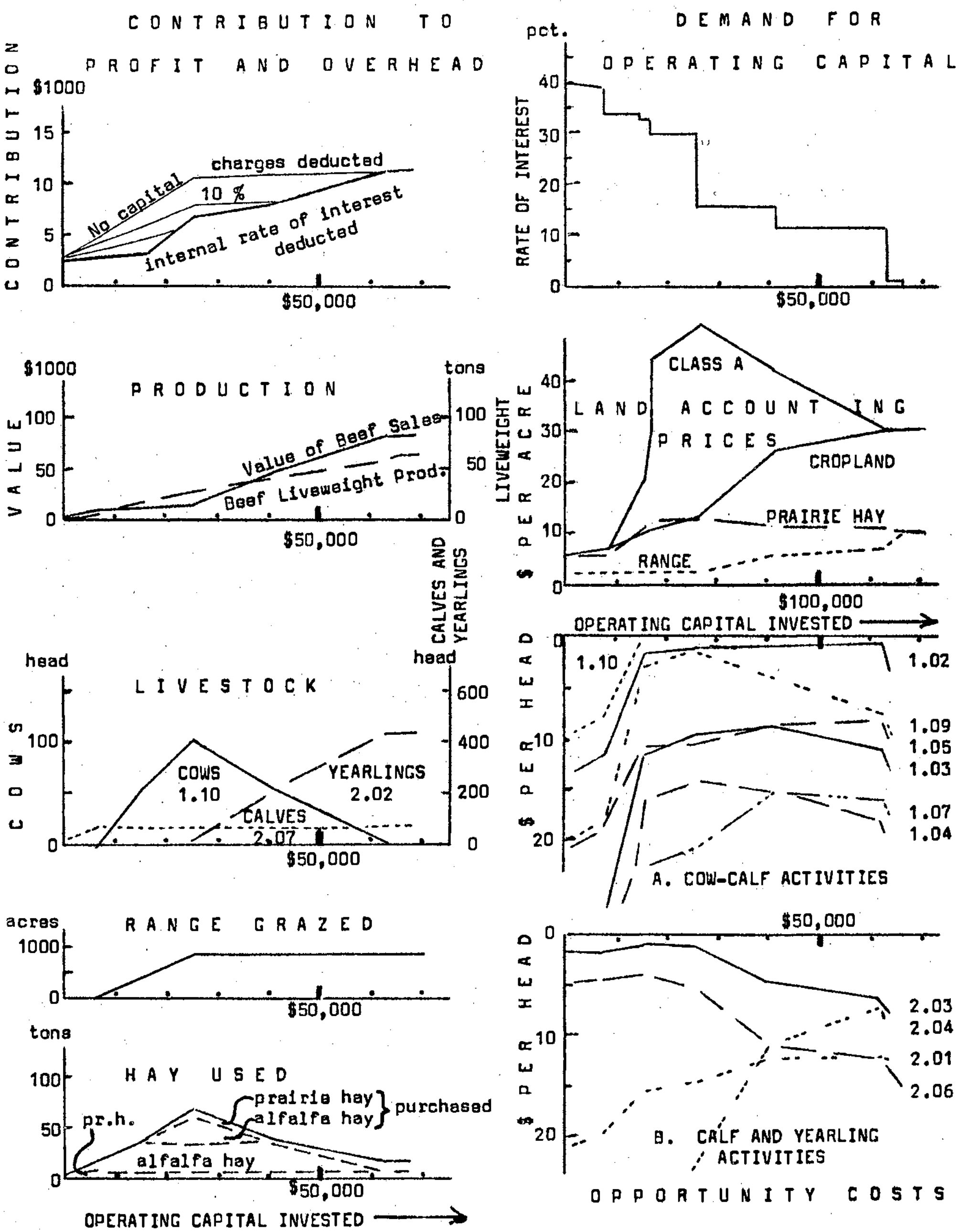

Fig. 13. Contribution to Profit and Overhead, Organizational Characteristics, Demand for Capital, and Accounting Prices, Small Ranch Model (Model No. S12).

Range Only (S13). The systems in this series show a simple and easily discernible pattern (fig. 14 and 15). As compared to S4 these principal differences are noted: Production will begin with a breeding herd, at a rate of interest of 29 per cent. As capital is increased, the breeding herd is supplemented by stockers, even before all land available is brought into production. Because all hay must now be purchased, contribution to profit and overhead are below the level obtained in S4, raising the highest efficiently usable level of operating capital from $69 to $70 per acre. The lower productivity of rangeland shows up in lower physical beef output per acre.

Range and Prairie Hay (S15). The organization of this variant is for all practical purposes the same as that of the preceeding resource combination. The addition of 28 tons of hay raised at home makes little difference on a unit this size. The slight saving in the cost of hay is simply added to the revenue contribution, but does not affect substitution rates enough to induce organizational changes.

Range and Cropland (S15). With the addition of cropland we immediately see activity 2.07 (calves wintered on small-grain pasture) enter the picture (appendix D, figures 5, 6, and table V). The O-point is moved back once again to the 38 per cent marginal rate of return on operating capital. The maximum revenue contribution is virtually as high as in S4. This happens through a substitution of steers for some marginal breeding cows and wintered calves which cost more than in S4, because the hay they require must be purchased.

Range, Prairie Hay, and Cropland (S16). Save for the absence of Class A land this land mix equals the one of the basic Four Section Ranch. The organization is virtually the same as in S4 (see appendix D,

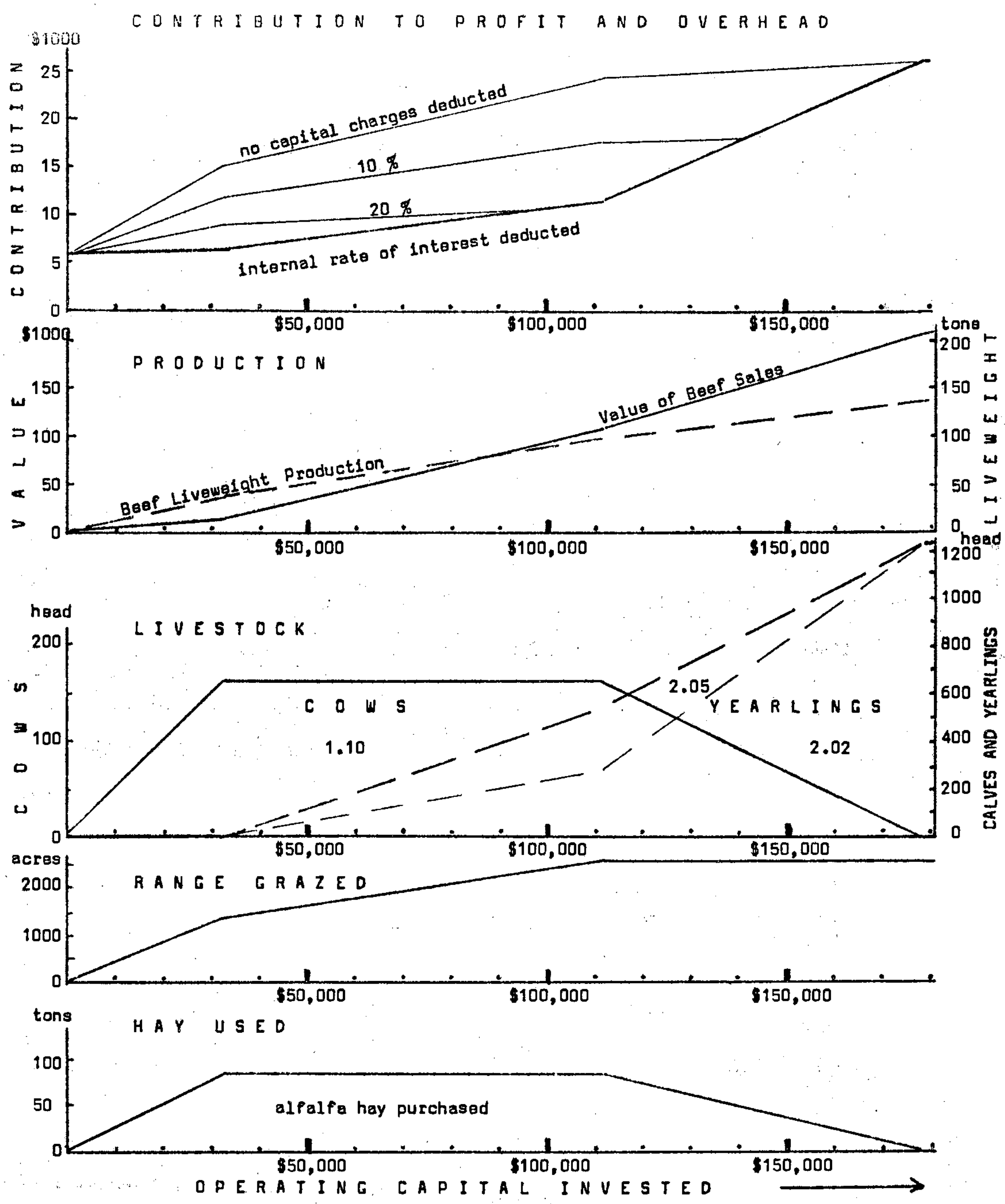

Fig. 14. Contribution to Profit and Overhead and Organizational Characteristics, Four Section Ranch. Range Only, Capital Charged for Months of Use Only (Model S13).

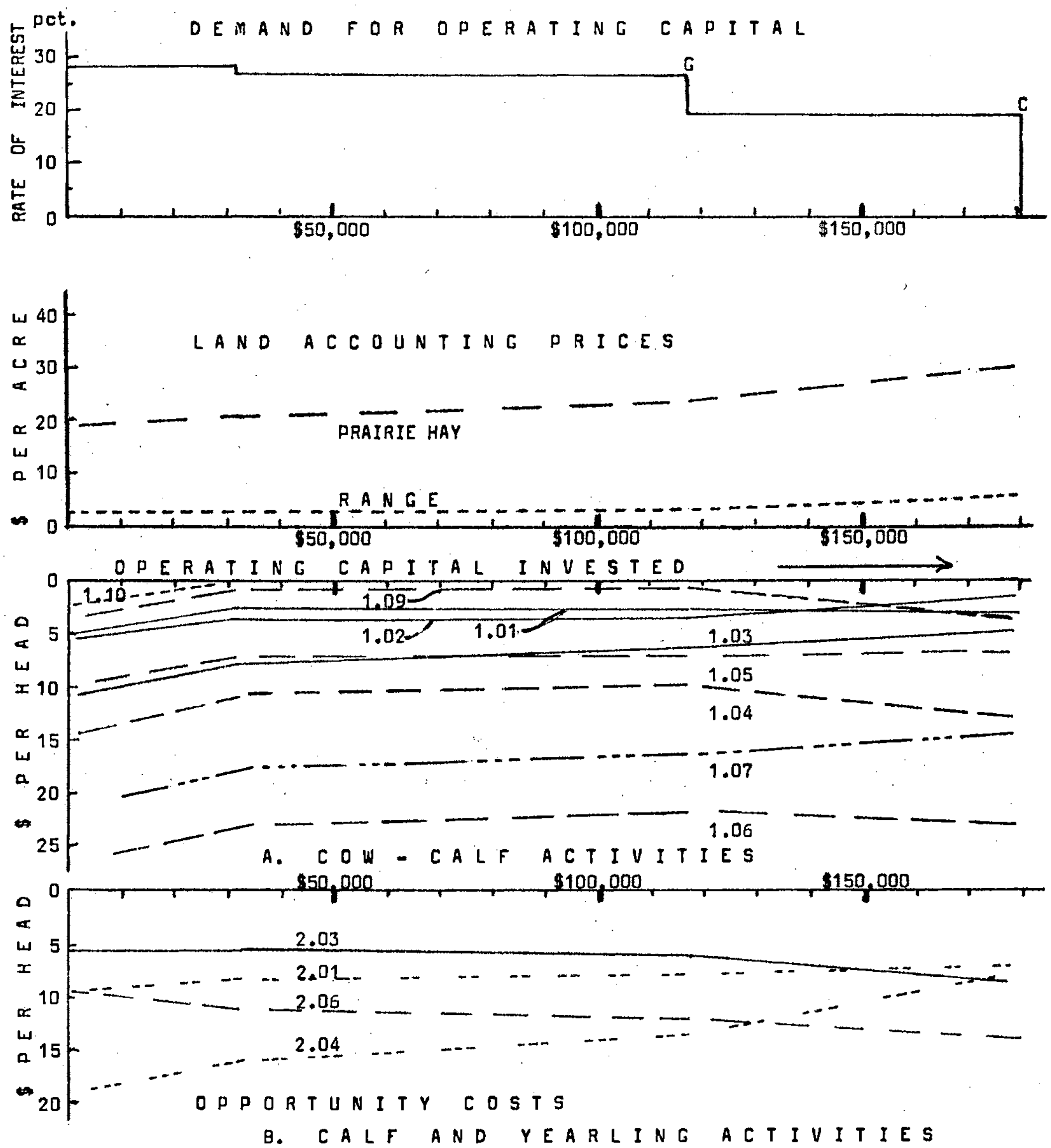

Fig. 15. Demand for Capital and Accounting Prices, Four Section Ranch. Range Only, Capital Charged for Months of Use Only (Model S13).

table V). However, alfalfa hay must be bought. The additional cost is not sufficient to cause any substitution of protein concentrate for alfalfa hay.

2. Land Mix Variants, Production Choices Restricted to Raised Cattle

Range only (S17 to S19). To appraise the effect of restricting the land capabilities under more constraining operating conditions this series should be compared to S5 to S7. The changes will of course parallel the changes from S4 to S13. The general pattern of organization is considerably simplified, the contribution to profit, overhead, and capital reduced, and more hay is purchased. In S17 (appendix D, fig. 7,8) the efficient level of operating capital per acre is lower than for the variant with the full complement of quality land. This is contrary to the observation in S13.

A rise in the price of hay by either 20 or 40 per cent (S19) will curb the hay purchases, substitute protein concentrates for alfalfa hay (1.09 for 1.10; 1.01 for 1.02), and reduce the contribution that may be obtained with the given resources. At the forty per cent price level the C-point is reached with a marginal rate of return to operating capital of only 1.3 per cent. The preceeding step yields 8 per cent at the margin for up to $60,000 operating capital, and 36 per cent for up to $56,000. This may be a more realistic expansion limit under adverse conditions (appendix D, fig. 7,8). No calves will be retained until all available land is utilized by cows. This is because the wintering-stocking operation, since it requires a large quantity of hay, is not competitive with calf raising until more capital becomes available. This contrasts with

S13 where purchased stocker yearlings come in even at high target rates of interest, and in direct competition for the available land with the calf raising activity.

Range and Prairie Hay Land (S20). Results for this variant bear the same relation to S17 as S14 bears to S13: This is substantially the same kind of operation, except that some hay is cut at home, saving operating capital for the purchase of hay, and providing slightly better marginal yields on capital (appendix D, table VI).

3. Range Only, Production Choices Restricted to Breeding Herd (S21)

In the preceeding series cows were replaced only beyond the G-point. Therefore, an artificial limitation to breeding herd activities takes effect beyond this point. As appendix D, table VI shows, the restriction to cow-calf activities cuts off the production opportunities beyond the G-point. It pushes this limit a little further out, requiring a little more hired labor than S17, without, however, adding anything to the level of contribution.

I. Four Section Ranch Variants with Option to Rent an Extra Section

The last group of variations on the "Four Section Ranch" is concerned with the effect of renting additional land. It will be shown that under the assumptions made the addition of one more section of land increases other inputs in near proportionate amounts. The small deviations from the proportionate ratio - as in capital requirement and labor hire -

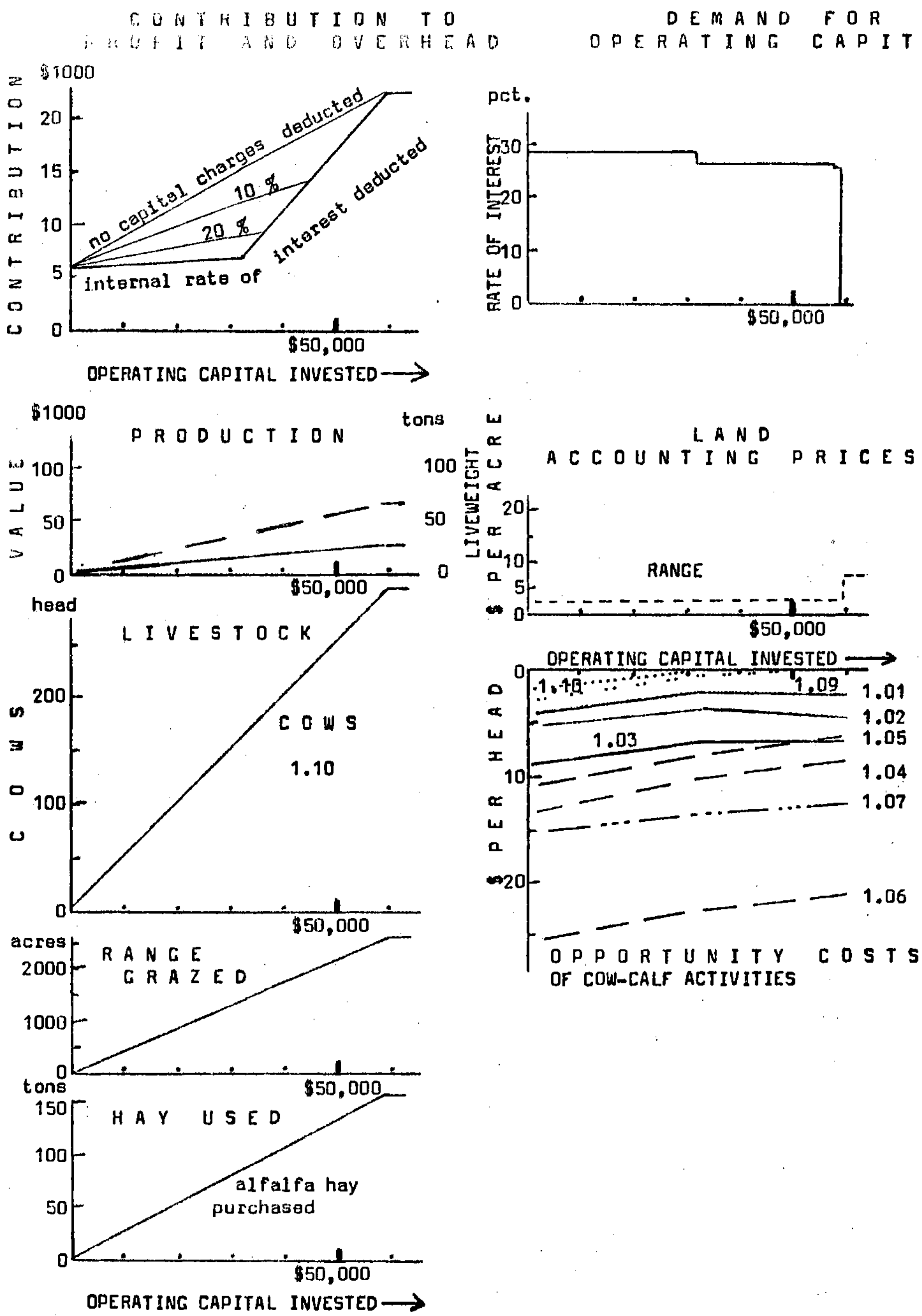

Fig. 16. Contribution to Profit and Overhead, Organizational Characteristics, Demand for Capital and Accounting Prices, Four Section Ranch. Range Only, Breeding Herd Only (Model No. S21).

are hardly significant.

The series (S22 to S24) is based on S5 to S7, the variant which limits activity choices to raised cattle only.[8]

In this Five Section plan (fig. 17, 18) the activities are the same as in the original Four Section plan. There is simply more of everything - more cows (354), more hay bought, more money invested ($100,000), more labor hired during fall and summer season, more calves wintered (as many as 225). At the new maximum, provided there is a ready supply of 'easy' capital, the number of cows is reduced to accomodate a limited number of stocker yearlings. The number of calves wintered is predetermined by the number of cows accomodated. Physical beef production per acre is unchanged from system S5.

A 20 per cent rise in the price of hay (S23, fig. 9, 10 in appendix D) eliminates the alfalfa purchases. Protein concentrates are substituted as winter supplement (activities 1.01, 1.09 for 1.02, 1.10). Otherwise the organization remains unchanged from S22. Because of the higher procurement costs for hay the marginal return to capital is lowered to 2.5 per cent. It is doubtful if this is considered a worthwhile investment.

A 40 per cent price rise in this series (S24) eliminates wintering activities, hence, by assumption, summer grazed yearlings. The new cutoff point C will be at a much lower capital level, with a marginal rate of return of 12 per cent.

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[8]Data for the R and new C-points are given in table VII in appendix D. The O-point and G-point are, of course, identical to the version without the rent option; owned land, costing less than rented land in terms of alternative income foregone, would be used up before renting in other land.

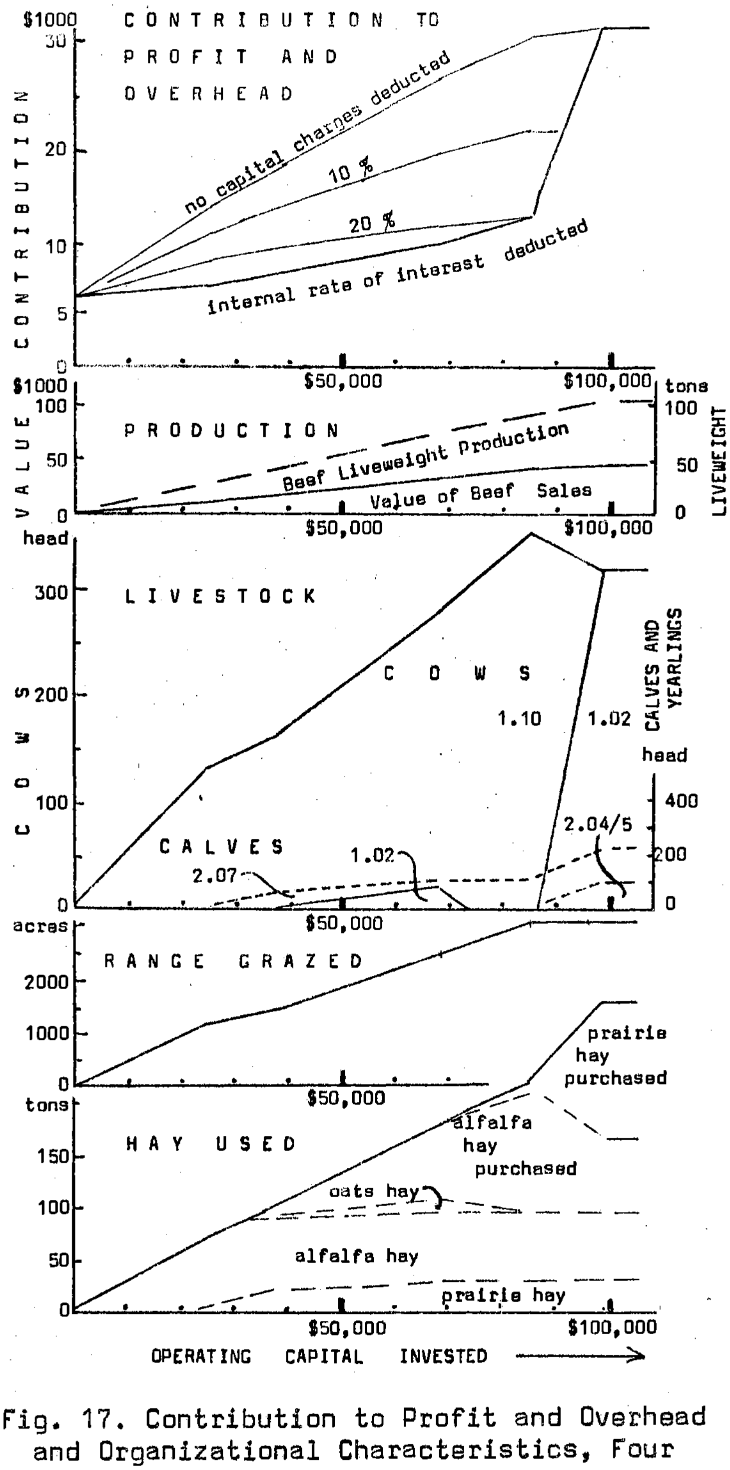

Fig. 17. Contribution to Profit and Overhead and Organizational Characteristics, Four Section Ranch, With Option to Rent an Additional Section of Range (Model No. S22).

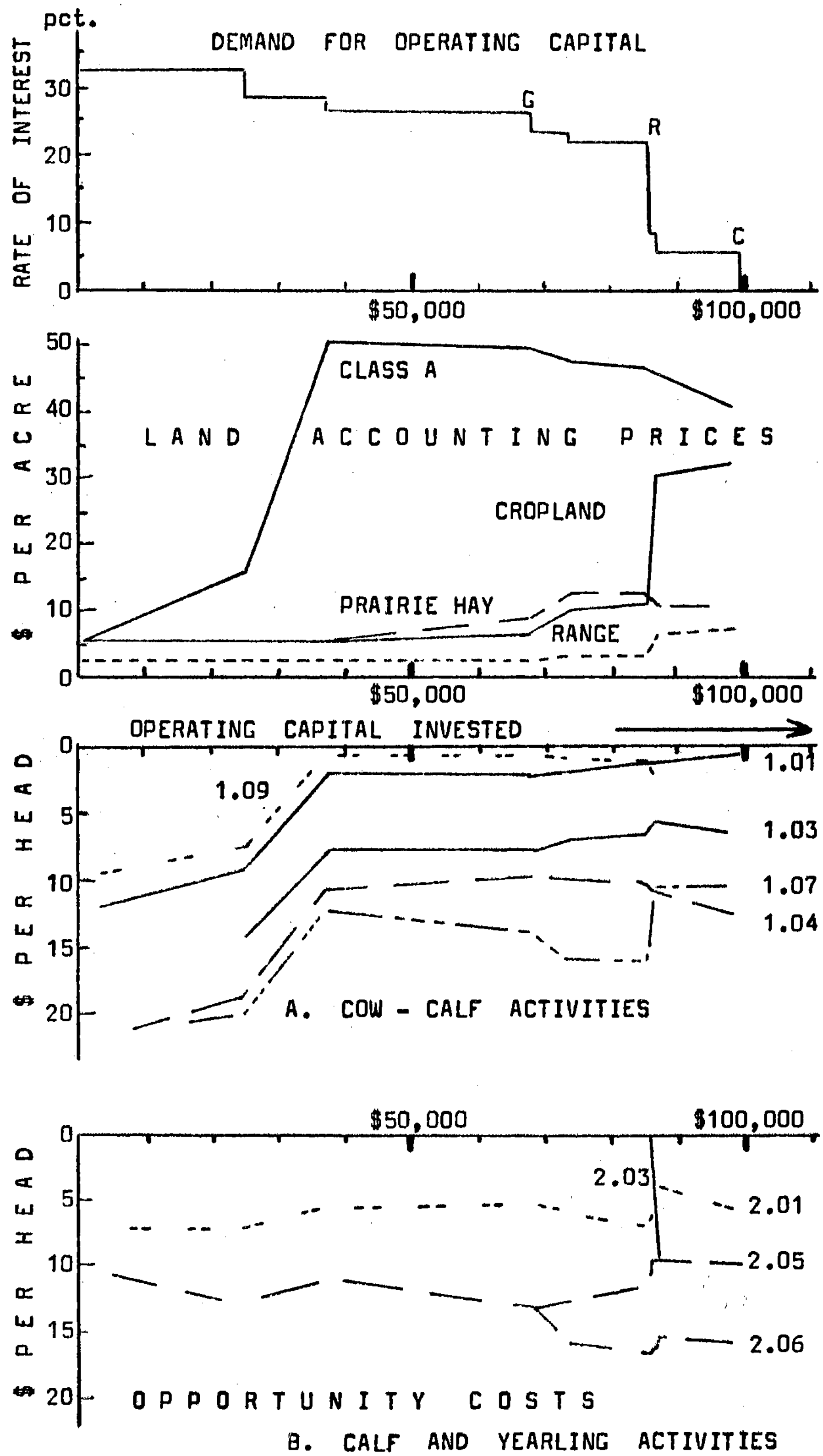

Fig. 18. Demand for Capital and Accounting Prices, Four Section Ranch, With Option to Rent an Additional Section of Range (Model No. S22).

CHAPTER IV

SOME GENERALIZATIONS PERTAINING TO THE MANAGEMENT OF CATTLE RANCHES DERIVED FROM THE STATIC ANALYSIS

The obvious products of the results reported in the preceeding chapter are descriptions of ranch organizations that bring forth the highest contribution to profit and overhead, provided the specific conditions of the model and its modifications - resource mix, productivity, prices - are met. In a strict sense very few ranches meet the specifications precisely at any one time, or even in the average over a longer period. In order to make the results useful for a large number of ranches it is necessary to generalize the findings.[1]

1. Among the ten options of organizing cow-and-calf enterprise, only four were ever selected. The two-breeding-season (1.10) alternative proved to be the favored one in the majority of cases. Where either land or the supply of labor in the fall became a critical limiting factor, spring calving was preferred. The difference between the profit contributions of both two-breeding season and spring-calving was always small so as to make the choice between these two alternatives more a matter of individual circumstances and preference than of economic necessity.

[1]The points that follow will be presented only to establish conclusions from this model, whether they represent restatements of well known facts or new findings.

2. The rejected cow-and-calf alternatives: fall calving (with alfalfa or cottonseed cake) costs rarely less than $10 per cow in income foregone; creep feeding costs from $5 to 10 more than the non-creep alternatives; a prairie hay supplement in place of alfalfa hay generally proved costlier, compared to other alternatives; putting cows with fall calves on small-grain pasture (1.08) was particularly costly, resulting in more than $30 per cow in terms of income foregone.[2]

3. The break-even point for alfalfa and cottonseed cake supplement for brood cows was definitely above the price of $25 per ton (cottonseed cake $3.80 per cwt). Depending on circumstances the break-even point varied between roughly $28 and $34 per ton.[3]

4. Wintering of calves on small-grain winter and spring pasture (activity 2.07) was always profitable and had the highest rate of return in capital. Only when purchase of short yearlings was deliberately restricted did other calf wintering alternatives emerge. Trap wintering with moderate gains was then chosen in preference to a rough-wintering alternative in order to provide the stocker cattle in instances where grazing appeared advantageous. Thus a wintering practice which puts on about 100 pounds per calf from weaning to April 1 is generally more profitable than a "survival" ration of cottonseed cake supplemented by

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[2]Creep feeding may be justified in case of a sudden, severe drought, in purebred breeding, where it is desireable to push calves to take advantage of a favorable market or to get them ready before an expected price break, or finally if calves are to be prepared for feedlot finishing by the breeder himself.

[3]If the operator has the time to feed hay, no extra costs arise. If he hires extra help, wages have to be added to the cost of feeding hay, bringing down the break-even point.

winter range, allowing for but 50 pounds of gain. The advantage continues even though the summer gain (activity 2.05) on grass (which alone justifies the cost of wintering the calf), is reduced somewhat by increasing the winter gains.

5. Grazing yearlings. If purchased yearlings are to be grazed, it is more advantageous to buy lean, range-wintered yearlings (activity 2.02, 2.05) rather than trap wintered animals bearing an extra 50 pounds (2.03, 2,06). Yearlings raised at home should be trap wintered.

6. In the models investigated, steer grazing on range alone was always a better choice than a combination of range and sudan grass pasture. Sudan grass, in a ranch with limited cropland, would be considered an emergency crop if drought curtails range grazing, not a regular feature.

7. It was not profitable in any case to carry long yearlings cver into a second year of grazing. The opportunity cost of this strategy was generally more than $30 per animal.

8. Throughout the variations of the ranch model the competitive position of cow-and-calf enterprises and yearling stocker enterprises remains the same. Cows are more advantageous as long as capital is scarce (hence costly), and land is easily available at the going rental rate. If land is limited and capital is in sufficient supply, i.e., cheaply obtainable, cows will be successively replaced by grazing yearlings. Underlying this is the fact that the (marginal) productivity of capital is assumed to be relatively high, the (marginal) productivity of land relatively low for a cow herd. The reverse hold for yearlings: Relatively high productivity per unit of land, low productivity per dollar invested in livestock.

9. Of crucial importance for the competitiveness of yearling stocking is the form of capital borrowing contracts. The marginal rate of return to operating capital borrowed on a short-term credit instrument for the few months the yearlings are on grass is 23 to 9 per cent, yet only 4 - 1.5 per cent if working capital has to be borrowed on a one-year contract.

10. A relatively small proportion of cropland adds a great deal of flexibility and income-creating potential to a ranch. Cropland provides grazing and forage, which is often available at different times from native grasses, - small grain pasturage - or is of superior quality - alfalfa. By permitting variety of organization seasonal labor requirements are often reduced. The value added per acre of productive cropland is several times greater than from rangeland, thus justifying a higher price. The high accounting price of cropland and the derived capital value suggest that substantial investments to improve and irrigate suitable land may be profitable.

11. The intensity of operation may be moderately raised by using more capital and labor, and by buying hay. This study points out the limits of conventional operation. Further intensification calls for intensified range management, or permanent improvements such as brush clearing, reseeding, fertilizer use or irrigation (51) (52).

12. Limiting the choice of enterprises limits the income levels that may be reached. Specialization as an aim in itself may be justified if experience or the ability to supervise a great variety of activity at once is lacking.

13. Even with a limited choice of activities as used in this study, the organization of a ranch is complicated and sensitive. While the principles of management remain the same everywhere, differences in actual resource availability and productivity may call for radically changed optimum orgainzations with only slightly different resource situations. To accomplish the calculating work necessary to modify the results it will be necessary to either employ computers, or develop simplified planning methods such as Weinschenck's difference method (53), the Swedish HYV method (54) (55), or Blechsteins's Kreuznach method. (56).

14. The Four Section Ranch model was calculated using long-term average prices and productivity factors. It is essentially a "stationary state" model, based on the fundamental notion that the best management strategy is to follow one basic prescription every year. In such a framework year-to-year changes must be seen as necessary evils, the goal being to hew as close as possible to the ideal model under any situation. This view overlooks the fact that exceptions far exceed the occurrence of average conditions. Variations in prices and productivities can constantly be expected. The remainder of this monograph is devoted to a study of strategies which incorporate some awareness of changes to come into organizational and operational plans.

CHAPTER V

PLANS FOR DIFFERENT PRICE LEVELS AND PRICE EXPECTATIONS

A rise or fall in the price of beef affects the relative advantage of beef enterprises competing for the use of range, cropland, capital labor and - most important - for the operator's attention. In this chapter, the effects of a change in the general level of prices, of a movement of prices from planning or steer-buying time to the time finished calves or steers are sold, and of diffused rather than discrete price expectations will be investigated.[1]

A. Description of Resources and Relationships in the "Four And Four" Model Ranch

In this series the amount of operating capital is set at a given level. Purchase prices and selling prices are varied by parametric programming. The results are presented (a) in a "price map" (17, ch. 8), and (b) in a price-contribution nomograph. The price map identifies the optimum enterprise combinations associated with various buying and selling

[1] This study of the effect of changing prices is dynamic in the sense that it takes account explicitly of the change of - albeit extraneously conceived - variables over time, if only over a period of 6 - 12 months, and stochastic to the extent that it operates with diffused price expectations.

prices. The income nomograph identifies the contribution to profit and overhead associated with all price configurations. The nomograph also demonstrates the price sensitivity of enterprises and the 'price risk' associated with each.

The "Four And Four" model ranch consists of four sections of land owned outright, an option to rent an additional four sections of range, plus 150 acres class A (alfalfa) cropland, and an 'intermediate' capital position defined as follows: the operator owns outright operating capital, equal to 7 per cent of the value of the real estate, he may borrow up to one half the value of the real estate at four per cent for the purchase of livestock, and up to twenty per cent of the value of the real estate value ($218,350) at seven per cent to finance all other operating expenses.[2]

B. Ranch Organizations as Influenced by Price Levels and Price Changes

1. Classes of Organizations Covered by the Price Map

In figure 19 the abscissa variable represents the purchase price of calves bought for wintering and steers for grazing (P_0). The ordinate variable is the deviation of the selling price level from the purchase

[2]The process specifications of this series differ slightly from those used in the Four Section Ranch of chapters II-IV. For full specifications see appendix E. In the main, in this model fall calving has a slight edge over spring calving, and wintering appears more favorable.

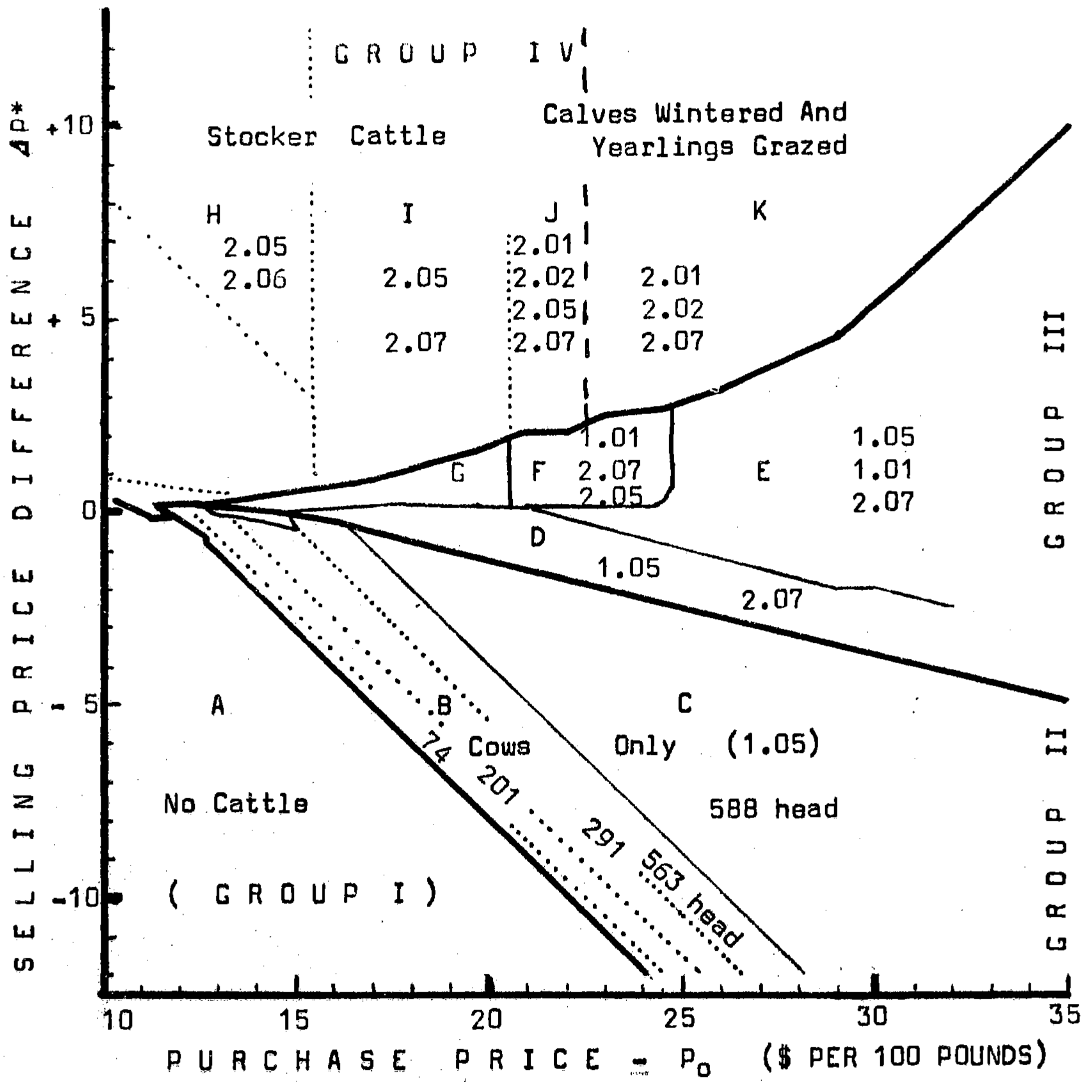

Fig. 19. Price Map: Calf Buying Price Versus Calf Selling Price (Difference to Buying Price), Four-And-Four Ranch Model.

price level (ΔP^*). P^* may be considered either the actual realized selling price, or the expected selling price upon which planning is based.[3]

As prices are varied, the optimum organization of the model of a firm will change only as the point of tangency with the maximum revenue contribution plane swings from one vertex point to the next (see chapter IV). In a price map this permits delineation of areas of common organization. Because many such changes take place, in fig. 19 a number of minor changes have not been mapped to avoid unnecessary confusion. The areas specifically identified as having a common organization are:

<u>Group I.</u> No Cattle

A - 'Sell out/rent'. Marginal rate of return on operating capital less than loan rate, rate of return on land less than rental rates.

<u>Group II.</u> Cows Only (activity 1.05)

B - Cow-calf transition. Same system as in (C), yet cow numbers vary from zero (boundary of A, lowest calf price) to near the number of cows in (C), range land successively taken under operator's management.

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[3]The price level is identified by the price of weaned feeder calves. However, differences between classes of livestock, and seasonal differences have been taken into account. All prices used are varied strictly in proportion with the feeder calf price. This is a simplifying assumption. Over short periods of time prices of individual classes of livestock may move somewhat independently of each other. The simplifying assumption was made for the obvious reason of keeping the problem manageable. In ad hoc studies of a particular ranch for a particular market situation price changes, may, of course, be specified individually for calves, yearlings. etc.

C - Cow-calf. Fall Calving, alfalfa hay supplement, 588 cows (activity no. 105) (598 above a calf price of $25.50 per cwt.).

<u>Group III.</u> Mixed Operations

D - Cow-calf (1.05) supplemented by calves wintered and fed on small grain pasture (2.07). Size and composition of herd varies.

E - As (D); (1.05) partially or totally replaced by spring calving cows (1.01). Proportions vary.

F - Spring calving cows (1.01), calves wintered on small-grain pasture (2.07) and summer-grazed range yearlings (2.05).

G - As (F); spring calving replaced by alfalfa-fed, fall calving cows (1.05).[4]

<u>Group IV.</u> Calves and Yearlings only

H - Yearlings grazed on range (2.05) and,as far as available, on sudan grass pasture (2.06); number of steers limited by available capital and purchase price.

I - As (H); some of the cropland diverted from sudan grass to pasture for calves (2.07).

J - Calves wintered in the rough (2.01) and subsequently grazed on range (2.02); supplemented by additional calves bought in the spring for grazing (2.05); cropland utilized by calves on small grain pasture (2.07).

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[4]This model did not include a cow-calf activity combining alfalfa supplement feeding with spring calving, or one incorporating spring and fall calving, which turned out to be the most profitable choices in the Four Section Ranch. If they had been allowed, they would probably monopolize the picture.

K - All calves bought in fall. Activities 2.01, 2.02, 2.07.

2. Optimum Organization for Constant Prices

No beef activity contributes anything to profit and overhead below a calf price of $11.25 per 100 pounds. With the slightest price improvement, and the hope for better days to come, yearling grazing is indicated (region H). Beyond $12 calf raising (B) is indicated. With further improved prices, mixed operations with cows and calf wintering/yearling grazing (group III) appear most promising.

3. Optimum Organizations if the Price Level Changes During the Period of Production

As the price level goes up, not only is more income generated, there is more latitude to adjust to change, and the regions of optimum organization themselves cover a wider latitude, indicating greater stability in the face of short-term price changes. The range of the mixed operations area develops as follows as the base (purchase price) increases:

base price	Stability range of selling price
$20/cwt	+$1.75 to -$1.25
25	+$2.75 to -$2.50
30	+$5.25 to -$3.75
35	+$10 to -$5.

It is, of course, true that within this range the exact composition of the optimal livestock mix varies.

The upper boundary of the 'mixed operations' region forms the lower boundary of the 'calf-and-stocker cattle' phase (group IV). The boundaries between the stocker subregions are dependent solely on the purchase price, while the selling price margin determines the proportion of cows and stocker cattle. A stocker/feeder calf price of $15.50 shifts cropland use from sudan grass (2.06) to oats-vetch pasture (2.07). Beyond $20.50 activity 2.01 (wintering calves) is introduced. Above a base price of $22.50 activity 2.05 is eliminated. Because the level of operating capital has been fixed, an increase in the general beef and price level reduces the number of animals that may be bought. At $10 as many as 2700 steers may be financed with the given base. At $15 the number falls to 1950; to 1500 at a $20 price base, and 1250, 1050, and 950 with price basie' of $25, $30, and $35, respectively. If more capital were made available, the number of steers bought would be increased and the competitive range of stocker operations expanded.

Lower selling prices suggest "pure" cow-and-calf operations (group II). The number of cows ultimately is limited only by the acreage available (to 588/598 head). As long as the feeder/stocker calf price stays above $16 per hundredweight, range is used to capacity by cows.

Only if prices fall below that mark is a gradual reduction in the number of cows indicated, until below the $12 price level all beef activities become unprofitable.[5]

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[5]The model specifies that a minimum income of about $7000 to cover land tax, other overhead and minimum living is available at this point. As prices fall, this minimum is earned by renting out all land and saving the capital. This is not a realistic assumption if prices stay depressed permanently. The rental rate is bound to fall if the level of calf prices falls permanently.

In summary, with prices falling stocker cattle operations are not among the favored activities. With prices increasing, a mixed operation with both a cow herd and varying numbers of calves wintered and summer grazed is the ranch organization of choice. Only with a positive price margin between spring and fall prices pure stocking operations are more advantageous than mixed operations.

A cow herd however, cannot easily be liquidated on short notice, and, more important yet, cannot be built up again within a short time, either. Thus, while it may be profitable to have only steers to reap the benefits of rising prices, cows should always be around to help cushion the effect of falling prices. This may tip the balance heavily in favor of cows. On the basis of the model calculations, taking into account the fixity of a cow herd, one might expect that cow herds will be the basic operatiion. Cows may be complemented by grazing steers, provided the price looks right, and pasture or cropland to plant to small grain pasture is available.

C. The Influence of Price Upon Profit and Overhead Contribution

Figure 20 shows the amount of contribution to profit and overhead that may be obtained by ranch organizations optimal for indicated price configurations. Each curve is associated with a given basing or purchase price as it prevailed during the beginning of a period of production, and relates the net contribution obtainable (ordinate) at various selling prices at the end of the period of production (abscissa) for the particular

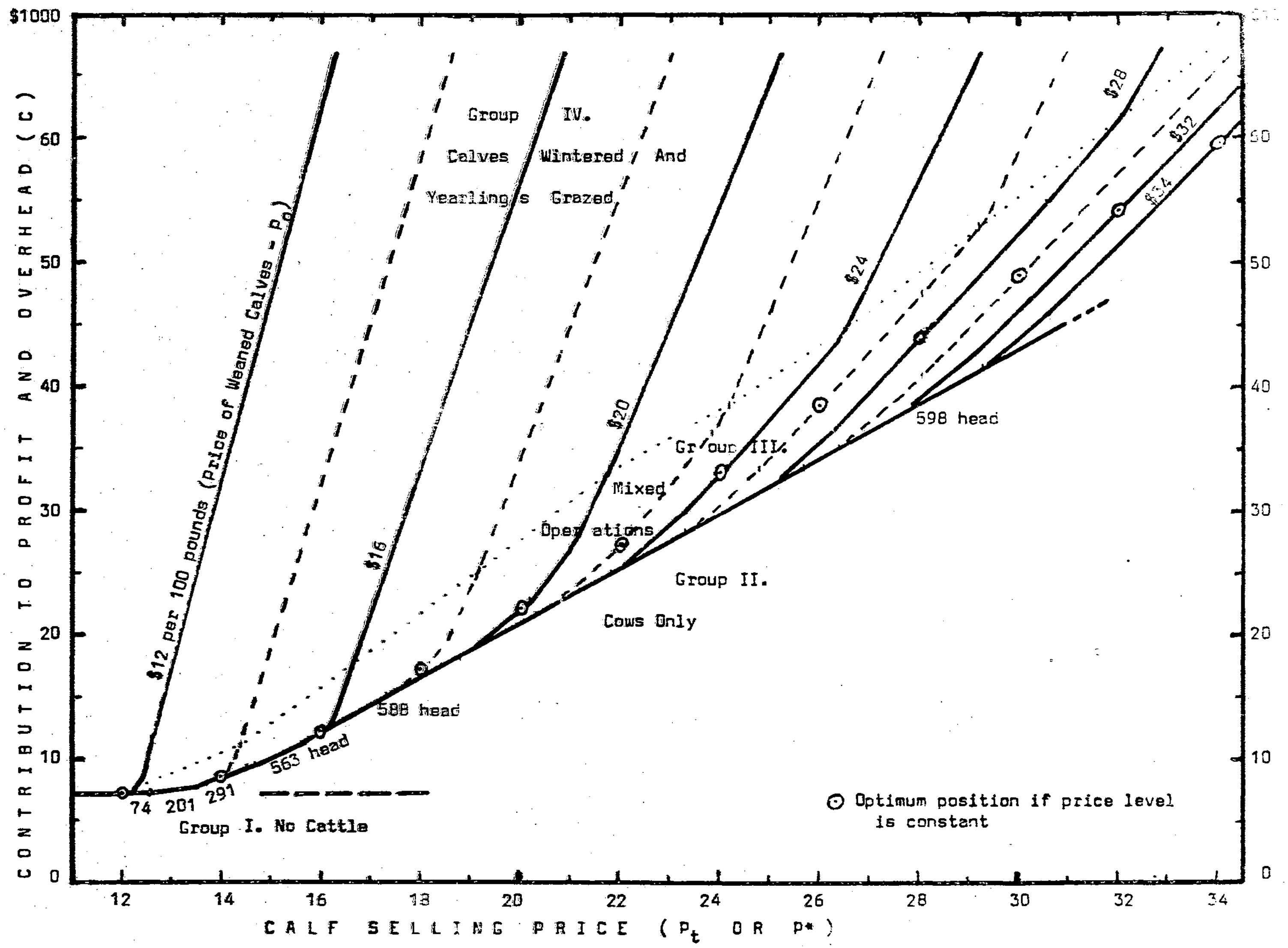

Fig. 20. Price Profit Map of the Four-And-Four Ranch Model: Relations Between Calf Buying and Selling Price, and Contribution to Profit and Overhead.

basing price. Table XV lists the contribution of various organizations (including the optimal one) for a number of basing prices, with selling price identical to basing price.

Figure 20 associates the value of the objective function with - constant, rising, and falling - beef price levels. It also gives some idea of the price sensitivity or the "price risk" associated with the various ranch cattle producing activities. The slope of the curves directly represents the price-income gradient, $\frac{\Delta C}{\Delta P}$. ($\Delta C$ = change in contribution to profit and overhead, ΔP = change in calf price). The steeper the curves, the greater the income change associated with a change of the price of beef during one full period of production.

Point estimates of the price/income gradients have been assembled in table XVI. Not unexpectedly the gradient increases from zero for the rent-out alternative, through cow-and-calf operations to pure steer stocking activities. By definition each organizational plan has a constant gradient. The succession of optimum plans called for, as the - anticipated or ex-ante - selling price varies, leads to a succession of constant price-income gradients, each of fixed value, but applicable only in the price range for which the organization is best adapted. Together these define a price-income curve which approximates a smooth curve. At the scale used in figure 20 it is difficult to identify all the vertices where the price-income gradients change. Only one series of vertex points, corresponding to the boundary between regions III and IV in the price map has been identified (dotted line).

TABLE XV

CONTRIBUTIONS TO PROFIT AND OVERHEAD, OPTIMAL AND SUBOPTIMAL PLANS FOR MODEL CATTLE RANCH, SOUTH CENTRAL OKLAHOMA (FOUR AND FOUR RANCH, INTERMEDIATE CAPITAL, VARIOUS PRICE LEVELS).

Description of Ranch Plan	Price Map Region[a]	Buying and Selling Price Level					
		$12/cwt.	$16/cwt.	$20/cwt.	$24/cwt.	$28/cwt.	$32/cwt.
I Sell out or rent out	A	$7,055[b]	$7,055	$7,055	$7,055	$7,055	$7,055
II Cow-Calf							
291 beef cows	B	6,185	10,580	14,975	19,375	23,770	28,165
588 beef cows	C	3,425	12,135	20,920	29,625	38,335	47,070
III Mixed Operations							
Cows, some small grain calves	D	1,976	12,210	22,090	32,410	42.835	52,975
Calves & year-lings, some cows	E,F,G	G/28,150	G/10,955	G/21,670	F/32,970	E/43,446	E/54,260
IV Calves wintering & Yearlings grazing	H,I,K	H/1,445	I/9,560	I/15,990	K/23,165	K/30,835	K/35,565

[a] Letters refer to subregions in figure 19.

[b] Underlined values are maximum for its price level.

TABLE XVI

THE EFFECT OF A DIFFERENCE BETWEEN BUYING AND SELLING PRICE ON CONTRIBUTION TO PROFIT AND OVERHEAD IN THE FOUR AND FOUR RANCH ($\frac{\Delta C}{\Delta P}$).
[$ GAIN PER 1$ INCREASE IN FEEDER CALF PRICE FROM BUYING TO SELLING TIME]

Description of Ranch Plan	Price Map Region[a]	Buying Price						
		$12/cwt.	$16/cwt.	$20/cwt.	$24/cwt.	$26/cwt.	$28/cwt.	$32/cwt.
I Sell out or rent out[b]	A	0	0	0	0	0	0	0
II Cow-and Calf								
291 beef cows	B	0	$1100	$1100	$1100	$1100	$1100	$1100
588 beef cows	C	0	0	$2220	$2220	$2220	$2220	$2220
III Mixed Operations								
primarily cows, some small-grain calves (104,107)	D	0	$2560	$3605	$3605	$3605	$3605	$3540
calves, some cows	E,F,G	0	G/$9775	G/$5235	F/$4570	$4380	E/$4405	E/$4105
IV Calf wintering yearling grazing	H,I,K	H/15009	I/$11785	I/$9750	K/$8425	$7930	K/$7490	K/$6770

[a]No change in income with change in beef price - provided the prices are only temporarily depressed, and the rental rate is not affected.

[b]Letters refer to subregions in fig. 19.

D. The Effect of Erroneous Price Estimates

While decisions are taken on the basis of estimated (ex ante) selling prices, income is determined on actual prices at the time of sale (ex post).

The price-income map (fig. 20) shows only price-income combinations in cases where, at the time the decision to buy steers is taken, the anticipated selling price has been estimated correctly. If the anticipated price turns out to be wrong, and assuming that no short-term disposition is possible, any gross deviation of the actual (ex post) selling price from the anticipated one (ex-ante) will result in a deviation from the expected income. There may be either a windfall profit or loss. Once inputs are committed, the final outcome C is a linear function of the realized beef price P_b: $C = K + P_bY$, where the cost constant K not only includes fixed costs, but also all variable costs including the cost of stocker calves, which have been committed irrevocably once a decision has been made. The effect of miscalculating future prices for any level of prices and any ranch organization considered may be visualized readily by laying a tangent through the point on the line representing a given organization. The steeper the slope the greater is the price sensitivity of anticipated returns.

By the criteria of the price-income gradient a steer stocking operation is more sensitive to short-term price changes than a cow-calf operation. While stocker cattle hold out the promise of greater gains when the price is moving in the right direction, it also may plummet income much more radically with an unexpected price drop.

Table XVI shows the cost of a one dollar error in anticipating price for the model ranch. Predictably a higher price than expected increases returns, a lower price than expected reduces returns. But a closer look is needed to demonstrate that no matter which way we err in predicting price, an error costs us, either in actual losses, or in opportunity costs, in income foregone which we miss by hedging on our price estimates.

In table XVII, for a given initial price level the income contributions obtained by anticipating selling prices correctly ("ex ante contribution") are compared with the income contributions obtained if prices deviate by specified amounts from expectations ("ex post contributions").

The differences between ex ante and ex post contributions on the same line measures the total windfall loss or gain (57, p. 178) (58, pp. 57, 288) (59, p. 261). The amount of the windfall could be calculated by multiplying price difference and price-income gradient (table XVI). It is a pure price effect. Distinct from windfall loss or gain is long-run loss or gain, measured by the differences between appropriate values in the "ex ante contribution" column. The differences between windfall (ex post) and long run (ex ante) loss/gain can be measured by subtracting the contributions of the ex ante column from values along the SW - NO diagonals. The difference between long-run loss or gain and windfall or price effect loss/gain is never positive. It is the (opportunity or actual) cost of imperfect price anticipation. We can call it the substitution effect. The substitution effect is that part of windfall losses that could have been avoided with proper forecasting and organization (table XVIII).

TABLE XVII

CONTRIBUTION TO PROFIT AND OVERHEAD FOR VARIOUS ANTICIPATED AND REALIZED SELLING PRICES, FOUR AND FOUR RANCH MODEL, FEEDER/STOCKER CALF PURCHASE PRICE $26 PER HUNDRED POUNDS. ORGANIZATIONS OPTIMAL FOR EXPECTED SELLING PRICE.

Expected Selling Price (Ex Ante Price) per 100 pounds	Optimum Program	Ex Post Contribution (Ex Post Price lower than Ex Ante Price by					Ex Ante Contri= bution[a]	Ex Post Contribution (Ex Post Price Higher than Ex Ante Price by				
		-$10	-$8	-$6	-$4	-$2		+$2	+$4	+$6	+$8	+$10
$12	A	7055	7055	7055	7055	7055	7055	7055	7055	7055	7055	7055
$14	B	-2610	-410	1785	3985	6180	8380	10580	12780	14980	17175	19370
$16	C	-10090	-5650	-1210	3230	7670	12110	16550	20990	24430	29870	34310
$18	C	-5650	-1210	3230	7670	12210	16550	20990	24430	29870	34310	38750
$20	C	-1210	3230	7670	12210	16550	20990	24430	29870	34310	38750	43200
$22	C	3230	7670	12210	16550	20990	24430	29870	34310	38750	43200	47640
$24	D	-5630	1580	8790	16000	23210	30400	37620	44830	52040	59250	66450
$26	E	-5255	3510	12270	21030	29790	38550	47310	56070	64840	73600	92360
$28	E	3510	12270	21030	29790	38550	47310	56070	64840	73600	92360	101120
$30	K	-20374	-4510	11350	27210	43070	58930	74790	90650	106510	122370	138230
$32	K	-4510	11350	27210	43070	58930	74790	90650	106510	122370	138230	154190
$34	K	11350	27210	43070	58930	74790	90650	106510	122370	138230	154190	170050

[a]and ex post contribution for correctly anticipated price.

TABLE XVIII

THE COST OF IMPERFECT PRICE ESTIMATES, FOUR AND FOUR RANCH MODEL, FEEDER STOCKER CALF PURCHASE PRICE $26 PER HUNDRED POUNDS. ORGANIZATIONAL OPTIMA FOR EXPECTED SELLING PRICE.

Expected Selling Price (Ex Ante Price)	Optimum Program	Cost of Overestimating Selling Price (Ex Ante - Ex Post) Ex Post Price Lower than Ex Ante Price by...					Ex Ante Contribution and Ex Ante Price=Ex Post Price	Opportunity Cost of Underestimating Selling Price (Ex Ante - Ex Post) Ex Post Price Higher than Ex Ante Price by...				
		-$10	-$8	-$6	-$4	-$2		+$2	+$4	+$6	+$8	+$10
$12	A	0	0	0	0	0	0	-1330	-5060	-9500	-13940	-17380
$14	B	-9665	-7465	-5270	-3070	-870	0	-2690	-3770	-6000	-7260	-11040
$16	C	-17140	-12700	-8840	-3820	-710	0	0	0	0	-540	-4240
$18	C	-12700	-8840	-3820	-710	0	0	0	0	-540	-4240	-8560
$20	C	-8840	-3820	-710	0	0	0	0	-540	-4240	-8560	-15740
$22	C	-3820	-710	0	0	0	0	-540	-4240	-8560	-15740	-27160
$24	D	-14010	-10530	-7760	-5000	-1230	0	-930	-2480	-6890	-15540	-24200
$26	E	-17370	-13050	-8725	-3400	-620	0	0	-2860	-9960	-17060	-14150
$28	E	-13050	-8725	-3400	-620	0	0	-2860	-9960	-17060	-14150	-21150
$30	K	-41370	-28940	-19070	-11340	-4240	0	0	0	0	0	0
$32	K	-28940	-19070	-11340	-4240	0	0	0	0	0	0	0
$34	K	-19070	-11340	-4240	0	0	0	0	0	0	0	0

This table derived from table XVII.

The stubstitution effect is of course zero for all correctly anticipated prices (ex ante column). The area of a zero substitution effect sometimes extends over a range of prices (here \$16 - 22, 26 - 28, 30 and up). Within each of these ranges no change of the optimum plans is indicated, hence no resource substitution is necessary if prices fluctuate within this range. (The 'no substitution' regions are boxed in in table XVII).

There is a bias apparent in the effect of overestimating and underestimating selling prices. The bias shows up most clearly if we "fold over table XVIII upon itself", i.e. by subtracting the cost of underestimating from the cost of overestimating by a like margin. A minus sign indicates that overestimating causes the greater cost. Table XIX presents the estimating bias associated with tables XVII and XVIII.

Overestimating obviously is more costly when a price increase is overestimated ($P^* - P_0 \geqq 4$, where $P_0 = 26$). Underestimating the selling price while it is already falling strongly ($P^* - P_0 \leqq - 12$) is equally obviously the more costly choice. In between the choices are not as obvious. Yet, excepting the \$16 level ($\Delta P^* = 10$) it appears that within the boundaries indicated overestimation on balance tends to be more costly.

E. Expected Values of the Contribution to Profit and Overhead

We know now the outcome of several ranch programs for a wide range of prices and price changes over a period of production. In this section we condense our information for each program, by multiplying the estimated probabilities of certain price changes with the outcomes which

TABLE XIX

THE DIFFERENCE OF THE COST OF OVERESTIMATING AND UNDERESTIMATING BEEF SELLING PRICES. FOUR AND FOUR MODEL RANCH, FEEDER/STOCKER CALF PURCHASE PRICE $26.

[DOLLARS]

Expected Selling Price P*		Optimum Program	(Cost of Overestimating) - (Cost of Underestimating) of Actual Price [= (Low Ex Post) - (High Ex Post)][a] Ex Post Price Differs from Ex Ante by ... ±$2	±$4	±$6	±$8	±$10
$12	A	no cattle	1330	5060	9500	13940	17380
$14	B	291 cows	1820	2900	5125	6490	10170
$16	C	588 cows	- 710	- 3820	- 3820	- 3280	415
$18	C	" "	0	- 710	- 3280	415	4740
$20	C	" "	0	540	3230	4740	11910
$22	C	" "	540	4240	8560	15020	23330
$24	D	565 cows 216 calves	- 297	- 2510	- 870	5015	10190
$26	E	540 cows 338 calves	- 620	- 850	1230	4010	- 2220
$28	E	" "	2860	9330	13650	5425	8100
$30	K	1220 calves 870 yearlings	- 4240	-11340	-19070	-28940	-41370
$32	K	" "	0	- 4240	-11340	-19070	-28940
$34	K	" "	0	0	- 4240	-11340	-19070

[a]minus (-): cost of overestimating greater than cost of under= estimating.

No sign: cost of underestimating.

we calculated for these price changes, and summate the products. The result of this operation are the expected values of the contribution to profit and overhead for each of the programs or strategies, for a given initial price, P_0. Our choice guide we modify by selecting the program with the highest expected value.

$$(5.1)\ E(C) = \sum^{t} p_t C_t \quad (t = 1 \ldots n; \quad \text{and} \quad \sum^{t} p_t = 1.0).$$

Here p_t is the probability of having a selling price P_t in one year follow a purchase price P_0 in the preceeding year.

Only a limited number of observations are available to estimate the probabilities of annual price changes. The longest series is "Prices Received by Farmers for Calves" (60) (61). For Oklahoma this series goes back to 1909. To eliminate the variation due to changes in the secular price level the raw data were first expressed in terms of their ten-year moving (centered) averages, and normalized to the 1957-59 price level (figure 21).[7]

From the adjusted data a table of transition probabilities or a Markov table (62) was constructed (table XX). Tables II to V, appendix E, contain the values of contributions of several ranching strategies for purchase prices of \$18, \$22, \$26, \$30 per 100 pounds, and sales prices P_t as expected according to table XX. The bottom line contains the expected value of each strategy, the sum of all outcomes weighted with the associated probabilities. The expected values in the bottom

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[7]See appendix E table I for further details.

TABLE XX

TRANSITION PROBABILITIES OF CALF PRICES (YEAR-TO-YEAR CHANGES) OKLAHOMA 1909-63[a]

First Year Price Changes	Unit	Second Year Prices: to $15.99	$16 to $19.99	$20 to $23.99	$24 to $27.99	$28 to $31.99	$32 and upward	Number of Years First Year Price Probability[c]
To $15.99	Number	-	-	1	-	-	-	1
	probability[b]			1.0				0.023
	ave. price change			$14.95 - $23.29				
$16 to $19.99	Number	1	5	4	-	-	-	10
	probability	0.10	0.50	0.40				0.227
	ave. price change	$16.92 - $14.95	$18.33 - $18.10	$18.86 - $21.16				
$20 to $23.99	Number	-	4	8	3	1	-	16
	probability[b]		0.25	0.50	0.18	0.06		0.364
	ave. price change		$20.98 - $19.03	$22.71 - $22.47	$22.56 - $24.98	$20.81 - $28.18		
$24 to $27.99	Number	-	1	3	5	3	-	12
	probability		0.083	0.25	0.417	0.25		0.273
	ave. price change		$24.95 - $17.24	$25.56 - $23.00	$25.39 - $24.98	$25.63 - $26.69		
$28 to $31.99	Number	-	-	-	1	-	2	3
	probability				0.333		0.667	0.068
	ave. price change				$28.14 - $26.77		$30.48 - $32.38	
$32 and upward	Number	-	-	-	2	-	-	2
	probability				1.0			0.045
	ave. price change				$32.38 - $25.34			

[a]See text for adjustments made to eliminate effect of changes in the general price level.
[b]Number of years in this price range following a year with price as indicated in the first column.
[c]Probability of a year recurring with price as indicated in first column.

row have been carried over into table XXI.[8] Table XXI contains significant information. It permits evaluation of the profit-generating potential of each strategy in terms of its expected value, for each of a number of initial price levels. Thus, at a price of $22 for weaned calves, mixed operation D (primarily a cow herd, with some calves kept over to next spring on small grain pasture) has the highest expected value, followed by a streight cow-and-calf setup (program C). With a purchase price of $18 per 100 pounds a program with only calves and yearlings (I) has the highest expected value.

Stocker cattle are more promising than any other kind of ranching program when the calf price is low. The probability of a price rise is never greater than when prices are down at the bottom.

It is not possible to switch back and forth between stocker cattle and a cow herd, but it is possible to vary the composition of the herd somewhat. For example, if prices and feed conditions warrant, some or all of the calves (program D - G) may be retained while calves would be sold at weaning time when prices are imminent.

A strategy which is based primarily on cows, with calf and yearling operations added as the occasion justifies, would be most advantageous on theoretical grounds, too. The expected value of such a strategy (D, table XXI) is greater than any other program. It exceeds the expected value of a strict calf-raising operation (C) by 9 per cent, and a program based on buying and selling stocker calves and yearlings (IV) by 25 per

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[8]Which also contains the expected values for purchase prices of $15 and $32 which, as seen in table XXI, have a single-valued expected selling price.

TABLE XXI

COMPOUNDED EXPECTED CONTRIBUTION TO PROFIT AND OVERHEAD, FOUR AND FOUR RANCH MODEL

Purchase Price P_{it}	Probability of Purchase Price Occurring P_t	II Cows Only B	II Cows Only C	III Mixed Operations D	III Mixed Operations Other	IV Calves and Yearlings Only
$15[a]	2.3 %	$(18274)	$(27150)	$(32004)	G $33212	H $107422
$18	22.7	13834	18684	19738	G 22329	I 23035
$22	36.4	sub=	26026	29238	F 24743	J 23098
$26	27.3	optimal	32096	34260	E 34480	K 20905
$30	6.8		43926	48618	E 50069	K ~52000
$32	4.5		32094	(28131)	E(26959)	(loss)
Weighted Average[b] (= $\sum^{t} P_t C_{it}$)			$ 27530	$ 29780	$ 28870	$ 23775

Figures in parenthesis are not optimal for this price range. They have been computed to estimate the outcome of a strategy which is followed every year.

[a]Selling price $23 (see preceeding table).

[b]The expected value of a strategy followed consistently year after year.

cent. An increase of 9 per cent of returns over variable cost is a respectable increase, amounting to perhaps 15 per cent and more in profits. This could be obtained on most ranches now specializing on raising feeder calves, simply by feeding out some calves, if there is lush and cheap winter pasture, and the price is right.

A pure stocker steer operation seems to be justified only if the operator has shown exceptional ability to gauge the market, has the capital required to carry the large number of animals, and will make sell and buy decisions solely on the basis of current market appraisals. This often means going against the market and abruptly changing the mode of operation.

CHAPTER VI

AN INTERTEMPORAL RANCH MODEL

The optimal management plan developed in Chapter V is based on maximization of the expected contribution to profit and overhead. This approach utilizes historic price probabilities as observed over fifty years. Yet it is a short-run plan, taking account explicitly of only two points in time, the beginning and the end of the production period. By invoking the "stationary state" concept, where prices, technology and nature-induced production conditions are assumed in equilibrium, and therefore constant.

We can extend the results of Chapter V to the long run. Most ranch production conditions vary most all the time. Still we may consider the plans advanced previously as norms, from which the manager would deviate as conditions require. But under what conditions should he deviate, and how much? Can we not advance more definite management recommendations?

A. Introductory Considerations

The approach chosen here is to extend the one-year model over a period of years, and optimize the stream of profit and overhead contribution obtainable over the entire period, while varying both the price and yield structure. The analysis can now be called "dynamic" in the Frisch (63) sense. The extension of a one-period linear programming model into several periods is conceptually simple (16, p. 265). The flow of inputs and outputs in each period of production is treated as a semiautonomous entity. The necessary connection from period to period is established by transferring certain outputs of one period as stocks which then will be available as inputs in a subsequent period. This is essentially an application of the Neumann model of economic growth (64), (16, p. 300 ff.) in the realm of the firm, with appropriate assumptions about the nature of the particular production process.

Growth models of farms over time have been put forward by Swanson (65), Loftsgard and Heady (66) (67), and Plaxico (68). In Loftsgard's model only one stock is transferred from one period to the next: liquid capital.[1] He assumes no changes in prices or productivities from year to year. Hence his growth model is a pyramid of annual programs, in which just one stock resource, capital, varies in quantity. The problem formulated by Loftsgard thus can be reduced to a parametric programming model.

Most production items are stocks which serve a specialized purpose, and are absolutely or conditionally "fixed" in the sense that at any given time it rarely pays to sell them, because "salvage value" or sales price is usually much lower than the normal value in use (9), (10), (11). This implies that a firm cannot be reorganized anew each year. The pattern of stocks held determines future operations in a certain way. A fixed asset once acquired (bought or produced) affects the choice of production method in future years, until it is either worn out or its use value no longer exceeds its sales value.

The particular restrictions imposed by the nature of the fixed

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[1]This makes the Loftsgard-Heady model formally analogous to the Ramsey model (69), (16, p. 267 ff.).

assets held by the firm can be incorporated into a linear programming model only if stock transfer activities are included for various types of assets.

Livestock enterprises, like many other biological systems, produce goods which may either be sold immediately, or retained as stocks for reproducing themselves in the future. The annual choice between stock and sales production can be made in such a way that the highest possible capital growth is sustained over time (16, p. 331), subject to the operator's given consumption preferences fixed in time (16, p. 331), (68).

If prices remain constant, the annual plan would approach an invariant pattern which insures steady, maximum "balanced" growth (16, p. 329). If, however, prices or physical productivities are subject to exogenous changes, the annual plans would be expected to vary for two reasons: (a) the annual growth rates differ, and (b) stocks of exhaustible resources, especially capital, may become so depleted over a series of low-income years that the stocks transmitted will not permit the ideal optimum organization.[2]

1. Price Changes Follow a Cyclical Pattern

Budgets and plans presuppose certain price expectations. The usual approach is to fit long-run plans to time-constant expected prices. Yet figures 2 and 21 show that the price of beef does not vary randomly. There is a definite cyclical pattern in the movement of prices. The pattern varies with respect to both amplitude and length of period. Successive

[2]The latter is an asymmetric effect, active only in low-income years.

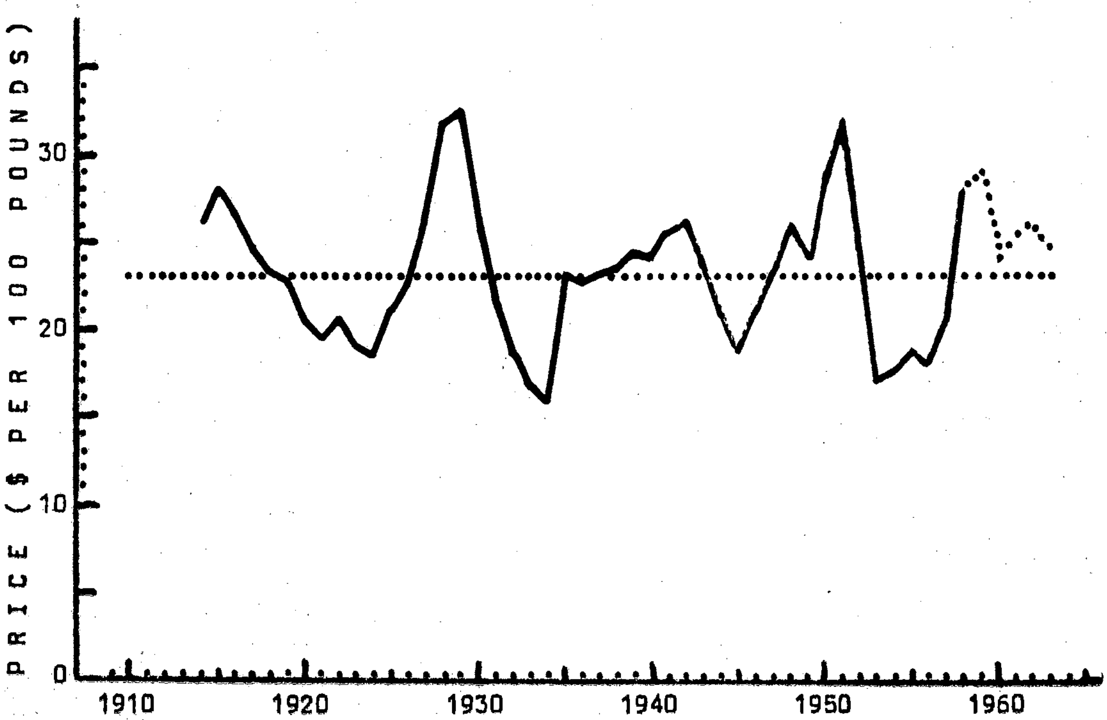

Fig. 21. Prices Received by Oklahoma Farmers for Calves, 1909-63; Deviation from 10-year moving average price, normalized to 1957-59 level (=$23.38). For source of data see appendix E, table VI.

peaks occurred 14, 13, 9, 8 years apart, successive troughs 13, 11, 10, 9,and 11 years apart. Still the basic pattern is of the nature of a sinusoidal curve, which has a downward beat a little steeper than the upswing.

2. Long-Run Plans as Part of a "Dynamic Management" Routine

A.G. Hart (6), (7) stressed that a rigid plan of production covering several production periods is inherently less profitable than a flexible plan. Usually it is possible to limit the number of initial, irrevocable decisions to the commitment of resources needed in the first period (72).

Later, when the time for the commitment of resources for the next production period arrives, one will proceed either according to the original plan, if it is learned that original expectations are becoming realized. If, however, it is learned in the meantime that the original expectations, upon which the first plan was based, will not come true, the manager is free to change his plan for the second production period. Within the limits set by the original commitments, he may still adjust volume of production, direction of production,and intensity of input to the modified expectations. It is clear that he would never willingly change the plan to make the outcome worse than he would have obtained from the original plan. Thus flexibility of plans as defined by Hart can result only in upward adjustments of expected outcomes.[3]

[3]The premise being that later information ipso facto will be both more certain and more accurate, because more information is available to arrive at an estimate. All modern probabilistic approaches to management (73) rest on this assumption.

According to Hart, management thus starts with some initial master plan which covers several periods of production. Yet only those resources needed in the first period of production are committed immediately. Periodically, before the inputs for the next period have to be committed, the plan is reviewed and, if the expectations of price and productivity parameters have changed, the plan is changed accordingly. Such a systematic approach to management deserves to be called "dynamic management."

It should be possible to incorporate such an approach into the scientific management of cattle ranches. The results certainly should be better than an approach based on one price only, the average. Because the average is the expected value of prices expected at certain points in time compounded over a period of time, it is twice removed from reality, and so is a plan based on average prices. Dynamic management would bring planning procedures one step closer to reality. It is difficult to predict in advance the increase in profits obtainable by a dynamic management procedure, because such estimates would be contingent upon certain assumptions of the accuracy of the forecasts on which plans are founded.

3. Specifications of the Model

In a plan which explicitly covers a period of several years, the management problem becomes somewhat different from the one-year plan. The question of the right mix of cows, replacement stock, and stockers arises anew each year. In addition there is the question of the optimum culling and replacement rate in relation to price level and productivity.

a. Activities

The assumed choices are: stocker cows, replacement heifers, wintering summer grazing calves for sale as long yearlings in the fall, raising heifer calves, or selling either heifer or steer calves as weanlings. The last activity would be a capital transfer activity, which serves three purposes: (a) it transfers liquid capital not needed in one year to the next; (b) it serves as part of a consumption or profit-taking function; and (c) it is a savings function.

This activity is essentially Swanson's "income transfer activity" (65) retaining a few characteristics of its own. Eighty per cent of the net receipts of a given year may be transferred to the capital constraint of the next year. The remaining 20 per cent is part of a postulated consumption or profit-taking function:

(6.1) $$H_i = 7000 - F_i + 0.2\ S_{i-1}$$

The variables in (6.1) are defined as follows:

H_i = total household consumption

F_i = fixed costs

S_{i-1} = surplus liquid capital in preceeding year.

The $7000 constraint and the transfer activity act as an additional "requirement on the time shape of the income stream" (65, p. 1255). As a savings or outside investment activity, this vector determines an opportunity cost for capital. The rate chosen (10 per cent) exceeds the market rate of interest,and reflects the uncertainty of expected outcomes, or acts as an insurance premium on capital. In either case it is viewed as a genuine cost. The rate of return in this activity sets a floor for all "own-rates" of return (16, p. 318) in all other activities. The interest rate of the transfer activity serves the purpose which ordinarily is achieved by discounting.

b. Criterion Function

Rather than maximizing the sum of discounted net revenues of all basis processes here the simple sum of the net revenues of the basis processes is maximized, subject to the restriction imposed by the transfer activity (see above). Since we assume fixed periods of investment (74, p. 875), either approach assures that the income stream is maximized. If capital is scarce, activities with high rates of return on capital will be chosen so as to maximize the rate of return on capital. Even with an abundance of capital no activity will be chosen which returns less than the opportunity rate of return on capital.

To estimate total returns from ranching alone, earnings from the transfer activity are deducted from the cumulative total contributions to profit and overhead over all years.

c. Constraints

In the dynamic model external and internal constraints are distinguished. Typical external constraints are the acreage allowed and the minimum fixed cost constraint. Examples of internal constraints are the number of cows, heifers etc. available in any one year. In generalized form the model employed here has the form:

$$(6.2) \quad C_1X_1 + C_2X_2 + C_3X_3 + \dots + C_{t-1}X_{t-1} + C_tX_t = C_{max}$$

subject to constraints

$$
\begin{array}{lrcl}
(6.3) & A_{1e1}X_1 & \leq & B_{1e} \\
& A_{2e2}X_2 & \leq & B_{2e} \\
& (-)A_{2i1}X_1 + A_{2i2}X_2 & \leq & B_{2i} \\
& A_{3e3}X_3 & \leq & B_{3e} \\
& (-)A_{3i2}X_2 + A_{3i3}X_3 & \leq & B_{3i} \\
& \vdots \quad \dots & & \vdots \\
& A_{tet}X_t & \leq & A_{tet} \\
& (-)A_{t,i,t-1}X_{t-1} + A_{tit}X_t & \leq & B_{ti}
\end{array}
$$

$$(6.4) \quad B_e,\ B_i,\ X = 0$$

The capital letters represent submatrices or subvectors for the years 1...t. A process vector may consist of three kinds of input-output elements: (1) subscript e represents external constraints and the associated requirements; subscript i refers to either (2) stock outputs of a given year (with - sign), or (3) stock inputs in the succeeding year. Types (2) and (3) form the time-related structure of capital stocks which is subject to modification in conformity with given intertemporal price and cost relations. The matrix is of the much discussed block-triangular form and can be solved advantageously by a special algorithm and computer program (75), (76), (77). The actual input output matrix for a typical year is given in table XXII. This model permits a series of choices as indicated in figure 22.

The model (table XXII) specifies the same weaning rates (a_{33}, a_{43}, a_{34}, a_{44}), death losses, minimum culling rates (a_{52}, a_{63}, a_{64}), costs

TABLE XXII

INTERTEMPORAL RANCH MODEL; OBJECTIVE FUNCTION AND CONSTRAINTS
OF THE BLOCK SUBMATRIX OF YEAR k,
PRICE LEVEL = 100

Constraint No.	Description	Unit	Process k1[a] winter + graze steers	k2 raise heifer calves	k3 raise coming heifers	k4 cow herd	k5 sell steer calves	k6 sell heifer calves	k7 sell heifers	k8 sell cows	k9 capital transfer		Constant kb
C	Objective		-182.84	-4.95	-24.41	0.88	120.05	101.25	155.88	140.00	0.10	=	max
C_o[b]	(Livestock value)			(-101.25)	(-155.88)	(-140.00)							
k-1, 3	steer calves	head	1									=	0
k-1, 4	heifer calves	head		1								=	20[c]
k-1, 5	yrlg. heifers	head			1							=	19[c]
k-1, 6	mature cows	head				1						=	120[c]
k, 1	op. capital	$	29.54	10.33	32.25	15.92					1	=	2750[c]
k, 2	rangeland	acres	2.67	4.75	8.36	8.36						=	1250
k, 3	steer calves	head			-0.304	-0.44	1					=	0
k, 4	heifer calves	head			-0311	-0.44		1				=	0
k, 5	yrlg. heifers	head		-0.95					1			=	0
k, 6	mature cows	head			-0.90	-0.86				1		=	0
k+1, 1	op. capital	$	-182.84	-5.38	-7.84	-16.80	-120.05	-101.25	-155.88	-140.00	-0.8	=	-7000

[a]process (1) omitted in first year block; [b]cost of initial livestock investment C_o added to first year coefficients C;
[c]initial endowment.

and prices as the preceeding models. While the objective function shows the net contribution to profit and overhead, the inequalities (K,1) represent gross cash outlay and gross cash receipts for each process.[4]

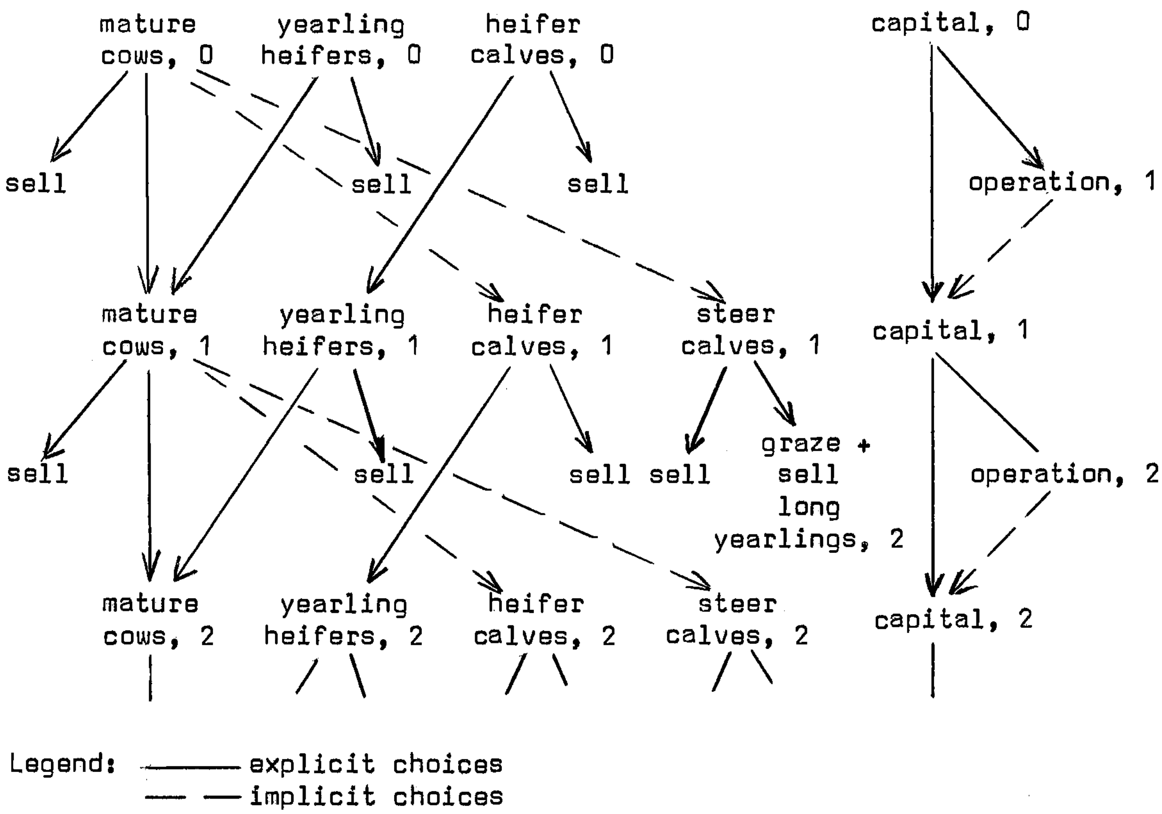

Figure 22. Decisions Incorporated into the Intertemporal Ranch Model.

[4]For convenience it is assumed that all production expenditures occur at the beginning of the production period - October 1, and all income is received one year later. Sales and shipping expense is subtracted directly from sales receipts.

d. The Planning Horizon

Ideally a growth plan for the firm should consider at least a full period of the cattle cycle. Practical limitations permitted inclusion of only five years in the program. To simulate the full cycle, these five years were started at successive years of the cycle, thus tracing various patterns of price developments which might be expected (figure 23).

Two end or terminal conditions were established. The first (versions A and C) required that the current value of the initial livestock set be available, but set no conditions on the number of livestock at the end of the period. In the other two versions (B, D) it was specified that the initial herd (cows, heifers, heifer calves) must be restored <u>in kind</u> at the end of the last period. As expected, this constraint added rigidity to the model and tended to depress operating profits.

e. Price and Cost Levels

Figure 23 illustrates the hypothetical eight year cycle of beef prices assumed. Because only five years may be considered at any one time, five-year models were computed beginning in each of the eight years of a full cycle. These were then compared to a growth model with constant prices.

Beef sales prices and values are varied up to 30 per cent from the average, strictly in proportion with the Index of Beef prices (figure 23) in versions A and B (appendix F, table I). In C and D in addition to prices, range capacity, marketing weights and certain costs (appendix F, table II) are varied inversely with beef prices. This, in effect, simulates low prices in periods of drought (appendix F, table III). The range capacity was varied up to 15 per cent from the average. Clearly a change in the beef price level will change the marginal revenue of all processes. In table XXIII the relative change of the marginal revenue of activity is presented. Changes in costs and productivities will aggravate the effect. Higher prices thus may lead to expansion, while low prices may force a contraction of the "normal" activity level.

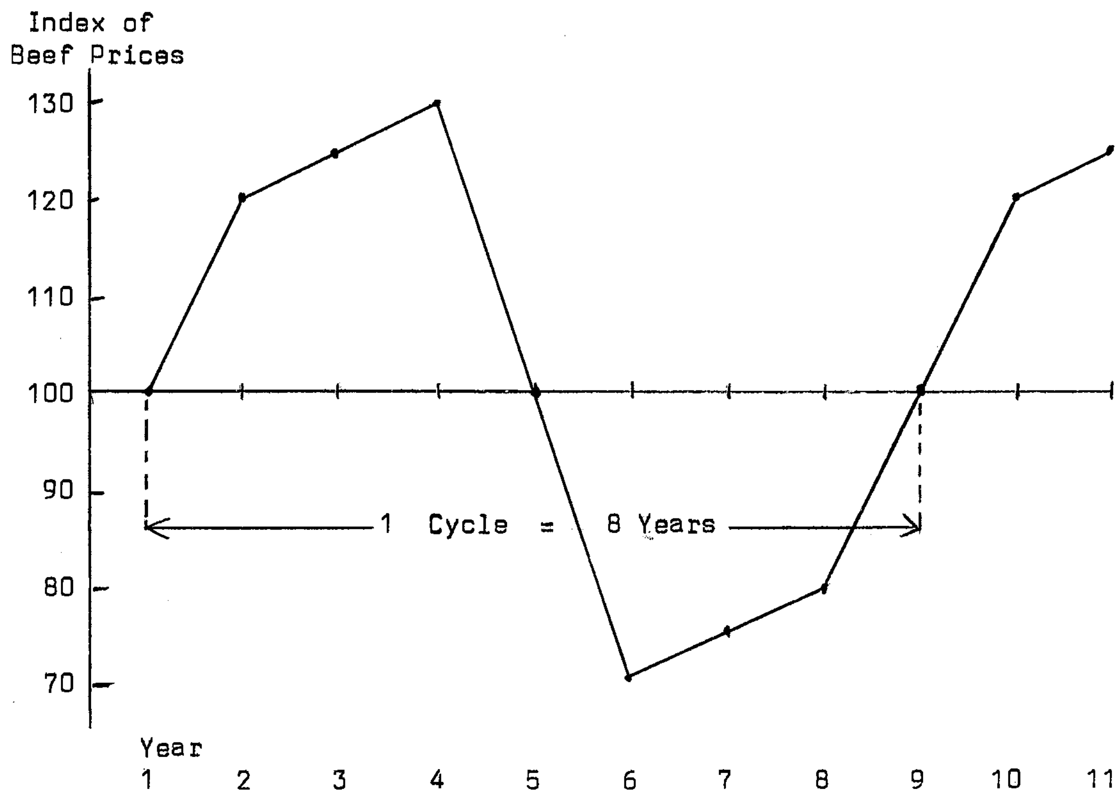

Fig. 23. The Hypothetical Beef Price Cycle of the Intertemporal Ranch Model.

Proportionate price changes affect marginal revenue processes differently because of differences in input-output structure (table XXIV). This changes the marginal substitution rates which in turn may demand changes in the organization of the firm.

TABLE XXIII

INTERTEMPORAL RANCH MODEL; RELATIVE CHANGES IN CONTRIBUTION TO PROFIT AND OVERHEAD, SALE OF STEER CALVES (PROCESS k5) WITH ASSUMED CHANGES IN BEEF PRICE, COST AND PRODUCTIVITY

Index Number of Beef Prices	Relative Change in C_{k5}: Only Price Varies A, B	Relative Change in C_{k5}: Price, Cost, and Productivity Changes C, D
70	69.4 %	65.0 %
75	74.5	70.6
80	79.6	76.3
100	100	100
120	120.2	125.2
125	125.4	131.8
130	130.6	138.4

B. Results

1. Price Changes Only

a. Activity Levels and Contributions

(i) "Normal" run. This is a plan for a period of five years with constant "normal" prices. Total contribution for the period (the objective to be maximized) could be considered a function of the expected long-run price:

$$(6.5) \quad C = f\,[e(p)]$$

TABLE XXIV

INTERTEMPORAL RANCH MODEL; RELATIVE CONTRIBUTION TO PROFIT AND OVERHEAD, WITH ASSUMED CHANGES IN BEEF PRICE LEVEL. (C_{k5} = 100)

Beef Price Index	Production Process k1 steers	k2 heifer calves	k3 heifers	k4 cows	Sales Process k5 steer calves	k6 heifer calves	k7 heifers	k8 calves
	Price Change Only (Variants A, C)							
70	116.8	-7.9	-32.2	-5.2	100	84.3	129.8	115.8
75	119.3	-7.1	-29.6	-3.9	100	84.3	129.8	116.0
80	121.2	-6.3	-27.2	-2.7	100	84.4	129.9	116.2
100	127.8	-4.1	-20.4	0.7	100	84.4	129.9	116.6
120	131.9	-2.8	-15.8	3.0	100	84.4	129.9	117.0
125	132.9	-2.4	-14.9	3.5	100	84.5	130.0	117.1
130	133.3	-2.1	-14.0	3.9	100	84.5	130.0	117.2
	Change of Price, Costs, and Productivity (Variants B, D)							
70	95.0	-22.6	-53.8	-26.9	100	84.3	129.7	115.7
75	102.5	-18.2	-45.8	-20.2	100	83.3	129.8	116.0
80	108.8	-14.4	-39.2	-14.6	100	83.3	129.9	116.2
100	127.8	-4.1	-20.4	0.7	100	84.4	129.9	116.6
120	133.0	-2.1	-14.9	3.5	100	84.4	129.9	117.0
125	133.6	-1.7	-13.7	4.1	100	84.5	130.0	117.1
130	134.1	-1.4	-12.7	4.6	100	84.5	130.0	117.2

$$V_{kj} = 100 \frac{C_{kj}}{C_{k5}}$$

The long run "normal" optimum plan for the model ranch seems to be a combination of about 100-130 cows (including heifers with calf), the necessary complement of heifer calves, steers wintered, grazed and sold as long yearlings, and heifer calves partly sold at weaning, partially retained to utilize range capacity (table XXV, col. 9).[5]

(ii) "Variable price" runs. Eight five-year runs, each beginning at a different station of the eight-year price cycle, are summarized in table XXV by the year in the cycle, in table XXVI by the price level of the year. The average of these eight runs is the expected returns as a function of prices expected in the short run:

(6.6) $e(C) = F[e(P_k)]$

The expected net contribution from ranching activities (the contribution of the "outside" activity k9 has been deducted here and in the following tables), an average of the eight runs covering the full price cycle, exceeds the corresponding value from the "normal" price run by less than one per cent. However, greater capital carryover provides additional interest earnings. On balance the mean of the variable price runs showed more steer calves sold at weaning time (process k5), and there seems to be a greater amount of capital put on reserve (k9).

More conspicuous are the changes which occur in individual years. Obviously sales are shifted from low-price to high-price years, whenever possible, subject to the need to maintain a breeding herd and the financing constraints. In no case are the conditions severe enough to

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[5]The replacement processes of this model do not seem to be stable. The number of heifers-with-calf varied from none to 43 per year in a 10-year model which had been tentatively calculated.

TABLE XXV

INTERTEMPORAL RANCH MODEL, AVERAGE CONTRIBUTION[a]
AND ACTIVITY LEVELS – PRICE CHANGES ONLY;
BY YEAR OF RUN

Process No. (1)	Description (2)	Variant (3)	Cyclical Price Variations: Year of Run 1 (4)	2 (5)	3 (6)	4 (7)	5 (8)	Average of years (9)	"normal" price (10)
	Contribution to Profit and Overhead [$]								
		A	9,200				10,230	11,430	11,320
		B	9,230	11,500	11,660	11,880	10,400	10,930	10,830
	Production Processes [head]								
1	steers (yrlg.)	A	b	21	26	31	36	29	39
		B	b	21	26	27	7	20	35
2	heifers (yrlg.)	A	20	28	29	35	36	30	27
		B	20	36	40	47	20	31	34
3	heifers w. calf	A	18	4	12	5	0	8	10
		B	18	3	9	14	38	15	16
4	cows	A	120	120	106	103	83	106	111
		B	120	120	105	97	96	108	105
	Sales Process [head]								
5	steer calves	A	37	28	20	10	31	25	13
		B	37	27	23	39	54	36	23
6	heifer calves[c]	A	30	25	16	10	37	24	29
		B	28	14	6	27	34	22	18
7	heifers[c]	A	15	14	22	33	34	24	19
		B	16	19	24	3	0	13	16
8	cows[c]	A	0	0	0	10	72	16	18
		B	0	0	0	0	0	0	0
9	capital surplus [$]	A	50	2,000	6,170	10,060	15,590	6,770	3,850
		B	40	2,050	5,790	8,650	11,910	5,690	4,780

[a]Objective to be maximized..

[b]none permitted.

[c]In addition to minimum culls of 3.5 per 100 heifers, 7 per 100 first year cows, 12 per 100 mature cows.

Details see appendix F, table IV.

A: Value of breeding herd to be abailable after 5 years.

B: Same number breeding animals to be retained after year 5 which was used in year 1.

TABLE XXVI

INTERTEMPORAL RANCH MODEL; AVERAGE CONTRIBUTION[a] AND ACTIVITY LEVELS, PRICE CHANGES ONLY; BY PRICE LEVEL.

Process No.	Description	Variant	Price Level							
			100	120	125	130	100	70	75	80
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
		Contribution to profit and overhead [$]								
		A	9,410	13,960	15,320	24,270	13,970	-1,600	8,670	7,420
		B	9,440	11,940	15,950	19,190	12,180	3,520	7,360	7,630
		Production Processes [head]								
1	steers (yrlg.)	A	20	51	55	54	0	0	29	20
		B	10	32	51	42	0	0	18	8
2	heifers (yrlg.)	A	34	22	27	39	34	4	42	35
		B	30	24	25	33	38	24	37	39
3	heifers w. calf	A	15	12	9	5	4	11	5	19
		B	22	11	8	12	21	12	17	19
4	cows	A	113	114	113	110	104	86	106	105
		B	112	111	111	108	104	108	104	106
		Sales Process [head]								
5	steer calves	A	12	9	9	50	47	18	31	35
		B	29	11	18	51	52	37	45	44
6	heifer calves	A	35	30	17	19	47	2	17	21
		B	36	29	19	13	28	14	13	23
7	heifers[b]	A	26	7	26	37	27	4	29	25
		B	10	10	12	10	24	4	17	15
8	cows[b]		minimum culling only							
		Capital Transfer [$]								
9	capital surplus	A	0	0	3,600	7,100	19,700	19,300	3,300	1,250
		B	610	850	3,300	8,180	15,050	13,050	3,220	1,260

[a]Objective to be maximized.

[b]In addition to minimum, cull of 3.5 per 100 heifers, 7 per 100 first year cows, 12 per 100 mature cows.

Details see appendix F, table IV.
A: Value of breeding herd to be available after 5 years.
B: Same number breeding animals to be retained after year 5 which was used in year 1.

force an accelerated culling of the breeding herd. Changes in herd size are controlled by the number of replacements. Wintering and grazing of young steers and heifers (k1, k2) is indicated prior to high-price years. The practice is entirely absent or reduced in low price years. The opposite holds true for the sale of weaned calves (k5, k6). There is a significantly low carryover of excess capital preceeding the high-price period, while capital carryover is highest at the beginning of a price decline. In this model the annual contribution to profit and overhead varies much more than would be indicated by the relations of tables XXIII, XXIV, due to the various substitutions that take place.

The requirement that the breeding herd be restored in kind at the end of the planning period (variant B) slightly depresses returns.

b. Idle Resources

In run 2A it appeared to be advantageous to sell off all cattle at the end of the next to last year of the sequence, in order to avoid losses in the last, low-price year (appendix F, table IV). Thus range is not utilized at all in this last year. In runs 1A and 3A as much as 40 per cent of all range are idled, up to 15 per cent in run 4A and 5A. Smaller acreages are idled in the B-runs, too, though there the requirement to retain the original number of breeding stock at the end prevents, of course, that the whole herd may be sold off prematurely.

The sellout solution of run 2A is, of course, the result of a short planning horizon and the particular price configuration. If additional years were included in the model, the herd would undoubtedly be carried over a low-price year. Under special conditions premature sellout may

TABLE XXVII

INTERTEMPORAL RANCH MODEL; SUMMARY OF RESULTS, NORMAL RUN, VARIABLE PRICE RUN AVERAGES.

Item	"Normal Run" Variant		Average of 8 "variable price" runs Variant	
	A	B	A	B
(1)	(2)	(3)	(4)	(5)
Contribution to Profit and Overhead, 5 years:	$ 80,187	$ 56,645	$ 82,004	$ 57,400
Less interest earned:	1,923	2,490	3,375	2,845
initial herd[a]	21,655		21,669	
Net Contribution, Ranch	56,609	54,155	56,960	54,555
per year	11,320	10,830	11,390	10,930
Consumption and fixed costs	7,769	7,996	13,774	12,790
Operating capital accumulated, after 5 years[b]	20,512	16,926	17,481	16,277

[a]Initial livestock endowment utilized, valued at prices of the last year. This makes the net contribution comparable in variants A and B.

[b]After paying off the initial investment in breeding stock, and allowing for fixed expenses and consumption in each year.

indeed be indicated, namely when an operation is to be closed out anyway, or if they could be replaced with certainty without incurring high replacement costs. This sellout certainly demonstrates that the operation does not pay by itself in a year with a 70 per cent price level. It is justified economically only because carrying over may make future earnings possible.

c. Shadow Prices

The marginal revenue of resources in a time-spanning model equals the actual returns in a given year times a compounding factor (74, p. 876), calculated for any time of reference. The reference period may be the beginning, the end, or any other convenient point in time (70). In this model the end of the period is the reference time.

Because interest was not transmitted along with the principal, instead of compound interest we have a <u>cumulative</u> rate of interest over time. To determine the gain from an amount A saved over t years, with the interest i withdrawn annually, the annual interest payments are simply added to the principal:

$$(6.7) \quad A_t = A(1 + i_1 + i_2 + \ldots + i_t)$$

Since moreover some of the savings capital is supposed to be spent annually, we have to modify this formula by an attrition factor, h, to allow for this drain:

$$(6.8) \quad RC_t = \quad (i_1 + hi_2 + h^2 i_3 + \ldots h^{t-1} i_t)$$

In the model, $i = 0.10$ and $h = 0.80$. Hence our minimum cumulative marginal rates of return to capital RC are

33.6 % in year 1

29.5 % in year 2

24.4 % in year 3

18.0 % in year 4 and

10.0 % in year 5.

If the "own rate" of returns exceeds the minimum interest rate in any one year because of scarcity of operating capital, the difference will be added to the minimum cumulative interest rate of that year, and to earlier years according to (6.8).

The marginal revenues which are transferred to future production periods also include the cumulative marginal contributions to income obtained from future processes utilizing the particular stock. This applies to cows, heifers, and calves. On the other hand, the marginal revenues of resources which are not transferable cannot contain any imputed future earnings. Their shadow prices are, therefore, strictly the marginal revenues of a given year. The use of range is a one-period resource in the model. The shadow price of range in tables XXIX and XXX is thus strictly a rental rate, immediately comparable to land shadow prices in a static model. The same applies to terminal activities like k1 and selling activities k5 to k8.

Because the shadow price of the capital transfer activity measures the difference between the minimum rate of return on capital and the "own" rate, i.e. the additional cost of withdrawing operating capital in one year, it directly indicates the lack of capital, and the opportunity cost of capital. Table XXVIII lists this quantity rather than the total cumulative rate of interest of capital. The latter may be estimated by adding the opportunity costs of capital transfer to the cumulative minimum rate

TABLE XXVIII

INTERTEMPORAL RANCH MODEL; SHADOW PRICES CAPITAL TRANSFER ACTIVITY; BEEF PRICES VARY. BY YEAR OF RUN.
[PER CENT]

Run No.	Price Level Initial	Price Level Average	Year of Run 1	2	3	4	5
1A	100	115	0	27.9	0	0	0
B			0	31.3	0	0	0
2-4A	120 - 130		0	none	0	0	0
B			0	0	0	0	0
5A	100	85	0	0	11.2	8.7	25.3
B			0	0	9.2	2.7	0
6A	70	89	0	12.4	78.9	37.5	23.7
B			0	97.3	58.5	28.9	0
7A	75	100	0	20.6	38.5	17.6	0
B					n.a.		
8A	80	111	0	36.9	8.1	0	0
B			0	36.0	6.3		
"Normal Run" A		100	0	8.8	0	0	0
B			0	8.8	0	0	0
For comparison, cumulative rate of interest			33.6	29.5	24.4	18.0	10.0

TABLE XXIX

INTERTEMPORAL RANCH MODEL;
SHADOW PRICES, RANGELAND.
BEEF PRICES VARY.
BY PRICE LEVEL
[dollar/acre/year]

Run No.	Price Level Initial	Price Level Average	Price Levels 100	120	125	130	100	70	75	80
1A	100	115	42.60	12.76	13.23	5.46	0	0	0	0
B			24.36	10.86	13.23	10.38	0	0	0	0
2A	120	119	0	44.35	14.40	7.84	0	0	0	0
B			0	28.84	14.40	12.41	0	0	0	0
3A	125	100	0	0	42.96	15.05	0	0	0	0
B			0	0	29.74	0	0.14	0	5.39	0
4A	130	89	0	0	0	44.17	1.30	0	5.81	0
B			0	0	0	29.49	1.30	0	4.18	5.85
5A	100	85	0	0	0	0	40.90	0	7.83	8.26
B			16.94	0	0	0	12.15	0	4.16	6.13
6A	70	89	9.81	0	0	0	0	61.09	0	0
B			6.51	20.85	0	0	0	23.60	0	0
7A	75	100	9.95	10.95	3.02	0	0	0	37.03	10.81
B			0	n.a.	0	0	0	0	0	0
8A	80	111	9.72	15.42	11.77	3.24	0	0	0	36.65
B			9.59	15.22	10.65	15.23	0	0	0	7.22
Average A			6.54	9.78	10.60	7.90	0.32	0	3.41	4.77
B			11.01	15.64	12.76	9.50	0.36	0	3.43	3.99

(last line in table XXVIII) in the given year, and, adjusted by the attrition factor, in all preceeding years. For example, in year five, run 5A, the full value of operating capital is 10 + 25.3 = 35.3. In the preceeding year the cumulative rate equals 18 + 8.7 + (0.8) (25.3) = 46.9. In year three it is 24.4 + 11.2 + 0.8(8.7 + (0.8) (25.3)) = 58.7. In year two and one the available capital is sufficient to make full use of the given stock. Yet the opportunity cost of capital in succeeding years is carried back:

$$I_2 = 29.5 + 0.8^2 \, (8.7 + (0.8)\,(25.3)) = 57.0, \text{ and}$$

$$I_1 = 33.6 + 0.8^3 \, (8.7 + (0.8)\,(25.3)) = 55.6.$$

Table XXVIII shows that even in the normal run some additional capital could be profitably employed in year two. Thereafter the ranch itself generates enough income to provide both sufficient income and finance the operations adequately.

The same is true in run 1, which combines years with price levels 100-120-125-130-100. The opportunity cost of capital is higher here because more income is foregone in the high-price year. The next three runs, beginning with price levels of 120 and above, generate enough income in the first year to fully finance operations in all succeeding years.

Beginning with run 5 capital shortages become apparent. It is clear now that the flexible model did not show up better compared to the "normal run" model simply because in those runs which started with one or more low-price years not enough capital was generated to maintain optimum production levels in succeeding years. If we had allowed a borrowing activity the flexible plan would have shown up more advantageously. It is clear from this table that it would have paid to borrow operating capital at rather high rates of interest. The amounts required would have been small compared to the value of the livestock. Still it was possible under the assumptions of variant A and B to build up the capital position over time even in the most critical runs 6, 7 and 8 which start with the lowest price levels.

A comparison of variants A and B reveals that generally in B the capital cost in the early years was higher than in A, lower in the later years. This plainly reflects the imposed requirement that a certain number of breeding stock be retained in the last year, thus reducing the need for operating capital. In the more flexible model A the herd was generally built up to a maximum value in the last year by carrying young stock as long as possible, thus increasing the capital requirements per dollar earned.

Table XXIX presents the shadow prices of rangeland, ordered by beef price level. The table gives some indication of the short-run variations in derived demand for range relative to changes in the price of beef. It is also possible to estimate the minimum justifyable purchase prices from the land shadow prices obtained, as was done in chapter IV.

In table XXX the shadow prices of rangeland were averaged by year of run, and compared to the value of the "normal run." The average of the middle years, which are more representative of a continuing operation, is depressed from the "normal run" level. Shadow prices of variant B tended to increase as time went on compared to variant A, again reflecting the forced increase of breeding stock requiring more grazing per dollar earned than young stock.[6]

For the sake of brevity other shadow prices had to be omitted.

TABLE XXX

INTERTEMPORAL RANCH MODEL; SHADOW PRICES OF RANGELAND, BEEF PRICES VARIE; AVERAGE OF RUNS OVER A PRICE CYCLE VERSUS "NORMAL RUN" DATA
[dollars per acre]

		Year of Run					Average
		1	2	3	4	5	
"Normal run"	A	36.53	7.70	9.08	7.82	0.57	12.34
	B	17.90	7.70	8.53	7.04	6.85	11.60
Average of variable price runs	A[a]	43.72	8.00	6.78	6.51	0.78	13.16
	B[b]	22.20	5.16	6.45	5.41	13.47	10.54

[a]Average of 8 runs

[b]Average of 7 runs

2. Beef Prices and Costs Varied

By varying costs, feed requirement and range capacities synchronously with the beef price, the model simulates the double pinch the rancher feels when a price change occurs as a result of widespread drouth. In general the results are comparable to those of the preceeding section. Clearly the extra pinch has somewhat the effect of an increase in price variation alone.

[6]The first year shadow price is generally quite high, due to the technicality that slightly more heifers were allowed in the first year than could be accomodated with the given acreage (see appendix F, table IV, section k3).

In this model, as in the previous one, the main differences between runs are caused by the capital constraints. In almost all runs capital hampers the full realization of the potential of other resources. In a number of runs either more initial capital or a relaxation of the terminal capital constraint had to be allowed to arrive at a feasible solution. Since only the absolute minimum was allowed, a number of the runs simulate progressive exhaustion and sellout of the capital stock (see appendix F, table IV) of a ranch, leading to lower and lower cow numbers, thus lower and lower earning capacity as well.

The general value of this sequence of runs is impaired by the shortness of the planning period.

a. Activity Levels and Contribution

The expected value of both run C and D (table XXXI, col 8) is 20 - 22 per cent lower than in the previous series (table XXV). This is the combined effect of the nonhomogeneous cost increase parallel with low prices (emergency feed) and lack of capital at critical periods. The latter could be remedied if capital could be borrowed (in reality this would be the course to take).

In variant C, which does not require that the breeding herd be restored in kind at the end of the period, it proves to be more profitable to sell off the entire herd in the last high-price year. This would permit repurchase of a cow herd before prices fully recover (see appendix F, table IV). This sell-off occurs in the first three runs, which begin with high-price years and end with low-price years. This explains in part the low values in table XXXI, col. 6 and 7 (variant C). In the remaining years, which start with a lower price, operating capital restricts expansion

TABLE XXXI

INTERTEMPORAL RANCH MODEL; AVERAGE CONTRIBUTION AND ACTIVITY LEVELS - PRICE AND COST CHANGES. BY YEAR OF RUN.

Process No. (1)	Description (2)	Variant (3)	Year of Run 1 (4)	2 (5)	3 (6)	4 (7)	5 (8)	Average all years (9)
			Contribution to profit and overhead [$]					
		C	9,980	11,730	11,960	9,230	1,080	8,800
		D	8,650	13,310	11,200	4,140	6,310	8,720
			Production Processes [head]					
1	steers (yrlg.)	C	0	9	15	13	10	13
		D	0	8	20	16	0	11
2	heifers (yrlg.)	C	14	20	21	24	16	19
		D	20	40	34	43	17	31
3	heifers w. calf	C	12	5	2	3	0	4
		D	16	10	7	2	34	14
4	cows	C	115	109	96	60	40	84
		D	108	107	101	93	82	98
			Sales Processes [head]					
5	steer calves	C	45	35	30	17	18	29
		D	44	36	31	42	46	39
6	heifer calves	C	42	29	20	11	18	24
		D	13	26	11	27	30	22
7	heifers	C	9	17	17	22	15	16
		D	6	31	21	10	6	15
8	cows	C	1	1	25	14	34	15
		D	0	0	0	0	0	0
9	capital surplus [$]	C	200	2,890	7,260	7,900	17,970	7,240
		D	120	2,160	8,030	11,130	11,350	6,560
02	range unused	C	124	182	287	578	813	397
		D	171	90	183	182	168	159

C: Capital to restore initial herd size retained at end of run.
D: Initial herd to be restored in kind at end of run.
C and D are not strictly comparable because number of runs different.

in the latter years.

Particularly in variant C emphasis has shifted to the quick sale of young stock to the neglect of replacements. In variant D this effect is less apparent since the terminal constraint forces replacements back in for the benefit of future operations.

Looking at the results arrayed by price levels (table XXXII) it is clear that steer and heifer grazing (rows 1, 2, 7) is even more severely limited to high price years (unless lack of capital precludes this). In years with high prices the production of virtually two years will be concentrated. It would pay to build up the cow herd in a period of advancing prices, in order to sell it before a price break becomes apparent. Thus virtually all capital would be reinvested prior to the peak price years, and great liquid reserves would be held during the low-income years.

b. Idle Resources

Idled acreages are listed at the bottom of tables XXXI and XXXII. Idled acreages in variants D and even more so in C exceed those in A and B by wide margins. This is the direct and most disturbing result of lack of operating capital at critical periods. A secondary reason is limited carrying capacities during some periods.

3. Some Implications of the Dynamic Model

The five year plans were drawn up in order to determine what decisions can profitably be made from period to period given expectations about the prices and costs in the planning period. The plans for the first year are essentially predetermined by the given livestock complement

TABLE XXXII

INTERTEMPORAL RANCH MODEL: AVERAGE CONTRIBUTION AND ACTIVITY LEVELS, PRICE AND COST CHANGES BY PRICE LEVEL.

Process No. (1)	Description (2)	Variant (3)	Price Level 100 (4)	120 (5)	125 (6)	130 (7)	100 (8)	70 (9)	75 (10)	80 (11)
	Contribution to profit and overhead [$]									
		C	6,360	6,110	6,780	29,710	6,910	940	4,760	5,670
		D	7,800	8,390	10,400	28,950	19,730	1,260	4,180	5,100
	Production Processes [head]									
1	steers (yrlg.)	C	3	2	21	38	0	0	11	10
		D	0	3	15	37	0	0	11	0
2	heifers (yrlg.)	C	15	21	22	46	4	2	22	18
		D	24	31	24	47	24	17	30	34
3	heifers w. calf	C	4	8	15	4	4	0	0	1
		D	14	16	22	8	11	10	12	19
4	cows	C	85	84	90	111	69	69	78	87
		D	91	94	102	114	108	98	89	81
	Sales Processes [head]									
5	steer calves	C	37	22	7	50	31	21	26	36
		D	42	26	15	52	51	35	43	41
6	heifer calves	C	22	21	2	50	31	8	16	28
		D	14	20	4	27	42	21	17	13
7	heifers	C	10	8	21	33	15	11	19	10
		D	7	7	15	35	11	5	17	18
8	cows	C	16	13	4	54	18	0	1	15
		D	4	0	0	0	0	0	0	0
9	capital surplus	C	10	10	540	3,560	24,880	22,610	5,990	270
		D	20	60	670	3,010	20,530	15,790	3,960	0
02	range unused	C	436	504	379	160	626	477	313	279
		D	257	297	216	100	145	73	79	126

C: Capital to restore initial herd size.
D: Initial herd to be restored in kind at end of run.
C and D are not strictly comparable, because number of runs different.

and available capital. It is necessary to produce all that is possible, and sell enough to adequately finance the operations of the next year (including fixed costs and household living). If the outlook is bright for the next two to three years, the breeding herd will be kept large. Also, grazing animals will be retained to the extent that available capital permits. Thus the greatest possible sales volume will have been built up when the market is highest.[7]

Run 1, 2,and 3 begin at fairly high price levels. Therefore sufficient income is received in the first years to finance future plans involving high capital investments.

Run 6, 7, and 8 also start in a rising market. However, incomes in the early years are quite low. The full potential cannot be reached because of lack of capital in the early years. The herd is allowed to shrink and sales are accelerated whenever possible in order to obtain the necessary funds for the coming year. Such a pace could lead to eventual attrition of the entire herd (run 6C, 7C/D), or it may be impossible to maintain the minimum income postulated ($7000 less fixed costs). The assumption that operating capital must always be financed from current income or savings is restrictive for many situations. If we dropped this assumption, plans would have looked like the plans in runs 1 - 3; sales would have been delayed whenever possible, and the herd would have been built up in time to maximize sales in high price years.

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[7]Income tax was not considered in this model; one would have to assume that the operator will equalize his earnings over a period of years as permitted by the 1964 Income Tax Act.

TABLE XXXIII

INTERTEMPORAL RANCH MODEL; SHADOW PRICES, CAPITAL TRANSFER ACTIVITY, PRICES AND COSTS VARY.

Run No.	Price Level Initial	Price Level Average	Year of Run 1	2	3	4	5
1 C	100	115		46.2			
D				46.6			
2 C	120	119		25.6			
D				53.3	30.7		
3 C	125	100		39.0			
D				39.0			
4 C	130	89		0			
D							24.1
5 C	100	85				35.9	40.9
D[a]					9.4	10.1	23.5
6 C[b]	70	89		159	127	208	63.1
D				n.a.			
7 C	75	100		not feasible			
D[b]			4100	342	312	145	517
8 C	80	111	4048	276	143	47.2	25.5
D				n.a.			

[a]Stock constrained in 5th year to 0.875.

[b]Initial working capital increased to make program feasible.

How dows the rancher act if a fall in prices is imminent? Under the price regimens envisaged no accelerated cow culling occurs (runs 3, 4, 5). As far as the capital position allows, sales are accelerated. Whether sales in the low price years are deferred depends on the size of capital reserves accumulated in preceeding years. If sales must be made because the receipts are needed, calves rather than yearlings will be sold.

CHAPTER VII

SUMMARY AND IMPLICATIONS OF FINDINGS

Relevant ranch situations of South Central Oklahoma's "Hereford Heaven" were programmed for optimum operations successively in a static, short-run stochastic, and dynamic frame work.

The purpose of the static model was to investigate the effect of certain a priori decisions, such as the admission of livestock purchases or stocker cattle processes, of size and tenure, and the relative scarcity or cost of operating capital upon the outcome of operations and the best organization to follow. General findings of this part have already been reported in chapter IV.

In the stochastic frame work it was desired to determine the ranch organization which would produce the highest expected contribution to profit and overhead over a range of prices, expected in the near future. The results also indicated the year-to-year price or market risk involved in the alternative production processes.

In a price map the ranch organizations most desirable for given combinations of buying and selling prices were summarized. Stocker cattle operations would be advantageous if a rise in price is expected. With essentially constant price levels some combinations of calf production with stocker operations is most profitable. If prices are expected to fall, it would be best to raise calves and sell them at weaning time.

It was also verified that the price risk is considerably higher for stocker cattle operations than for cow-and-calf operations. Relatively small price changes may wipe out all stocker profits.

Taken over all possible initial price situations, a combination of cows and stocker cattle would have the highest expected returns, followed by a pure cow operation. Stocker operations have the lowest expected value.

Expected outcomes have also been estimated for various initial price levels. Stocker cattle have the highest expected value at very low initial price levels (because of the likelihood that prices will advance and give the operator the benefit of a positive price margin). At average and higher than average initial price levels mixed operations would be preferable, while at the highest initial prices it would be most advantageous to sell the calves at weaning.

The question of the best ranch organization was finally approached from the viewpoint of the dynamic economic organism moving forward over time. The method chosen permitted explicit consideration of the conditional fixity of long-lived resources such as breeding stock, and of patterns of expectations which approximate the cyclical price changes which have characterized the cattle market for generations.

The dynamic model shows (a) the explicit path of organizational growth and adaptation to market and cost situations, and (b) it identifies decisions which are "right" not only for the year for which commitments of resources take place, but also for the years to come.

It is rather difficult to generalize the results of dynamic models, partly because it is the very purpose of such estimates to be specific rather than general about the course to take, partly because rather specific assumptions have to be made as to the resources at hand and the prices expected in order to make the model plausible to the prospective user. The subordinate role of generalization is compensated for by the potential usefulness of the method explored in practical ranch management work. It is entirely possible that in the years to come management consultations will be based on dynamic plans tailored specifically for individual ranches, incorporating new expectations about the market into an annual review of the original master plan.

One rather obvious generalization is the need for adequate (capital or credit) reserves to carry the ranch over adverse periods. The reserves have to be several times the minimum needs for operating capital under constant price assumptions. Lack of reserves will seriously hamper the future earning potential and may even lead to an attrition of the other productive resources of the ranch.

If prices are expected to fluctuate, the problem of management becomes one of timing production and sales in such a way that total returns, suitably discounted, are maximized. The dynamic model shows that under certain conditions considerable shifts in production and sales are advisable. Sales should be concentrated in high price periods. Furthermore, high-price periods will attract high volume, low margin production processes such as stocker operations. Low price period, on the contrary, should be bridged by selling low volume, high margin products such as weanling calves. With uniformly high prices an equilibrium in the model ranch would incorporate a considerable number of stocker yearlings, and just enough cows, calves, and replacements to keep the ranges fully stocked at all times.

One purpose of the dynamic analyses was to learn more about optimum selection, culling and replacement policies. This objective was only partially achieved. A semblance of equilibrium between cows, heifers and heifer calves was reached only after the third year, when the terminal conditions of the model were already beginning to affect the enterprise choices. There was no evidence that negative selection (culling) beyond the minimum level specified in the model ever would be advantageous. Instead the level of positive selection (number of replacement heifers retained) was varied according to the conditions in any given year.

It is almost certain that operations based on long-run plans, but kept flexible until a decision has to be made, are more profitable than plans based on long-run expectations only, which require makeshift adjustments from time to time. No attempt to estimate the advantages accruing from dynamic versus static management has been made here.

The author feels that the present study raises a number of questions which it might be useful to consider. What is the economic replacement policy under conditions similar to those envisaged here? Careful herd records such as those of the Turner Ranch (78) and the Miles City Experiment Station (79), (80), (81) would provide the basic biological data.

The advantages of "dynamic management" over the static approach might be measured by simulating the returns of dynamic plans based on expectations (as published by the U.S.D.A. and the State Extension Service) and long-run static plans, and comparing the outcomes of the two alternatives, if the actual prices experienced (ex post) are used to determine the returns (82). Alternatively, Markow chain analysis could be used to determine the expected values of alternative management strategies (83),(84).

Dynamic ranch plans should be subjected to sensitivity analysis as was used to evaluate the models in chapter III and V.

There is an urgent need to develop methods of incorporating changing expectations into dynamic management plans in systematic, routine-type, and simple procedures which could be performed by statistical personnel and be used to adjust management recommendations to ranchers as fast as expectations change. Large ranch operations could do this on their own, private or public management services and associations might perform this service for their clients.

Richard Goodwin (85, p. 196) demonstrated that "if only a small part of the producers are cycle conscious," commodity cycles caused by lagged production response could be wiped out. On the contrary, if all producers acted so as to take advantage of a given cycle, the cycle would not disappear, but merely be shifted in phase and possibly in amplitude, too.

It may not only be sufficient, it may be necessary to recommend the use of dynamic beef herd management techniques based on expected future prices, not on experienced current ones, to just a minority of ranchers. While these may be the only ones who benefit directly from their superior management, the entire industry would benefit indirectly because cycles arising out of random variations of production and disappearance would be wiped out in a short while, thus bringing greater stability to the industry, adding to the very condition which favors stable, long-run, and easily administered plans, the kind most appropriate for the majority of operators.

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A P P E N D I C E S

APPENDIX A.

LONG-RUN PRICE TRENDS AFFECTING THE BEEF INDUSTRY

The trend parameters described here cover the period 1925 - 1962 (61, 86). Numbers in parentheses below the trend constants are estimated standard deviations.

1. Trend of the Ratio

$$\frac{\text{Price index, slaughter steers, all grades, Chicago}}{\text{Index of prices received by farmers, all farm products}}:$$

$$I_B = 100.87 + \underset{(\pm 0.142)}{0.738} \text{ (year - 1962)} \qquad t_b = 5.16$$

Average 1957-59 = 100. This regression function measures the relative change in the level of slaughter cattle prices compared to the price level of all farm products. If 1925 is chosen as the base period, the beef price in 1962 is 136 per cent of the general farm price level.

2. Trend of the Ratio

$$\frac{\text{Price, stocker and feeder steers, all weights and grades, Kansas City}}{\text{Price, slaughter steers, all grades, Chicago}}:$$

$$I_S = 89.12 + \underset{(\pm 0.088)}{0.471} \text{ (year - 1962)} \qquad t_b = 5.32$$

Prices in dollars per 100 pounds. The stocker and feeder steer price level in Kansas City in 1962 was 89 per cent of the price of slaughter steers in Chicago. The ratio of the stocker/feeder and slaughter steer prices narrowed down even though the <u>difference</u> of the prices, in absolute terms, increased during this period (see section 4, below).

3. Trend of the Ratio

$$\frac{\text{Price, feeder calves, good and choice, Kansas City}}{\text{Price, slaughter steers, all grades, Chicago}}:$$

$$I_C = 105.34 + \underset{(\pm 0.152)}{0.782} \text{ (year - 1962)} \qquad t_b = 5.16$$

Price in dollars per 100 pounds. The feeder calf price in Kansas City in 1962 was five per cent higher than the slaughter steer price in Chicago, and increased by .78 per cent of the slaughter steer price every year.

4. Trend of the Difference

Slaughter Steer Price, Chicago,

less Stocker and Feeder Steer Price, Kansas City:

$$D = 3.734 + \underset{(\pm 0.021)}{0.034} \text{ (year - 1962)} \qquad t_b = 1.58$$

In 1962 the price of slaughter steers in Chicago was $3.74 per 100 pounds higher than the price of stocker and feeder steers in Kansas City. The difference tends to increase slowly, even though the price ratio (see section 2) has narrowed down over the years. The trend constant (3.4 cents annual increase) was not significant at the five per cent level.

APPENDIX B, TABLE I

SEASONAL PRICES OF SALABLE LIVESTOCK AS USED IN THE BUDGETS[a]

Livestock Class, Grade	Annual Average	Price ($ Per Cwt.)						
		April	May		July	Aug.	Sept.	Oct.
		1	10	31	20	10	1	10
Steer Calves, Good and Choice up to 500 Lbs.	26.00			26.50	25.60			25.00
Heifer Calves, Good and Choice up to 500 Lbs.	24.00			24.50	23.60			23.00
Stocker and Feeder Cattle, Good, 500-799 Lbs.	22.75	26.25	24.25			22.25	21.95	
Slaughter or Feeder Cattle, Good, 800-1,100 Lbs.	22.75					22.25		
Slaughter Cows Utility	15.60			15.90	15.40			14.50

[a]Adapted from (47)

APPENDIX B, TABLE II

PRICES USED IN THE BUDGETS.

Item	Pricing Unit	Price
Cottonseed cake, 40% protein	ton	$76.00
Creep feed formula feed[a]	ton	50.60
Grain mix for bull[b]	ton	52.00
Alfalfa hay, good quality	ton	25.00[c]
Prairie hay or equivalent, good quality	ton	18.00[c]
Mineralized salt blocks	ton	60.00
Hauling and marketing livestock	cwt.	0.50
Rental Rates		
Grazing range	acre	2.50
General cropland (upland)	acre	6.00
Class I Cropland (bottomland or irrigated)	acre	1/3 of production
Credit costs per year		
For investment in livestock	dollar	variable
All other working capital	dollar	4% above interest on livestock capital
Hired labor	man-hour	$1.00

[a]5½ parts rolled milo, 3 parts oats, 2 parts cottonseed cake, ½ part molasses.

[b]1 part rolled milo; 1 part oats.

[c]Basic price changed in some models.

APPENDIX B, TABLE III

WEANING WEIGHT, ANIMALS SOLD, BEEF SOLD PER COW (LIVEWEIGHT) SALES VALUE PER HEAD AND AVERAGE SALES PRICE PER 100 POUNDS BEEF SOLD.

Act./ Budget Number	Weaning Weight Cwt.		Number of Animals Sold per Hundred Cows			Cwt. Beef Sold per Cow	Sales Value per Head			Sales Price per Cwt. Beef
							Calf			
	Steer	Heifer	Steers	Heifers	Total[a]		Steer	Heifer	Cow	
1.01/2	4.85	4.60	44	28	84	4.61	$121.25	$105.80	$143.12	21.72
1.03	5.20	4.95	44	28	84	4.86	130.00	113.85	143.12	21.86
1.04/5	4.90	4.50	40	28	80	4.40	125.44	106.20	152.00	22.31
1.06	5.60	5.20	40	28	80	4.88	143.36	122.72	152.00	22.53
1.07	5.00	4.60	40	28	80	4.47	128.00	108.56	152.00	22.34
1.08	4.60	4.30	40	28	80	4.23	121.90	105.35	156.93	22.95
1.09	4.90	4.50	20	14	40	4.51	125.44	106.20	152.00	21.99
1.10	4.85	4.60	22	14	42	4.51	121.25	105.80	143.12	21.99

[a]Includes 12 cull cows weighing 9.87 cwt. each.

APPENDIX B, TABLE IV

UNPRICED PHYSICAL REQUIREMENTS OF BUDGETED COW-CALF ACTIVITIES

Budget Number	Prairie Type Hay Tons/Cow	Alfalfa Hay Tons/Cow	Oats-Vetch Grazing A.U.M./Cow
1.1	0.030	-	-
1.2	-	0.436	-
1.3	0.030	-	-
1.4	0.030	-	-
1.5	-	0.590	-
1.6	0.030	-	-
1.7	0.880	-	-
1.8	0.290	-	4.48
1.9	0.028	-	-
1.10	-	0.507	-

Alfalfa hay may be used instead of prairie hay if prices permit, but not vice versa.

APPENDIX B, TABLE V

COSTS OF CROP ENTERPRISES, (PER ACRE)

Budget Number	Crop	Seed and Fertilizer	Machinery for Establishment	Custom Hire[a]	Total
3,1	Alfalfa hay	$4.12	$0.53	$25.80	$30.45
3,2	Prairie hay	-	-	9.92	9.92
3.3	Oat hay	2.20	2.22	12.44	16.86
3.4	Sudan hay	0.70	2.22	11.00	13.92
3.5	Oats-vetch grazing	10.05	1.84	-	11.89
3.6	Sudan grazing	0.70	2.22	-	2.92

[a]D.B. Jeffrey et al. (88)

APPENDIX B, TABLE VI

SEASONAL LABOR REQUIREMENTS FOR CROP ENTERPRISES
(MAN-HOURS PER ACRE)

Budget Number	Crop	Harvest Labor	All Other Labor				All Labor
			Oct-Dec.	Jan-Apr.	May-Sept.	Total	
3.1	Alfalfa	10.40	-	-	0.60	0.60	11.0
3.2	Prairie	3.50	-	-	-	-	3.50
3.3	Oats	7.61	-	0.37	1.91	2.28	9.89
3.4	Sudan	3.98	-	-	3.02	3.02	7.00
3.5	Oats-vetch grazing	-	-	0.37	1.98	2.28	2.28
3.6	Sudan grazing	-	-	1.03	1.63	2.70	2.70

APPENDIX B, TABLE VII

DISPOSITION OF THE OPERATOR'S WORK TIME

	Specific	Overhead
	Hours per Year	
(1) Total time allocated for work on ranch	2580	
	Specific	Overhead
(2) Overhead labor		780
(3) Work time available to perform duties associated with specific processes	1800	
	Hours per month	
(4) Average per month	150	65
(5) Since overhead labor may be shifted to a limited extent, maximum work time in any one month for specific processes:	200	
(6) Available for specific processes, Fall (October - December, 3 months)	600	
(7) -- ditto, Winter - Spring (January - April, 4 months)	800	
(8) -- ditto, Summer (May - September, 5 months)	1000	

Note: The limits set by (6), (7), (8) are subject to restriction (3): Operator's total annual work time associated with specific processes may not exceed 1800 hours, even though in some periods his monthly time for specific processes exceeds the average of 150 hours.
Additional labor is available by hiring casual help at $1.- per hour.

APPENDIX C.

INPUT - OUTPUT COEFFICIENTS AND CONTRIBUTION TO OBJECTIVE (OVERHEAD AND PROFITS) OF THE STATIC MODELS

Row No.	Item	Unit	Cow-and Calf Activities					
			1.01	1.02	1.03	1.04	1.05	1.06
00	Objective	$	- 18.77	- 9.45	- 28.25	- 24.88	- 9.35	- 42.97
	Land							
01	Total Acreage	acre	8.96	8.59	8.96	9.33	8.59	9.33
02	Cropland	acre						
03	Class A Cropland	acre						
04	Prairie Meadow	acre						
	Rent Options							
05	Any Acreage	acre						
06	Cropland	acre						
07	Class A Cropland	acre						
08	Prairie Meadow	acre						
	Operating Capital[a]							
09	Livestock, Fall	$	192.00	192.00	192.00	192.00	192.00	192.00
10	All Other, Fall	$	15.06	5.74	24.42	21.28	5.74	39.13
11	Livestock, Spring	$	192.00	192.00	192.00	192.00	192.00	192.00
12	All Other, Spring	$	15.06	5.74	24.42	21.28	5.74	39.13
	Labor[b]							
13	Total	man-hr.	5.58	6.50	6.68	5.43	6.38	6.73
14	October-December	man-hr.	4.05	4.76	4.05	1.74	2.47	2.54
15	January-April	man-hr.	0.74	0.74	1.74	1.02	1.02	1.52
16	May-September	man-hr.	0.79	1.00	0.89	2.67	2.89	2.67
	Roughage							
17	All Hay	ton	0.030	0.436	0.030	0.030	0.590	0.030
18	Alfalfa Hay	ton		0.436			0.590	
	Salable Livestock							
19	Weaned Calves, October 10	head	- 0.72	- 0.72				
20	Roughed Yearlings, April 1	head						
21	Trap-wintered Yrlgs., Apr. 1	head						
22	Long Yearlings, August 10	head						
	Sales Accounting							
23	Net Beef Production, Lvwt.	ton	- 0.230	- 0.230	- 0.243	- 0.220	- 0.220	- 0.244
24	Sales Volume	$	- 17.18	- 17.18	-106.25	- 98.15	- 98.15	-109.95

[a]Capital requirements for static models no. 1, 2, 3, 5 - 10, 17 - 24. Other models drop rows 10 and 11. Rows 9 and 10 of Stocker Cattle Activities are modified as shown in rows 25, 26, to account for lower borrowing costs.

[b]Labor for haying activities does not include harvest labor. This is provided by the custum operator.

[c]The parametric capital cost coefficient is varied between -0.40 and zero.

APPENDIX C (continued).

(2)

Row No.	Cow-and-Calf Activities (ct'd.) 1.07	1.08	1.09	1.10	2.01	Stocker Cattle Activities 2.02	2.03	2.04	2.05	2.06
00	-18.70	-29.01	-20.39	-8.13	-11.27	-0.94	-3.14	-9.75	-0.94	-3.14
01	7.84	7.37	9.02	8.47	2.00	2.00	1.55	0.33	2.00	1.55
02		1.40					0.75			0.75
03										
04										
05										
06										
07										
08										
09	192.00	192.00	177.50	177.50	115.24			115.24		
10	15.06	25.50	18.12	5.86	11.27			9.75		
11	192.00	192.00	177.50	177.50		137.88	137.88		150.94	150.94
12	15.06	25.50	18.12	5.86		0.94	31.36		0.94	31.36
13	6.38	9.58	5.50	6.44	1.33	0.76	2.93	2.23	0.76	2.93
14	2.47	2.89	2.89	3.62	0.58			1.00		
15	1.02	2.99	0.88	0.88	0.75	0.28	1.08	1.23	0.28	1.08
16	2.89	3.79	1.73	1.94		0.48	1.29		0.48	1.29
17	0.880	0.290	0.028	0.507	0.050			1.000		
18				0.507						
19			-0.36	-0.36	1.00			1.00		
20					-0.99	1.00	1.00			
21								-0.99	1.00	1.00
22						-0.995				
23	-0.224	-0.211	-0.225	-0.225	-0.022	-0.110	-0.130	-0.047	-0.103	-0.118
24	-99.84	-97.09	-57.66	-57.66			-172.53		-173.79	-178.00
25	Operating Capital, Livestock, Full Year $				57.62	57.42	57.42	57.62	68.89	62.89
26	Operating Capital, All Other, Full Year $				5.64	0.30	1.31	4.88	0.39	13.07

APPENDIX C (continued)

(3)

Row No.	Stocker Cattle Activities 2.07	2.08	2.09	Alfalfa Own 3.01	Alfalfa Share-rented 3.02	Prairie Hay 3.03	Oats Hay 3.04	Sudan Grass Hay 3.05	Hay Purchase Alfalfa 3.06	Hay Purchase Prairie 3.07	Rent Out Alfalfa (Share) 3.08
00	- 14.95	- 22.64	- 8.39	-30.45	-30.45	- 9.92	-16.86	-13.92	-25.00	-18.00	0
01	1.21	8.00	6.67	1.00		1.00	1.00	1.00			1.00
02	0.88			1.00			1.00	1.00			1.00
03				1.00							1.00
04						1.00					
05					1.00						
06											
07					1.00						
08											
09	115.24	166.88	166.88								
10	14.95	17.51	3.26	30.45	30.45	9.92	16.86	13.92	25.00	18.00	
11		166.88	166.88								
12		17.51	3.26	30.45	30.45	9.92	16.86	13.92	25.00	18.00	
13	3.28	2.31	4.41	0.60	0.60	0	2.28	3.02			
14	0.38	0.73	1.43								
15	0.82	0.98	0.98				0.37				
16	2.07	0.60	1.00	0.60	0.60		1.91	3.02			
17	0.333	0.025	0.667	- 2.75	- 1.83	- 1.10	- 1.45	- 1.25	- 1.00	- 1.00	- 0.92
18			0.667	- 2.75	- 1.83						- 0.92
19	1.00										
20											
21											
22		1.00	1.00								
23	- 0.129	- 0.132	- 0.132								
24	-177.66	-225.78	-225.78								
25	67.23	166.88	166.88								
26	13.05	17.51	3.26								

APPENDIX C (continued).

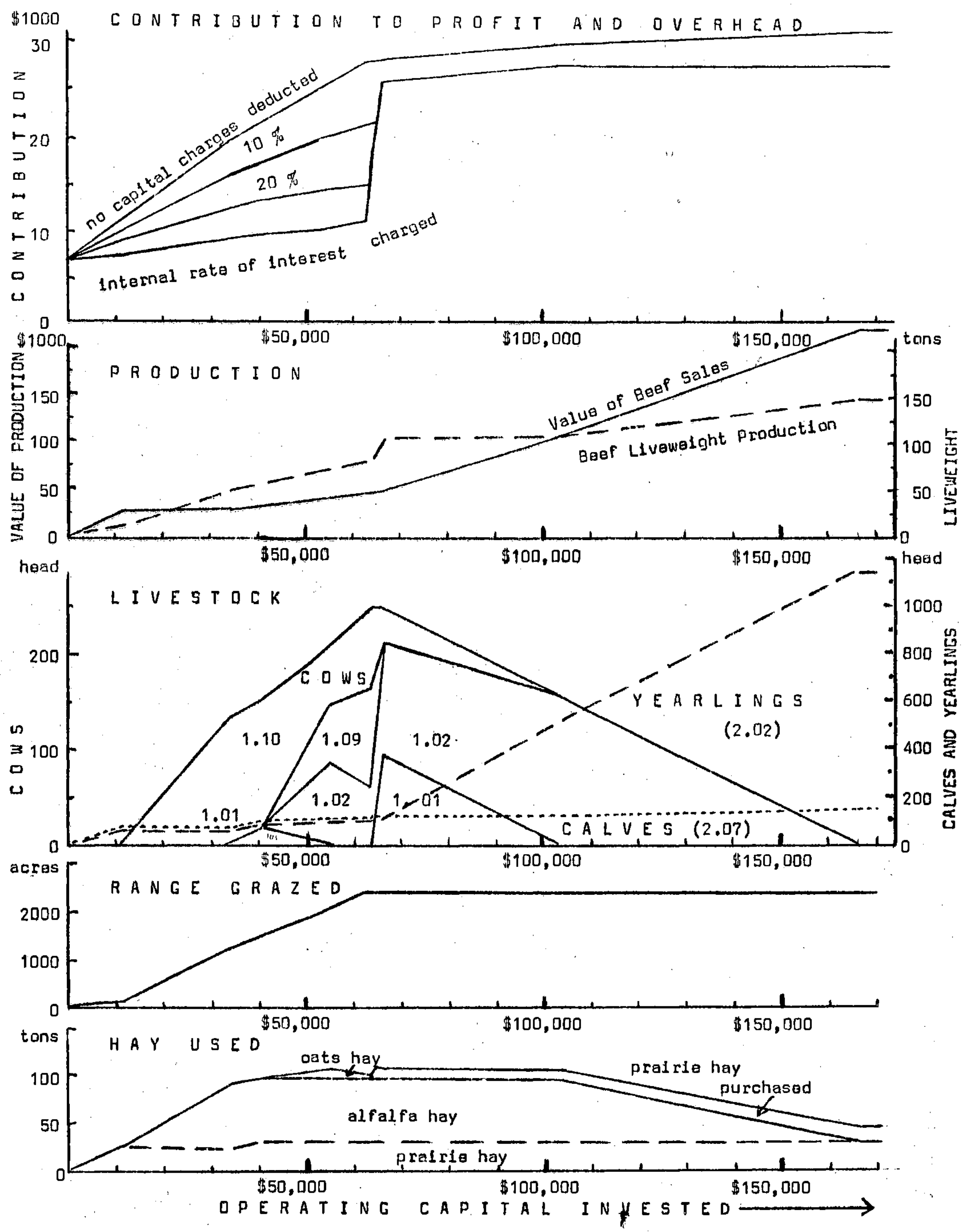
(4)

Row No.	Rent In: Range 4.01	Rent In: Cropland 4.02	Rent In: Prairie Meadow 4.03	Rent Out: Range 4.04	Rent Out: Cropland 4.05	Rent Out: Prairie Meadow 4.06	Weaned Calves October 10: Sell 4.11	Weaned Calves October 10: Buy 4.12	Roughed Yearlings April 1: Sell 4.13	Roughed Yearlings April 1: Buy 4.14
00	- 2.50	- 6.00	- 6.00	2.38	5.70	5.70				
01	- 1.00	- 1.00	- 1.00	1.00	1.00	1.00				
02		- 1.00			1.00					
03										
04			- 1.00			1.00				
05	1.00	1.00	1.00							
06		1.00								
07										
08			1.00							
09										
10	2.50	6.00	6.00					2.38		
11										
12	2.50	6.00	6.00							2.62
13										
14										
15										
16										
17										
18										
19							1.00	- 1.00		
20									1.00	- 1.00
21										
22										
23										
24							-115.24		-137.81	

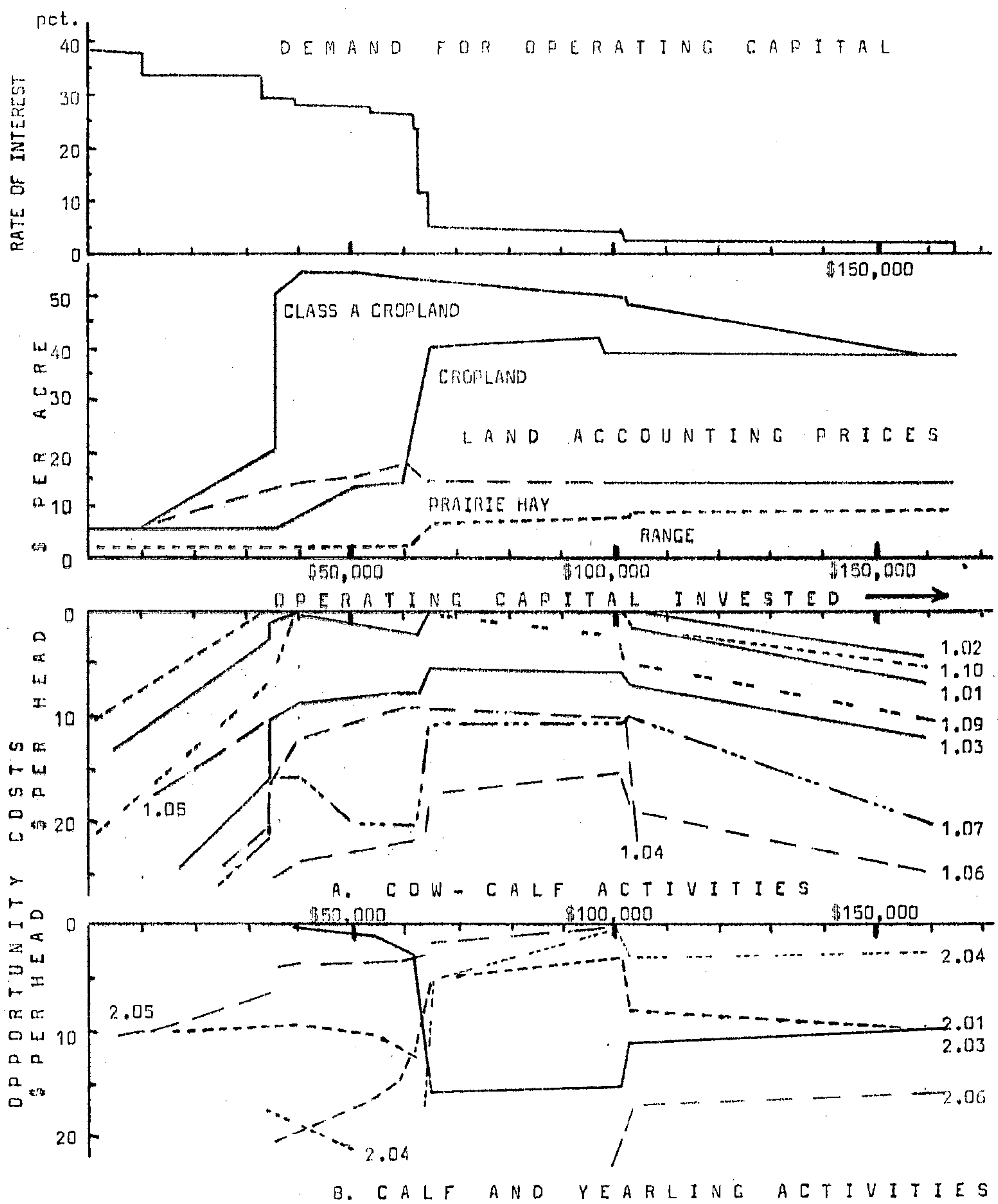
APPENDIX C (continued)

(5)

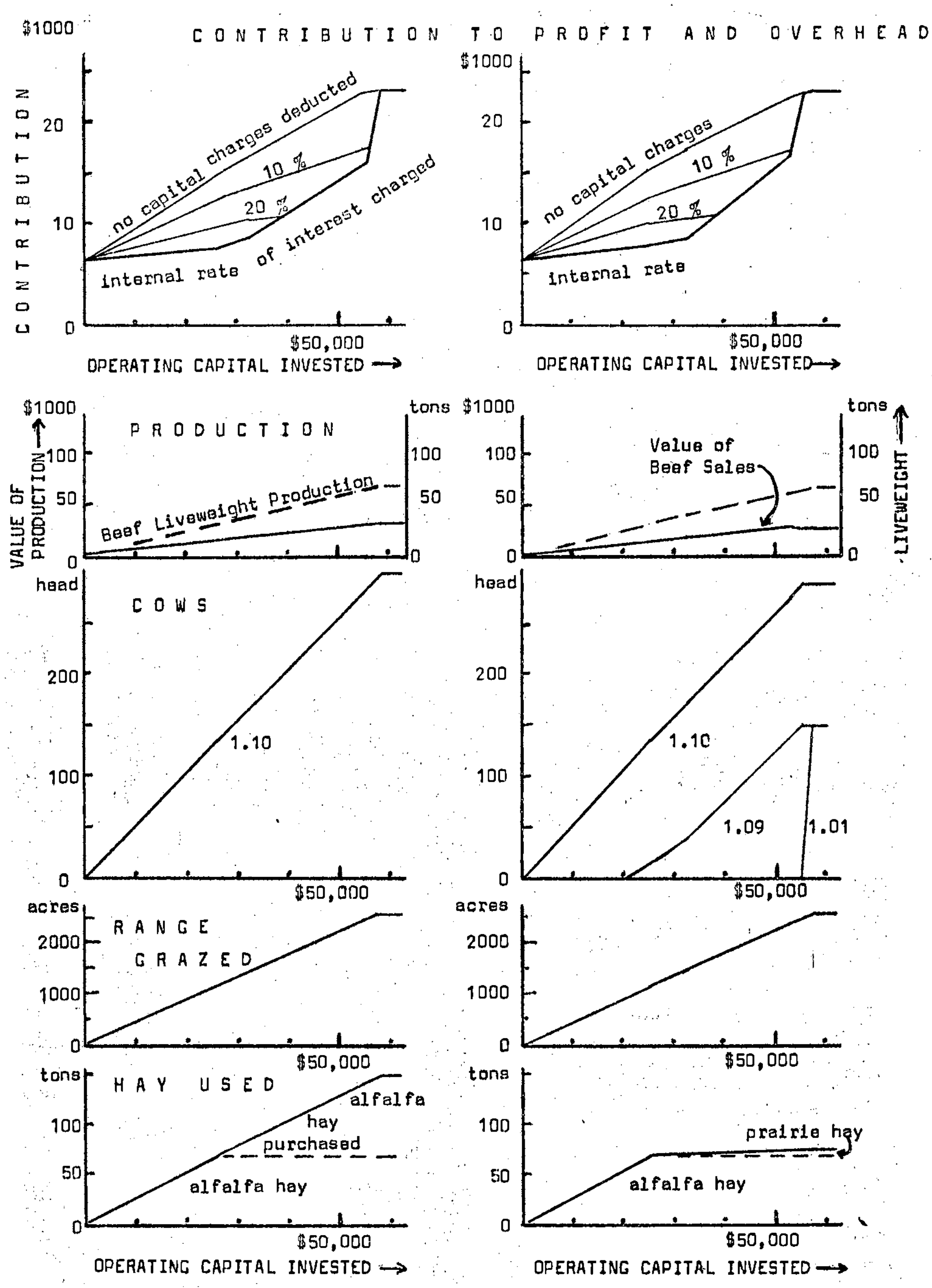
Row No.	Trap-wintered Yearlings, April 1 Sell 4.15	Buy 4.16	Long Yearlings August 10 Sell 4.17	Buy 4.18	Livestock Sales Account 4.19	Borrow Operating Capital f. Livestock 4.20	Other Exp. 4.21	Hire Labor Fall X - XII 4.22	Winter I - IV 4.23	Summer V - IX 4.24
00	- 2.88	-153.82	- 3.75	-170.63	1.00	-0.XX[c]	-0.04	-1.00	-1.00	-1.00
01										
02										
03										
04										
05										
06										
07										
08										
09						-1.00	1.00			
10				3.75			-1.00	1.00	1.00	1.00
11						-1.00	1.00			
12		2.88		3.75			-1.00	1.00	1.00	1.00
13								-1.00	-1.00	-1.00
14								-1.00		
15									-1.00	
16										-1.00
17										
18										
19										
20										
21	1.00	- 1.00								
22			1.00	- 1.00						
23										
24	-150.94		-166.88		1.00					



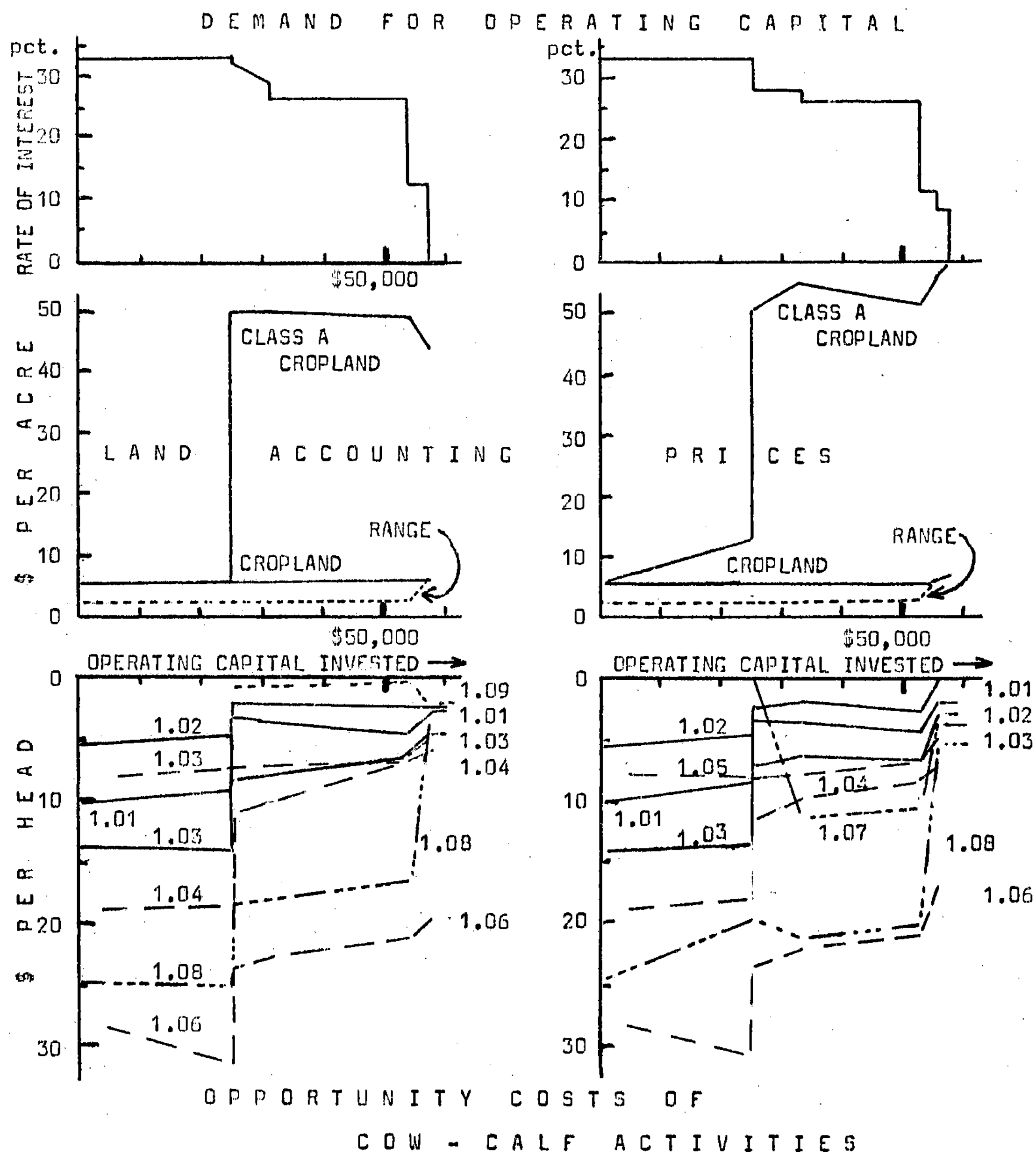
Appendix D.
Fig. 1. Contribution to Profit and Overhead and Organizational Characteristics, Basic Four Section Ranch Model. Hay Price Raised 40 per cent (Model No. S2).



Appendix D.
Fig. 2. Demand for Capital and Accounting Prices, Basic Four Section Ranch Model, Hay Price Raised 40 per cent (Model No. S2).

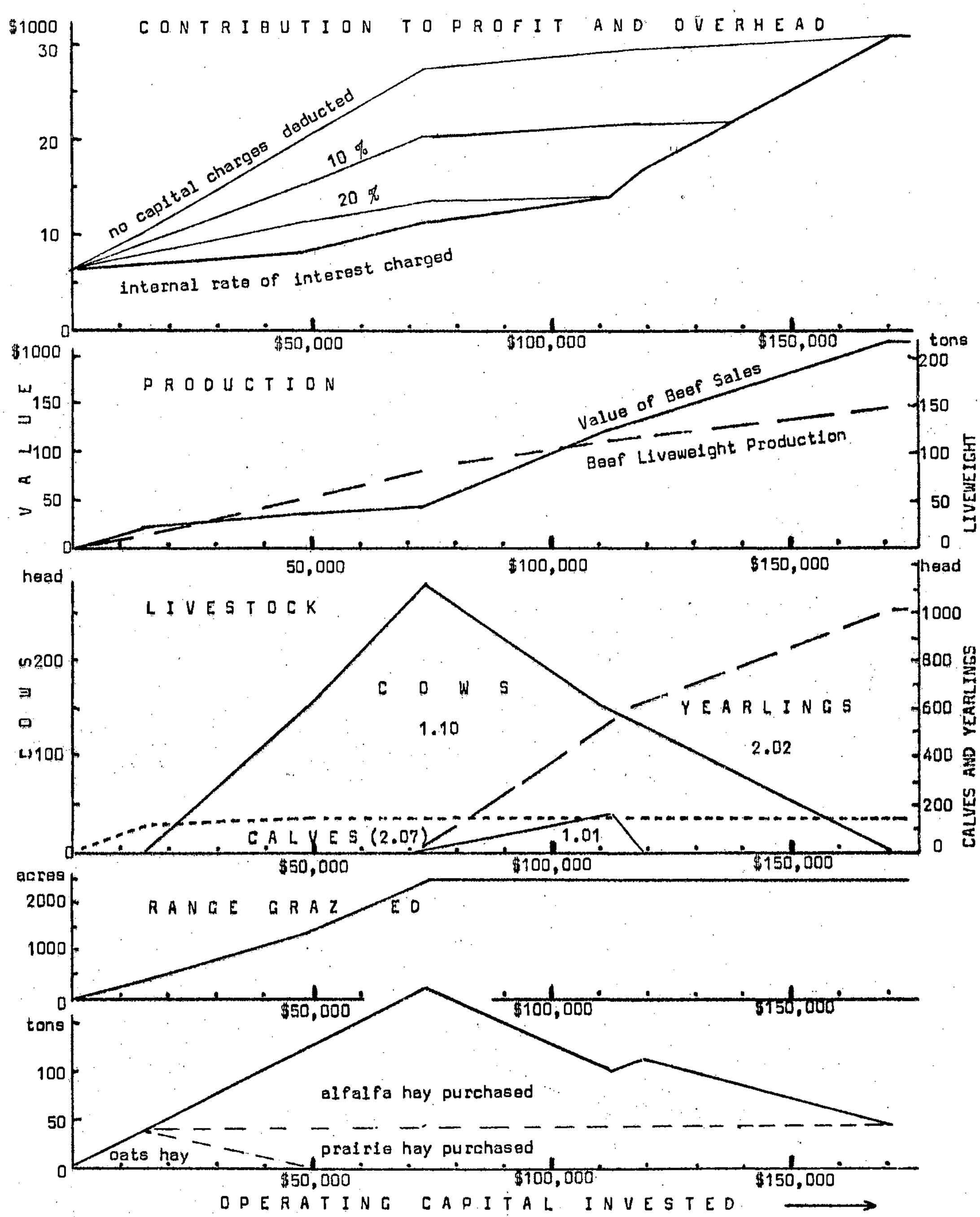


Appendix D.
Fig. 3. Contribution to Profit and Overhead and Organizational Characteristics, Four Section Ranch. Breeding Herd Only.
Left: Normal Hay Price (Model No. S8); Right: Hay Price up 40 per cent (Model No. S10).

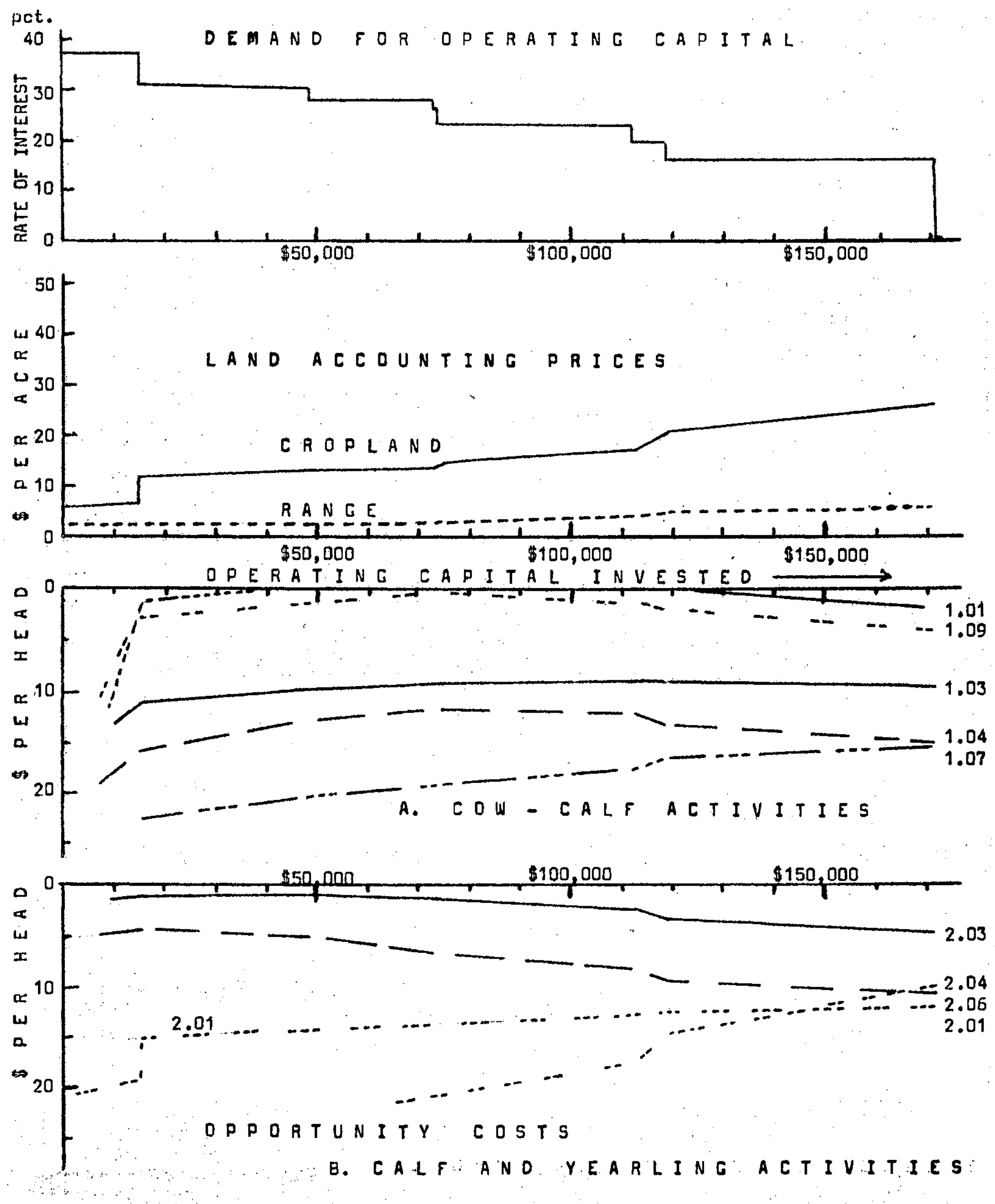


Appendix D.

Fig. 4. Demand for Capital and Accounting Prices, Four Section Ranch. Breeding Herd only.
Left: Normal Hay Price (Model No. S8).
Right: Hay Price up 40 per cent (Model No. S10).

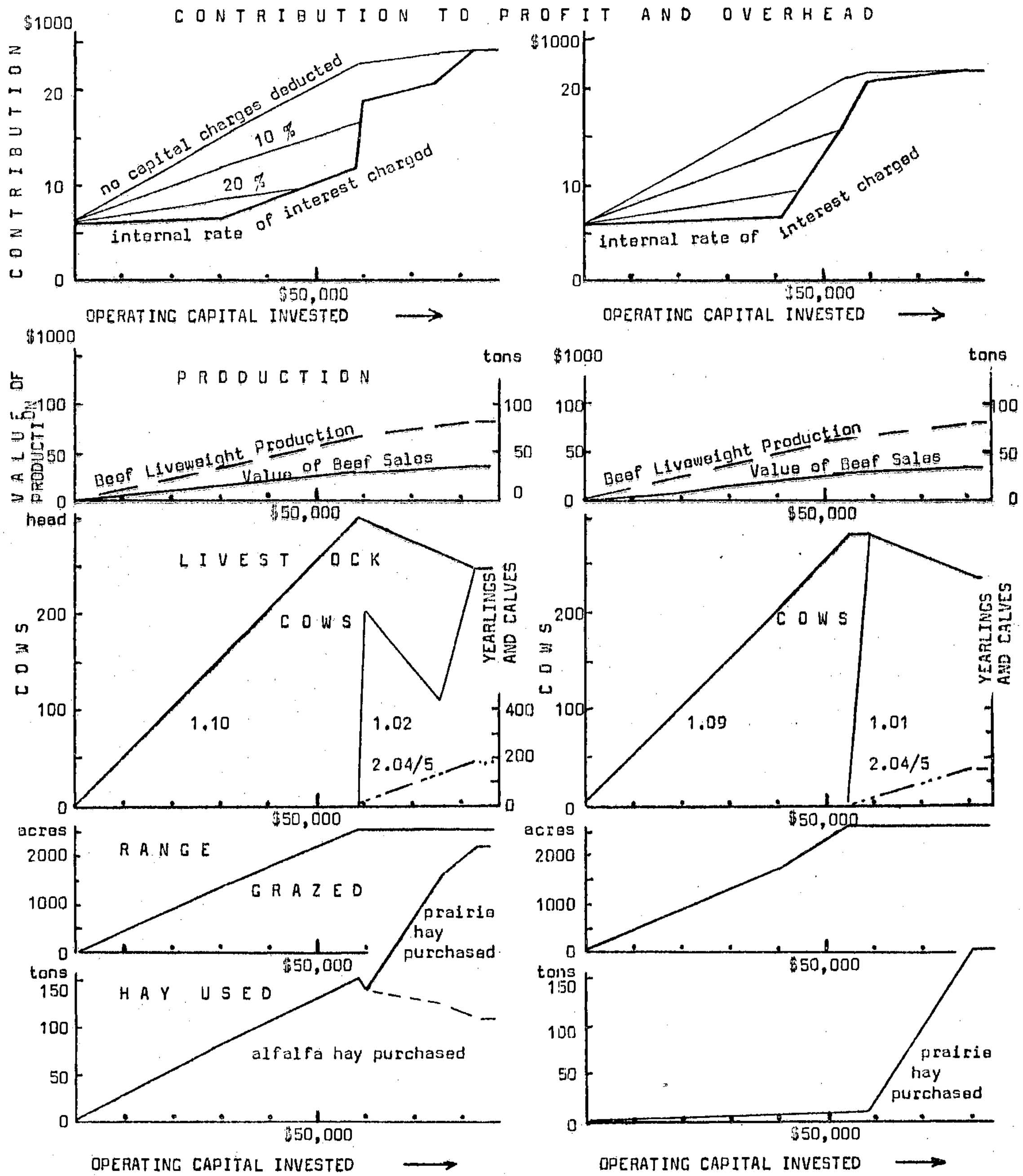


Appendix D.
Fig. 5. Contribution to Profit and Overhead and Organizational Characteristics, Four Section Ranch. Range and Cropland, Capital Charged for Months of Use only (Model No. S15).



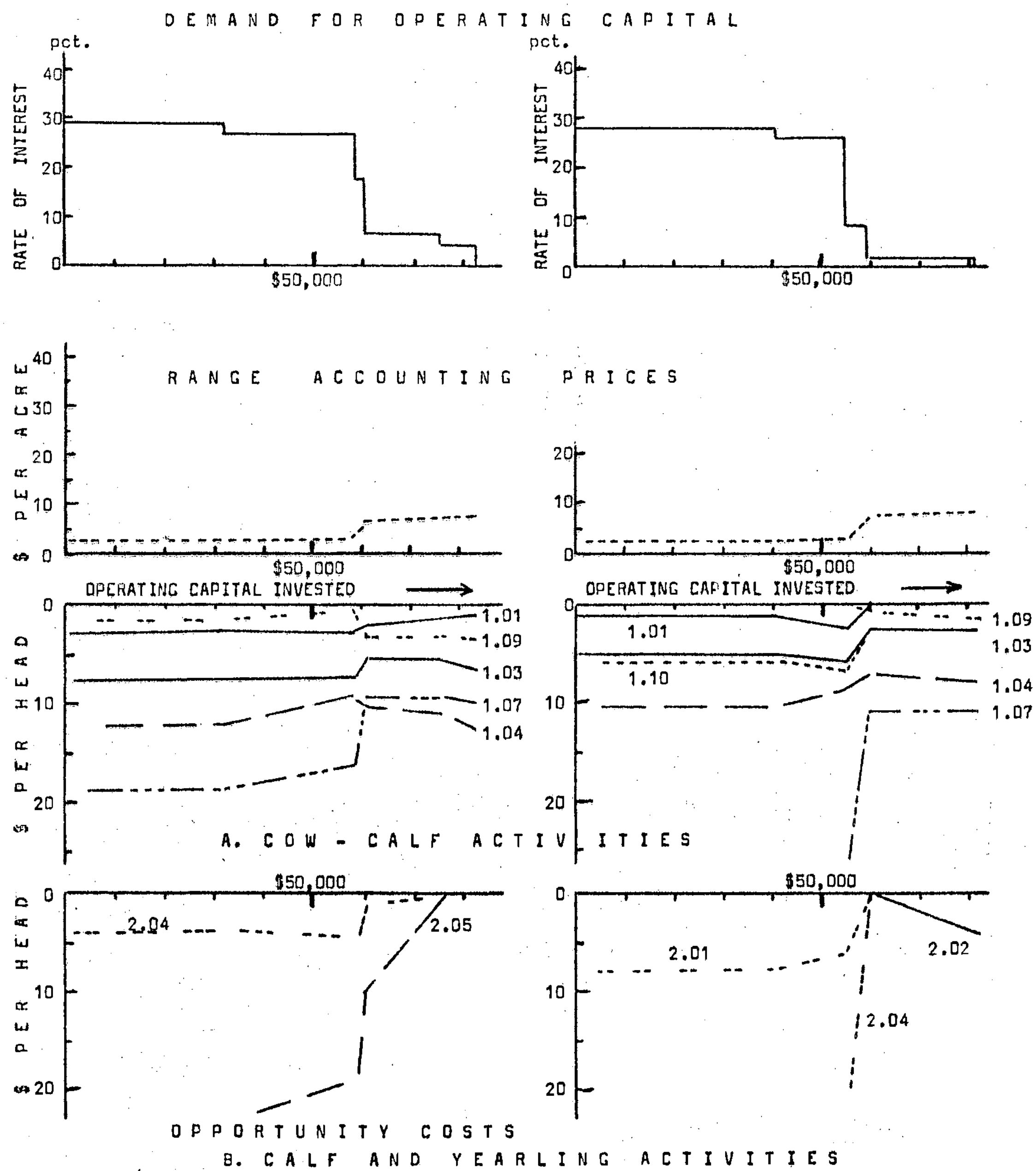
Appendix D.

Fig. 6. Demand for Capital and Accounting Prices, Four Section Ranch. Range and Cropland, Capital Charged for Months of Use only (Model No. S15).

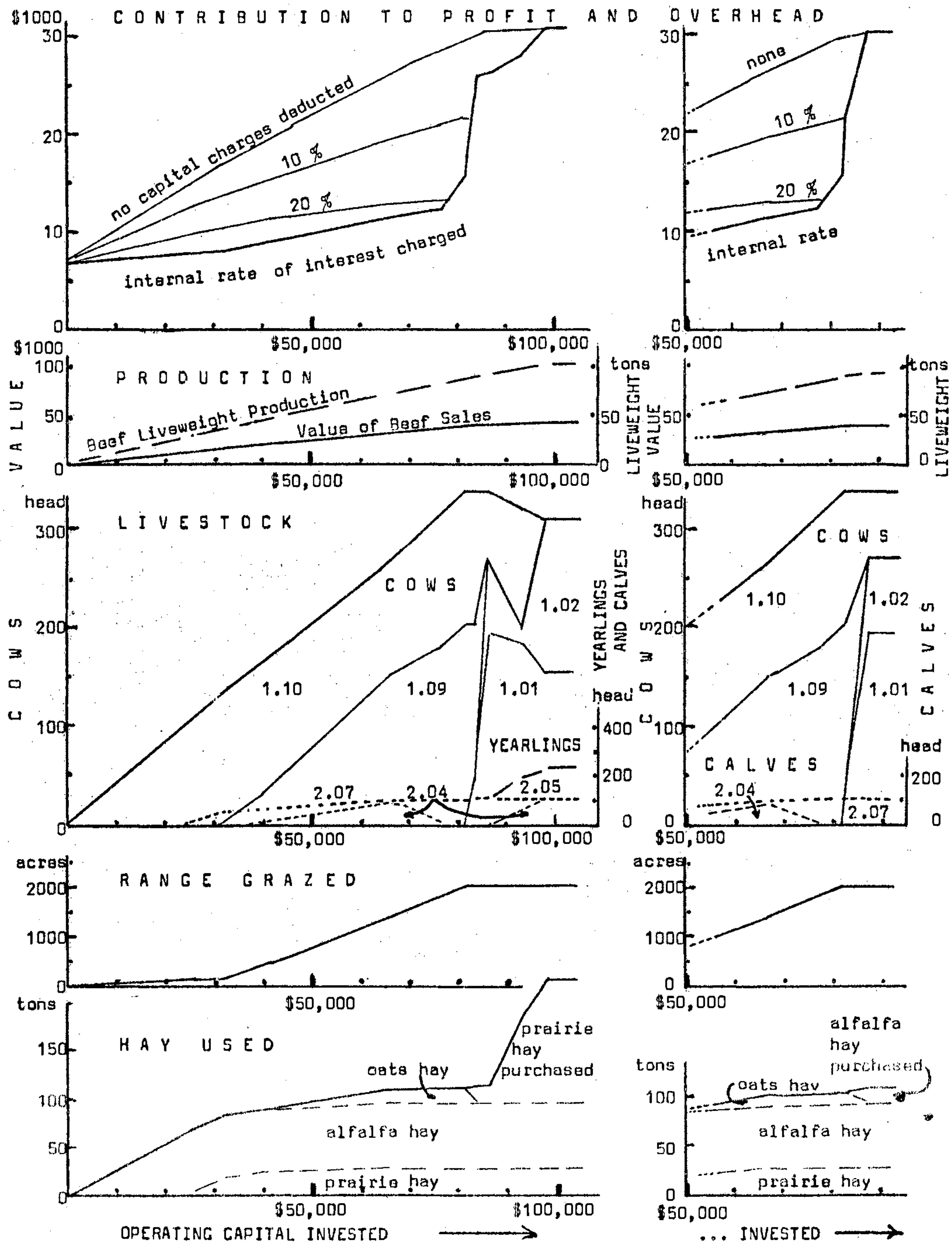


Appendix D.

Fig. 7. Contribution to Profit and Overhead and Organizational Characteristics, Four Section Ranch. Rangeland, Raised Cattle Only.
Left: Normal Hay Price (Model No. S17); Right: Hay Price up 40 per cent (Model No. S19).

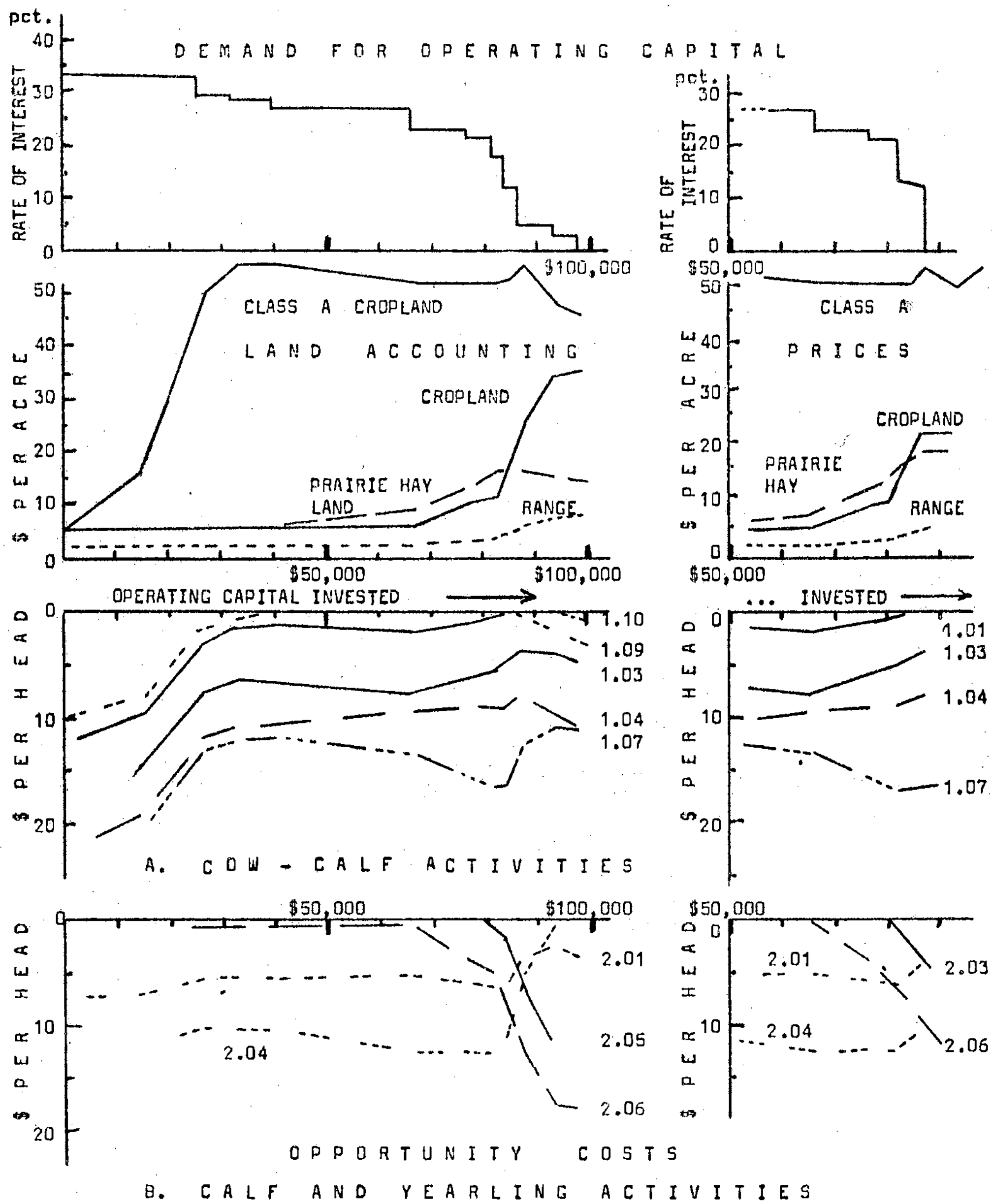


Appendix D.
Fig. 8. Demand for Capital and Accounting Prices, Four Section Ranch. Rangeland, Raised Cattle Only.
Left: Normal Hay Price (Model No. S17).
Right: Hay Price up 40 per cent (Model No. S19).



Appendix D.

Fig. 9. Contribution to Profit and Overhead and Organizational Characteristics, Four Section Ranch. With Option to Rent an Additional Section of Range.
Left: Hay Price up 20 per cent (Model No. S23).
Right: Hay Price up 40 per cent (Model No. S24).



Appendix D.
Fig. 10. Demand for Capital and Accounting Prices, Four Section Ranch. With Option to Rent an Additional Section of Range. Left: Hay Price up 20 per cent (Model No. S23). Right: Hay Price up 40 per cent (Model No. S24).

APPENDIX D, TABLE I. THE CHARACTERISTICS OF STATIC RANCH MODELS AT CRITICAL POINTS[a] -- THE BASIC FOUR SECTION RANCH MODEL

Line	Description	Unit	Capital Charged for Full Year (S - 1)			(S - 2)	(S - 3)	Capital Charge Method Relaxed (S - 4)		
			O	G	C	C	C	O	G	C
		(hay price level:)	normal	normal	normal	up 20%	up 40%	normal	normal	normal
1	Operating Capital Level	dollar	11,200	65,300	169,400	167,000	166,900	18,400	69,500	171,600
2	ditto, per acre	dollar/acre	4.40	27.50	66	65	65	7.20	27.10	67
3	Target Rate(s) of Interest[b]	per cent	38.4	26.4/ 4.0	1.5	2.1	2.0	39.0	27.4/23.5	9.3
	Income Contribution at ...[c]									
4	Target Rate of Interest	dollar	6,600	10,500	27,800	26,700	26,700	6,600	9,500	22,400
5	10% Rate of Interest	dollar	9,800	20,800	(13,500)[h]	(13,500)[h]	(13,500)[h]	10,000	20,700	(21,900)[h]
6	Zero Rate of Interest	dollar	11,000	27,400	30,400	30,200	30,100	11,200	27,000	30,200
7	ditto, per acre	dollar/acre	4.30	10.70	11.85	11.80	11.75	4.35	10.55	11.80
8	Value of Beef Sales	dollar	26,700	49,500	216,500	220,700	219,600	24,100	36,400	220,700
9	ditto, per acre	dollar/acre	10.40	19.30	84.50	86.20	85.60	9.40	14.20	86.20
10	Beef Production Volume	tons	19.8	83.1	152.8	148.4	147.6	17.5	77.5	148.4
11	ditto, per acre	pounds/acre	15	65	119	116	115	14	61	116
12	Number of Cows	head	0	255	0	0	0	0	279	0
13	Number of Calves Wintered	head	83	114	351	143	136	136	114	143
14	Number of Stocker Cattle	head	69	96	1,141	1,176	1,177	0	0	1,176
15	Rangeland Utilized	acres	83	2,400	2,400	2,400	2,400	45	2,400	2,400
16	Hay Utilized	tons	28	165	256	48	43	45	179	48
17	Labor Hired[d]	man-hours	0	311F	0	0	0	0	452F	0
	Accounting Price of Land Use:									
18	Rangeland	dollar/acre	2.38[f]	6.22	9.99	9.64	9.59	2.38[f]	2.61	7.89
19	Prairie Hay Land	dollar/acre	5.82	11.18	10.34	14.54	17.64	7.33	12.88	11.10
20	Cropland	dollar/acre	6.54	31.60	39.30	39.20	38.20	10.53	15.34	32.20
21	Class A Cropland	dollar/acre	6.54	42.70	39.30	39.20	38.20	10.53	50.00	32.20
	20-Year Values[e]									
22	Rangeland	dollar/acre	6.30	74	118	115	114	6.10	12.00	70
23	Prairie Hay Land	dollar/acre	15.25	134	124	174	211	18.80	54	99
24	Cropland	dollar/acre	17.10	378	470	468	456	27.00	64	287
25	Class A Cropland	dollar/acre	17.10	510	470	468	456	27.00	210	287

Footnotes see next page

APPENDIX D, TABLE II. THE CHARACTERISTICS OF STATIC RANCH MODELS AT CRITICAL POINTS[a] — BASIC MODEL, CHOICE OF ACTIVITIES RESTRICTED

Line	Description	Unit	Raised Cattle only					Breeding Herd only				
			(S - 5)			(S - 6)	(S - 7)	(S - 8)			(S - 9)	(S- 10)
			D	G	C	C	C	D	G	C	C	C
		(hay price level:)	normal	normal	normal	up 20%	up 40%	normal	normal	normal	up 20%	up 40%
1	Operating Capital Level	dollar	25,600	68,700	78,300	77,300	70.700	25,600	55,000	57,900	57,900	57,900
2	ditto, per acre	dollar/acre	10.00	26.80	30.60	30.20	27.60	10.00	21.50	22.60	22.60	22.60
3	Target Rate(s) of Interest[b]	per cent	32.3	26.5/22.1	5.1	2.5	11.9	33.3	26.1/12.4	12.4	9.2	8.4
	Income Contribution at ...[c]											
4	Target Rate of Interest	dollar	6,600	8,700	23,600	25,200	18,400	6,600	8,700	16,200	17,600	18,100
5	10% Rate of Interest	dollar	12,500	20,000	(19,600)[h]	(19,400)	19,800	12,500	17,500	17,600	(17,200)	(17,100)
6	Zero Rate of Interest	dollar	15,100	26,900	27,600	27,200	26,900	15,100	23,000	23,400	23,000	22,900
7	ditto, per acre	dollar/acre	4.90	10.50	10.80	10.60	10.45	5.90	9.00	9.15	9.00	8.95
8	Value of Beef Sales	dollar	13,400	34,400	36,800	36,300	34,200	13,400	28,100	29,500	29,500	28,800
9	ditto, per acre	dollar/acre	5.25	13.40	14.40	14.20	13.35	5.25	11.00	11.50	11.50	11.25
10	Beef Production Volume	tons	30.6	76.8	84.2	83.0	76.9	30.6	63.8	67.1	67.1	65.8
11	ditto, per acre	pounds/acre	24	60	66	65	60	24	50	52	52	51
12	Number of Cows	head	136	279	256	253	270	136	283	298	298	289
13	Number of Calves Wintered	head	0	108	184	182	114		(not permitted in this series)			
14	Number of Stocker Cattle	head	0	0	69	67	0		(not permitted in this series)			
15	Rangeland Utilized	acres	1,149	2,400	2,400	2,400	2,400	1,149	2,400	2,525	2,525	2,521
16	Hay Utilized	tons	69	176	220	177	110	69	144	151	151	74
17	Labor Hired[d]	man-hours	0	415F	464F	200F/152S	240F	0	425F	480F	480F	511F
	Accounting Price of Land Use;											
18	Rangeland	dollar/acre	2.38[f]	2.58	7.46	7.76	5.38	2.38[f]	2.58	5.94	6.39	7.00
19	Prairie Hay Land	dollar/acre	5.70[f]	8.69	10.68	14.68	20.60	5.70[f]	5.70	5.94	6.39	7.00
20	Cropland	dollar/acre	5.70[f]	6.54	32.40	35.80	23.30	5.70[f]	5.70	5.94	6.39	7.00
21	Class A Cropland	dollar/acre	15.96	49.80	40.80	45.80	56.80	50.70	49.60	44.20	56.70	56.30
	Twenty-Year Values[e]											
22	Rangeland	dollar/acre	7.60	11.50	89	93	40	7.70	18.80	43.30	58	64
23	Prairie Hay Land	dollar/acre	18.20	38.60	128	175	153	18.40	41.50	43.30	58	64
24	Cropland	dollar/acre	18.20	29.00	387	428	173	18.40	41.50	43.30	58	64
25	Class A Cropland	dollar/acre	51	221	488	548	422	164	362	322	512	512

Footnotes see table D-I

APPENDIX D, TABLE III. THE CHARACTERISTICS OF STATIC RANCH MODELS AT CRITICAL POINTS[a] -- TENURE AND SIZE VARIANTS

Line	Description	Unit	Tenant-Operated 4-Section Ranch (S - 11)			Small Owner-Operated Ranch (S - 12)		
			O	G (R)	C	O	G	C
		(hay price level:)	normal	normal	normal	normal	normal	normal
1	Operating Capital Level	dollar	18,700	116,300	180,400	7,360	26,000	63,700
2	ditto, per acre	dollar/acre	7.30	45.50	70.50	7.65	27.10	65.50
3	Target Rate(s) of Interest[b]	per cent	34.8	22.9/19.9	10.1	39.0	29.9/16.0	10.5
	Income Contribution At ...[c]							
4	Target Rate of Interest	dollar	50	3,400	13,900	2,480	3,260	7,760
5	10 % Rate of Interest	dollar	3,070	13,700	14,000	2,840	7,980	8,220
6	Zero Rate of Interest	dollar	4,300	21,800	23,100	4,300	10,350	11,350
7	ditto, per acre	dollar/acre	1.68	8.50	9.00	4.50	10.80	11.80
8	Value of Beef Sales	dollar	23,100	121,100	222,800	9,630	14,080	82,500
9	ditto, per acre	dollar/acre	9.00	47.40	87	10.00	14.70	86
10	Beef Production Volume	tons	16.9	110.7	149.8	7.0	29.2	55.5
11	ditto, per acre	pounds/acre	13	87	117	15	61	116
12	Number of Cows	head	0	146	0	0	103	0
13	Number of Calves Wintered	head	130	143	143	54	46	57
14	Number of Stocker Cattle	head	0	535	1,189	0	0	435
15	Rangeland Utilized	acres	43	2,375	2,425	18	890	890
16	Hay Utilized	tons	43	104	48	18	68	19
17	Labor Hired[d]	man-hours	0	0	0	0	0	0
	Accounting Price of Land Use:							
18	Rangeland	dollar/acre	3.46	3.48	7.60	2.38[f]	2.58	7.24
19	Prairie Hay Land	dollar/acre	10.51	12.44	11.20	5.85	13.14	11.13
20	Cropland	dollar/acre	8.61	17.08	31.40	6.57	13.32	30.33
21	Class A Cropland	dollar/acre	21.20	47.80	31.40	6.57	50.94	30.33
	Twenty-Year Values[e]							
22	Rangeland	dollar/acre	9.90	17.00	64	6.10	15.30	60
23	Prairie Hay Land	dollar/acre	30.10	61	95	15.00	78	92
24	Cropland	dollar/acre	24.70	83	266	16.80	79	252
25	Class A Cropland	dollar/acre	61	234	266	16.80	302	252

Footnotes see table D-1

APPENDIX D, TABLE IV. THE CHARACTERISTICS OF STATIC RANCH MODELS AT CRITICAL POINTS[a] -- LAND MIX VARIANTS; CAPITAL CHARGE METHOD RELAXED (I)

Line	Description	Unit	Range only (S - 13)			Range and Prairie Hay Land (S - 14)		
		(hay price level:)	O normal	G normal	C normal	O normal	G normal	C normal
1	Operating Capital Level	dollar	32,500	115,500	180,300	32,500	111,700	180,300
2	ditto, per acre	dollar/acre	12.70	45	70	12.70	44	70
3	Target Rate(s) of Interest[b]	per cent	28.9	26.6/19.1	19.1	28.9	26.6/19.1	14.6
	Income Contribution at...[c]							
4	Target Rate of Interest	dollar	6,100	6,800	11,800	6,100	6,900	15,300
5	10 % Rate of Interest	dollar	12,200	17,900	18,800	12,300	17,900	(18,800)[h]
6	Zero Rate of Interest	dollar	15,400	24,600	26,500	15,500	24,500	26,500
7	ditto, per acre	dollar/acre	6.00	9.60	10.35	6.05	9.65	10.35
8	Value of Beef Sales	dollar	16,400	111,500	211,700	16,400	109,500	211,700
9	ditto, per acre	dollar/acre	6.40	44	83	6.40	43	79
10	Beef Production Volume	tons	37.4	100.6	140.9	37.4	99.2	140.9
11	ditto, per acre	pounds/acre	29	79	110	29	77	110
12	Number of Cows	head	166	166	0	166	166	0
13	Number of Calves Wintered	head	0	0	0	0	0	0
14	Number of Stocker Cattle	head	0	573	1,275	0	560	1,275
15	Rangeland Utilized	acres	1,404	2,550	2,550	1,404	2,525	2,550
16	Hay Utilized	tons	84	84	0	84	84	0
17	Labor Hired[d]	man-hours	0	0	0	0	0	0
	Accounting Price of Land Use							
18	Rangeland	dollar/acre	2.38[f]	2.85	8.44	2.38[f]	2.68	6.00
19	Prairie Hay Land	dollar/acre	not determined			5.70[f]	5.70	6.00
20	Cropland	dollar/acre	20.60	23.10	38.80	23.20	25.00	34.50
	Twenty-Year Values[e]							
21	Rangeland	dollar/acre	8.10	14.50	43	8.10	13.60	38
22	Prairie Hay Land	dollar/acre	not determined			19.50	29	38
23	Cropland	dollar/acre	70	117	197	79	127	220

Footnotes see table D-1

APPENDIX D, TABLE V. THE CHARACTERISTICS OF STATIC RANCH MODELS AT CRITICAL POINTS[a] -- LAND MIX VARIANTS: CAPITAL CHARGE METHOD RELAXED (II)

Line	Description	Unit	Range and Cropland (S - 15)			Range, Prairie Hay and Cropland (S - 16)		
			O	G	C	O	G	C
		(hay price levels)	normal	normal	normal	normal	normal	normal
1	Operating Capital Level	dollar	15,400	75,000	173,600	7,100	74,200	171,600
2	ditto, per acre	dollar/acre	6.00	29.30	68	2.80	29	67
3	Target Rate(s) of Interest[b]	per cent	37.8	26.3/23.0	16.0	39.5	27.4	16.0
	Income Contribution at...[c]							
4	Target Rate of Interest	dollar	6,600	9,100	16,700	6,600	8,600	16,900
5	10 % Rate of Interest	dollar	9,300	20,200	21,800	8,700	20,300	21,800
6	Zero Rate of Interest	dollar	10,300	27,000	30,200	9,400	27,000	30,200
7	ditto, per acre	dollar/acre	4.00	10.55	11.80	3.70	10.55	11.80
8	Value of Beef Sales	dollar	20,100	41,400	222,800	14,700	41,400	220,700
9	ditto, per acre	dollar/acre	7.85	16.20	87	5.75	16.20	86
10	Beef Production Volume	tons	14.6	81.6	149.8	10.6	81.0	148.4
11	ditto, per acre	pounds/acre	11	64	117	8	63	116
12	Number of Cows	head	0	277	0	0	278	0
13	Number of Calves Wintered	head	113	143	143	82	143	143
14	Number of Stocker Cattle	head	0	0	1,189	0	0	1,177
15	Rangeland Utilized	acres	38	2,425	2,425	28	2,400	2,400
16	Hay Utilized	tons	38	188	48	28	188	48
17	Labor Hired[d]	man-hours	0	471F	0	0	459F	0
	Accounting Price of Land Use							
18	Rangeland	dollar/acre	2.38[f]	2.61	7.89	2.38[f]	2.61	7.89
19	Prairie Hay Land	dollar/acre		not determined		5.70[f]	12.88	11.10
20	Cropland	dollar/acre	6.46	13.84	32.20	5.70[f]	15.34	32.20
	Twenty-Year Values[e]							
21	Rangeland	dollar/acre	8.10	13.60	122	6.20	9.85	47
22	Prairie Hay Land	dollar/acre		not determined		14.40	47	66
23	Cropland	dollar/acre	16.90	52	191	14.40	56	191

Footnotes see table D-1

TABLE D-VI. THE CHARACTERISTICS OF STATIC RANCH MODELS AT CRITICAL POINTS[a]
LAND MIX VARIANTS: FULL CAPITAL CHARGE METHOD, CHOICE OF ACTIVITIES RESTRICTED

Line	Description	Unit	Raised Cattle								Breeding Herd	
			Range Only					Range and Prairie Hay Land			Range Only	
			(S-17)			(S-18)	(S-19)	(S-20)			(S-21)	
		hay price level:	O normal	G normal	C normal	C up 20%	C up 40%	O normal	G normal	C normal	O normal	G;C normal
1	Operating Capital Level	dollar	32,500	61,200	84,100	83,700	82,300	32,500	58,900	82,900	32,500	59,500
2	ditto, per acre	dollar/acre	12.70	23.80	32.80	32.70	32.10	12.70	23.00	32.40	12.70	23.20
3	Target Rate(s) of Interest[b]	per cent	28.9	17.8/6.3	4.0	3.6	1.3	28.9	26.5	3.9	28.9	26.1/0
	Income Contribution At...[c]											
4	Target Rate of Interest	dollar	6,100	12,000	20,800	20,000	20,900	6,200	6,900	20,900	6,100	7,100
5	10% Rate of Interest	dollar	12,200	16,800	(15,800)	(14,700)	(13,800)	12,300	16,600	(15,900)	12,200	16,600
6	Zero Rate of Interest	dollar	15,400	22,900	24,200	23,000	22,000	15,500	22,500	24,200	15,400	22,600
7	ditto, per acre	dollar/acre	6.00	8.95	9.45	8.97	8.60	6.05	8.80	9.45	6.00	8.82
8	Value of Beef Sales	dollar	16,400	29,800	35,100	34,600	33,900	16,400	29,500	34,700	16,400	29,800
9	ditto, per acre	dollar/acre	6.40	11.60	13.70	13.50	13.25	6.40	11.50	13.55	6.40	11.60
10	Beef Production Volume	tons	37.3	68.2	84.1	82.9	81.0	37.3	67.1	83.2	37.3	67.8
11	ditto, per acre	pounds/acre	29	53	66	65	63	29	52	65	29	53
12	Number of Cows	head	166	298	248	245	240	166	298	247	166	301
13	Number of Calves Wintered	head	0	0	179	177	173	0	0	177	0	0
14	Number of Stocker cattle	head	0	0	177	175	171	0	0	176	0	0
15	Rangeland Utilized	acres	1,400	2,550	2,550	2,550	2,550	1,404	2,525	2,525	1,404	2,550
16	Hay Utilized	tons	84	137	287	179	180	84	151	285	84	153
17	Labor Hired[d]	man-hours	0	133F	57F/294S	240F	545F	0	479F	50F/330S	0	489F
	Accounting Price of Land Use											
18	Rangeland	dollar/acre	2.38[f]	6.94	7.74	7.65	8.15	2.38[f]	2.62	7.75	2.38[f]	8.61
19	Prairie Hay Land	dollar/acre	--	--	--	--	--	5.70[f]	5.70[f]	10.56	--	--
	Twenty-Year Values[e]											
20	Rangeland	dollar/acre	8.20	78	93	92	97	8.20	9.80	93	8.20	103
21	Prairie Hay Land	dollar/acre	--	--	--	--	--	19.70	21.30	126	--	--

Footnotes see table D-I

APPENDIX D, TABLE VII. THE CHARACTERISTICS OF STATIC RANCH MODELS AT CRITICAL POINTS[a] -- BASIC FOUR SECTION RANCH WITH AN ADDITIONAL RENT OPTION; RAISED CATTLE ONLY

Line	Description	Unit	Basic Land Mix (S - 22) R	(S - 22) C	(S - 23) C	(S - 24) C	Range only (S - 25) R	(S - 25) C	(S - 26) C	(S - 27) C
		(hay price level:)	normal	normal	up 20%	up 40%	normal	normal	up 20%	up 40%
1	Operating Capital Level	dollar	86,300	99,900	98,200	87,000	76,200	107,300	105,200	104,700
2	ditto, per acre	dollar/acre	27.00	31.00	30.65	27.20	23.80	33.55	32.85	32.70
3	Target Rate(s) of Interest[b]	per cent	21.5/7.9	5.1	2.5	11.9	23.1/17.8	4.1	3.6	1.3
	Income Contribution at...[c]									
4	Target Rate of Interest	dollar	12,300	26,400	28,300	20,000	8,900	23,700	24,000	24,400
5	10% Rate of Interest	dollar	22,200	(21,500)	(21,000)	21,700	18,800	(17,400)	(16,200)	(15,200)
6	Zero Rate of Interest	dollar	30,800	31,500	30,800	30,400	26,400	28,200	26,800	25,700
7	ditto, per acre	dollar/acre	9.60	9.85	9.60	9.50	8.25	8.80	6.50	8.05
8	Value of Beef Sales	dollar	43,300	45,600	44,800	41,300	37,300	43,900	42,800	42,300
9	ditto, per acre	dollar/acre	13.55	14.25	14.00	12.90	11.65	13.75	13.40	13.20
10	Beef Production volume	tons	94.6	105.3	103.4	93.2	84.8	105.2	102.6	101.3
11	ditto, per acre	pounds/acre	59	66	65	43	53	66	64	63
12	Number of Cows	head	354	319	313	342	376	310	303	300
13	Number of Calves Wintered	head	114	229	225	114	0	224	218	216
14	Number of Stocker Cattle	head	0	114	110	0	0	221	216	214
15	Rangeland Utilized	acres	3,040	3,040	3,040	3,040	3,190	3,190	3,190	3,190
16	Hay Utilized	tons	218	292	223	113	191	358	268	225
17	Labor Hired[d]	man-hours	726F/145S	170F/833S	486F/326Sp	629F	763F	889F	839F	831F
	Accounting Price of Land Use									
18	Rangeland	dollar/acre	3.86	7.46	7.89	5.40	3.41	7.70	7.65	8.15
19	Prairie Hay Land	dollar/acre	12.10	10.68	14.60	20.60	--	--	--	--
20	Cropland	dollar/acre	14.38	32.40	36.10	23.40	--	--	--	--
21	Class A Cropland	dollar/acre	46.20	40.80	46.00	56.70	--	--	--	--
	Twenty-Year Values[e]									
22	Rangeland	dollar/acre	38.00	89	94	41	18.40	92	91	97
23	Prairie Hay Land	dollar/acre	119	128	174	155	--	--	--	--
24	Cropland	dollar/acre	142	387	431	176	--	--	--	--
25	Class A Cropland	dollar/acre	456	487	550	427	--	--	--	--

Footnotes see Table D-I

APPENDIX D, TABLE I - VII, Footnotes:

[a]Typical points are defined as

O - Highest target rate of interest which justifies production. The operating capital (line 1) is the maximum amount that may be invested at this rate.

G - The level of operating capital which just permits to make efficient use of all rangeland allotted.

R - Level of operating capital which requires use of all rentable land allotted.

C - Capacity point. No further efficient increases in operating capital are possible, because the marginal return to capital would fall to zero or less (technically, an internal rate of interest of less than one per cent is taken as the cutoff point).

[b]Two interest rates for point G: the first one is the highest which just permits to use all the rangeland; the second is the one where further increases in operating capital are justified. The lower value is used to discount the 20-Year value of land at this point.

[c]Includes income from renting out land which cannot be used efficiently in production, at given rates of interest.

[d]F - Labor hired in the Fall (October - December);
Sp- Labor hired in the Spring (January - April);
S - Labor hired during five summer months (May - September).

[e]The present value of 20 annual marginal product values per acre (accounting price), discounted at a rate equivalent to the internal rate of interest at that level of operating capital used, but not less than 5.5 per cent.

[f]These are minimum accounting prices of land corresponding to a rental rate.

[g]The second figure applies at a zero internal rate of interest.

[h]Parentheses indicate a suboptimal organization for a 10 per cent or higher rate of interest.

[i]For the O and G points of this series see models S5/7 (appendix D, table II).

[j]For the O and G points of this series see models S-17/19 (appendix D, table VI).

[k]For the O and G points of this series see model S-20 (appendix D, table VI).

APPENDIX E, TABLE I

SPECIFICATION OF THE "FOUR AND FOUR" RANCH MODEL OF CHAPTER V.

i	Resource	b	Activities[a] 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	Cj		-2.50	2.65	-6.50	6.37	-5.0	-7.0	4.0	26.0	-1.0	-1.0	-1.0	-1.0		-18.0	-9.92	-16.87
1	range	2550	-1.0	1.0	-1.0	1.0									1.0		1.0	1.0
2	cropland	150			-1.0	1.0												1.0
3	class A	50			-1.0	1.0												
4	prairie hay	25															1.0	
5	range	rent 2400	1.0															
6	class A	opt. 150																
7	op. capital	0	2.50		6.50		-100	-100	100		1.0	1.0	1.0	1.0		18.0	9.92	16.87
8	"free" equity real estate[b]	21835					50											
9	free equity chattel[b]	0						25										
10	labor XI-III	800									-1.0							0.37
11	" IV-V	320										-1.0						
12	" VI-VII	320											-1.0					1.03
13	" VIII-X	480												-1.0				0.88
14	grazing	0													-1.5			
15	hay	0														-1.0	-1.1	-1.45
16	beef output	0								1.0								

continued

i	Activities[a] 17	1.04	1.05	1.07	1.08	1.11	1.01	1.06	2.01	2.01 2.02	2.04 2.05	2.04 2.06	2.07	2.06	2.06
0	-13.92	-22.19	-14.76	-17.58	-28.97	-24.92	-17.65	-40.49	-128.93	-132.02	-129.01	-131.39	-134.82	-142.06	-144.60
1	1.0		0.214		1.375	0.184						0.752	0.875		0.752
2	1.0		0.214		1.375	0.184						0.752	0.875		0.752
3			0.214			0.184									
4															
7	13.92	214.19	206.75	209.58	220.97	216.92	209.65	232.49	128.93	132.02	129.01	131.39	134.82	142.06	144.60
10		3.12	3.98	3.98	4.49	5.12	3.65	3.68	1.25	1.25	2.05	2.65	1.02		0.60
11	2.62	0.56	0.63	0.63	0.63	0.87	1.05	0.86		0.33	0.38	0.73	0.44	0.38	0.73
12	0.40	0.42	0.42	0.42	1.86	0.40	0.46	0.52		0.28	0.28	0.58	0.92	0.28	0.58
13		1.35	1.48	1.35	2.56	1.90	0.42	1.35	0.18	0.30	0.30	1.27	0.95	0.10	0.99
14		14.08	12.88	11.68	9.04	13.00	13.44	14.08	3.0	6.0	3.0	1.2	0.5	3.0	1.2
15	-1.25	0.03		0.88	0.29		0.03	0.03	0.05	0.05	1.0	1.0	0.33		
16		-3.775	-3.775	-3.840	-3.734	-3.840	-3.852	-4.285	-5.140	-6.349	-6.656	-6.854	-6.816	-6.349	-6.612

[a] description of activities
- 1 rent range
- 2 rent out range
- 3 rent class A cropland
- 4 rent out class A cropland
- 5 borrow against real estate equity as security
- 6 borrow against chattel as security
- 7 save (4% interest)
- 8 beef selling activity
- 9-12 hire labor
- 13 AUM transfer
- 14 buy hay
- 15 harvest prairie hay
- 16 harvest oats hay
- 17 harvest sudan hay

fall-calving cow-calf
- 1.04 cottonseed cake supplement
- 1.05 alfalfa hay supplement
- 1.07 prairie hay supplement
- 1.08 small grain pasture
- 1.11 silage supplement

spring-calving cow-calf
- 1.01 cottonseed cake supplement
- 1.06 calves creep fed
- 2.01 wintering calves on grass
- 2.01 summer pasture roughed calves
- 2.04 trap wintering calves
- 2.05 summer pasture for trap wintered calves
- 2.06 sudan grass pasture for trap-wintered calves
- 2.07 calves wintered on small-grain pasture

[b] credit line L is calculated as follows:

$$L = \frac{1}{m}(mV-D)$$

where V is the value of the asset to be mortgaged, D indebtedness, and m the minimum equity ratio acceptable to the credit institution. The expression in parenthesis is the "free" equity in the 8- column.

[c] this figure is varied parametrically from $12 to $35

APPENDIX E, TABLE II

FOUR AND FOUR RANCH, EXPECTED CONTRIBUTION TO PROFIT AND OVERHEAD, FEEDER/STOCKER PURCHASE PRICE (P_b) + $26; SELLING PRICE EXPECTATIONS FROM TABLE XX

		Ex Post Expected Selling Price			
		$16 - 22	$ 24	$26 - 28	$30 up
		Organization:			
Ex Ante Selling Price	Probability of Selling Price Occurring	C 588 cows (1.05)	D 565 cows (1.05) 216 calves (2.07)	E 65 cows (1.05) 475 cows (1.01) 338 calves (2.07)	K 869 calves (2.01) 354 calves (2.07) 869 yearlings (2.02)
		Expexted Contribution			
$16	0.041%	$12,212	$1,581	$-5,255	$-36,234
18	0.042	16,553	8,790	3,507	-28,304
20	0	20,993	15,998	12,268	-20,374
22	0.125	24,443	23,206	21,029	-4,512
24	0.333	29,874	30,414	29,791	11,348
26	0.207	34.314	37,622	38,552	27,208
28	0	38,754	44,830	47,313	43,069
30	0.250	43,195	52,038	56,074	58,930
Weighted Mean:		$32,096	$34,260	$34,480	$20,905

APPENDIX E, TABLE III

FOUR AND FOUR RANCH, EXPECTED CONTRIBUTION TO PROFIT AND OVERHEAD,
FEEDER/STOCKER PURCHASE PRICE (P_b) = \$22;
SELLING PRICE EXPECTATIONS FROM TABLE XX

		Ex Post Expected Selling Price			
		\$16 - 20	\$ 22	\$ 24	\$26 up
		Organization:			
		C	D	F	J
Ex Ante Selling Price	Probability of Selling Price Occurring	588 cows (1.05)	536 cows (1.01) 354 calves (2.07)	354 calves (2.07) 96 calves (2.01) 819 steers (2.05) 96 steers (2.02) 87 cows (1.01)	354 calves (2.07) 351 calves (2.01) 687 steers (2.05) 351 steers (2.02)
		Expected Contribution			
\$18	0.125	\$16,553	\$8,485	\$-10,985	\$-16,855
20	0.125	20,993	18,447	5,123	1,158
22	0.375	24,443	27,409	21,231	19,171
24	0.219	29,874	36,371	37,339	37,184
26	0.094	34,314	45,333	53,447	55,197
28	0.062	38,754	54,295	69,555	73,210
Weighted Mean:		\$26,026	\$29,238	\$24,743	\$23,098

APPENDIX E, TABLE IV

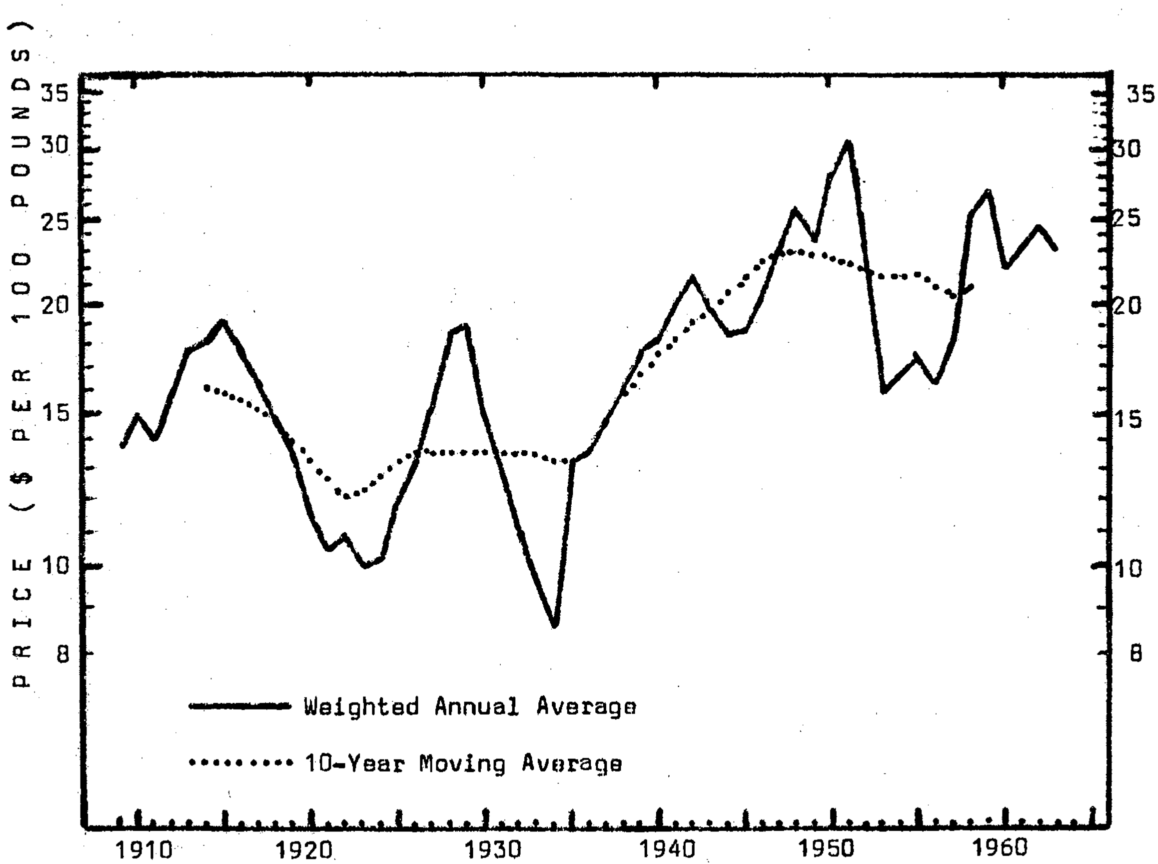
FOUR AND FOUR RANCH, EXPECTED CONTRIBUTION TO PROFIT AND OVERHEAD, FEEDER/STOCKER PURCHASE PRICE (P_b) = $18; SELLING PRICE EXPECTATIONS FROM TABLE XX

		Ex Post Expected Selling Price				
		$14	$16	$18	$20	$22
		Organization:				
Ex Ante Selling Price	Probability of Selling Price Occurring	B 291 cows (1.05)	C 588 cows (1.05)	D 569 cows (1.05) 108 calves (2.07)	G 174 cows (1.05) 83 calves (2.07) 1345 steers	I 298 calves (2.07) 1358 steers (2.05)
$14	0.05	$8,383	$7,672	$5,428	$-9,108	$-29,814
$16	0.05	10,581	12,112	11,198	3,572	-8,504
$18	0.50	12,779	16,553	16,968	16,252	12,806
$20	0.17	14,977	20,993	22,738	28,932	34,116
$22	0.23	17,175	25,433	28,508	41,610	55,737
Weighted Mean:		$13,834	$18,684	$19,738	$22,329	$23,035

APPENDIX E, TABLE V

FOUR AND FOUR RANCH, EXPECTED CONTRIBUTION TO PROFIT AND OVERHEAD,
FEEDER/STOCKER PURCHASE PRICE (P_b) = $30;
SELLING PRICE EXPECTATIONS FROM TABLE XX

		Organizations:			
Ex Ante Selling Price	Probability of Selling Price Occurring	C 598 cows (1.05)	D 574 cows (1.05) 207 calves (2.07)	E 552 cows (1.05) 320 calves (2.07)	K 657 calves (2.01) 354 calves (2.07) 657 yearlings (2.02)
$26.75	0.333	$35,905	$36,250	$35,606	$ -5,000
32	0.667	47,936	54,827	57,450	75,000
Weighted Mean:		$43,926	$48,618	$50,069	$ 52,000



Appendix E, Fig. 1. Weighted Annual Price Received by Oklahoma Farmers for Calves, 1903-63; deflated by U.S. index of prices paid by farmers for production and living expenses. Ratio scale. Source of data see appendix E, table VI.

APPENDIX E, TABLE VI

PRICES RECEIVED FOR CALVES BY OKLAHOMA FARMERS, 1909-1963
(DOLLARS PER 100 POUNDS)

Year	Annual Average Price[a]	Index of Prices Paid Production and Living[b]	Annual Average Price Deflated by Cost Index	Centered 10 Year Moving Average[c]	Annual Average Price Adjusted[d]
t	P_t	C_t	$P_{tc} = \frac{P_t \cdot C_{58}}{C_t}$	P_{at}	$P^* \frac{P_{tc} \cdot P_{58}}{P_{at}}$
1909	4.80	35[e]	13.71		
10	5.40	36	15.00		
11	4.95	36	13.75		
12	5.80	37	15.68		
13	6.60	37	17.84		
14	6.90	38	18.16	16.17	26.26
1915	7.30	38	19.21	15.96	28.14
16	7.50	42	17.86	15.60	26.77
17	8.80	55	16.00	15.19	24.63
18	9.30	67	14.53	14.55	23.34
19	9.80	73	13.42	13.76	22.80
1920	8.80	78	11.28	13.00	20.29
21	5.60	54	10.37	12.40	19.55
22	5.50	51	10.79	12.13	20.80
23	5.40	54	10.00	12.30	19.01
24	5.50	54	10.19	12.78	18.64
1925	6.70	56	11.97	13.24	21.14
26	7.20	55	13.09	13.53	22.62
27	8.30	54	15.37	13.66	26.31
28	10.40	56	18.57	13.65	31.81
29	10.40	55	18.91	13.55	32.63
1930	7.60	51	14.90	13.54	25.73
31	5.60	44	12.73	13.63	21.84
32	4.15	38	10.92	13.62	18.75
33	3.70	38	9.74	13.46	16.92
34	3.65	43	8.49	13.28	14.95
1935	6.00	45	13.33	13.38	23.29
36	6.10	45	13.55	13.91	22.77
37	7.10	48	14.79	14.80	23.36
38	7.20	45	16.00	15.86	23.59
39	7.80	44	17.73	16.89	24.54

Appendix E, Table VI continued

t	P_t	C_t	P_{tc}	P_{at}	P*
1940	8.20	45	18.22	17.67	24.11
41	9.60	48	20.00	18.29	25.57
42	11.80	55	21.45	19.05	26.33
43	12.40	61	20.33	19.95	23.83
44	11.90	64	18.59	20.73	20.97
1945	12.40	66	18.79	21.52	18.79
46	14.70	72	20.42	22.55	21.17
47	19.70	85	23.18	23.17	23.39
48	23.60	92	25.65	23.05	26.02
49	20.80	88	23.64	22.72	24.33
1950	25.30	90	28.11	22.54	29.16
51	30.60	100	30.60	22.27	32.13
52	23.40	100	23.40	21.92	24.95
53	15.20	96	15.84	21.55	17.18
54	15.80	96	16.46	21.68	17.75
1955	16.60	95	17.74	21.54	18.96
56	15.60	96	16.26	20.84	18.24
57	17.90	98	18.27	20.53	20.81
58	25.50	101	Ø 25,25	20.96	28.18
59	26.90	101	26.63		
1960	22.10	101	21.88		
61	23.50	101	23.27		
62	25.30	103	24.56		
63	24.10	104	23.17		

[a]Source:(60), p. 40.

[b]1957 = 1959 = 100. Source: (61), February 1964, p. 38.

[c] $P_{at} = \frac{1}{10} \sum_{t-4}^{t+4} P_t + \frac{1}{20} (P_{t-5} + P_{t+5})$

[d] Prices normalized to 1957-59 level. P_{58} = \$23.38

[e] Extrapolated.

APPENDIX F, TABLE I

INTERTEMPORAL RANCH MODEL; CONTRIBUTION TO PROFIT AND OVERHEAD GROSS REVENUE AND PRODUCTION EXPENSE FOR SELECTED BEEF PRICE LEVELS (VERSION A, B)

	Production Processes				Sales Processes			
Beef Price Index	k1 Steers	k2 Heifer Calves	k3 Heifers	k4 Cows	k5 Steer Calves	k6 Heifer Calves	k7 Heifers	k8 Cows
	Contribution to Profit and Overhead (c_{kj})							
70	97.27	-6.60	-26.84	-4.34	83.30	70.20	108.02	96.50
75	106.58	-6.33	-26.43	-3.47	89.42	75.38	116.00	103.75
80	115.92	-6.05	-26.03	-2.60	95.55	80.55	123.98	111.00
100	153.30	-4.95	-24.41	0.88	120.05	101.25	155.88	140.00
120	190.68	-3.85	-22.80	4.36	144.55	121.95	187.78	169.00
125	200.02	-3.58	-22.39	5.23	150.68	127.12	195.75	176.25
130	209.37	-3.30	-21.99	6.10	156.80	132.30	203.72	183.50
	Gross Revenue (Additions to Capital, End of Year, $-a_{k+1,1,j}$)							
70	126.77	3.73	5.41	11.58				
75	136.12	4.00	5.82	12.45		(identical with		
80	145.46	4.28	6.22	13.32				
100	184.84	5.38	7.84	16.80		c_{kj} values		
						above)		
120	220.22	6.48	9.45	20.28				
125	229.56	6.75	9.86	21.15				
130	238.91	7.03	10.26	22.02				
	Production Expense (Capital Requirement, Begin of Year, $a_{k1,j}$)							
all	29.54	10.33	32.25	15.92	0	0	0	0

$c_{kj} = a_{k+1,1,j} - a_{k1,j}$

APPENDIX F, TABLE II

CHANGES IN RANGE CAPACITY, MARKETING WEIGHT, INPUTS AND COSTS ASSOCIATED WITH GIVEN BEEF PRICE LEVELS.

Beef Price Index	Range Capacity % of normal	Marketing Weight % of normal	Hay		Other Feed Supplements	
			Supplement Pound per A.U.M.	Price $ per Ton	Calves $ per Head	Other $ per Head
70	85	94	50	24	6	3
75	87.5	95	41.7	23	5	2.50
80	90	96	33.3	22	4	2
100	100	100	0	18	0	0
120	110	104	0	14	0	0
125	112.5	105	0	13	0	0
130	115	106	0	12	0	0

APPENDIX F, TABLE III

INTERTEMPORAL RANCH MODEL: NET CONTRIBUTION TO PROFIT AND OVERHEAD, GROSS REVENUE AND TOTAL EXPENDITURES, VARIOUS PRICE LEVELS OF BEEF CATTLE AND INPUTS (VERSION C, D)

	Production Processes				Sales Processes			
Price Index	K1 steers	K2 heifer calves	K3 heifers	K4 cows	K5 steer calves	K6 heifer calves	K7 heifers	K8 cows
	Contribution to Profit and Overhead (c_{jk})							
70	74.22	-17.68	-42.02	-21.00	78.16	65.85	101.33	90.41
75	86.92	-15.42	-38.91	-17.14	84.83	71.49	110.02	98.31
80	99.77	-13.22	-35.90	-13.36	91.63	77.24	118.87	106.36
100	153.30	- 4.95	-24.41	0.88	120.05	101.25	155.88	140.00
120	200.20	- 3.19	-22.39	5.30	150.43	126.92	195.44	175.96
125	211.60	- 2.73	-21.76	6.45	158.33	133.59	205.73	185.31
130	222.82	- 2.27	-21.20	7.61	166.36	140.37	216.18	194.81
	Gross Revenue (additions to capital, end of year ($-a_{k+1,1,j}$)							
70	118.29	3.50	5.07	10.85				
75	128.48	3.80	5.45	11.80				
80	138.85	4.10	5.83	12.76		identical with		
100	182.84	5.38	7.84	16.80		c_{kj} values above		
120	225.57	6.74	9.75	21.11				
125	235.94	7.10	10.36	22.24				
130	246.13	7.46	10.89	23.38				
	Production Expense ($a_{k1,j}$)							
70	44.07	21.18	47.10	31.85		none		
75	41.56	19.22	44.36	28.93				
80	39.08	17.33	41.73	26.12				
100	29.54	10.33	32.25	15.92				
120	25.37	9.93	32.14	15.81				
125	24.34	9.83	32.12	15.79				
130	23.31	9.73	32.09	15.76				

$c_{kj} = a_{k+1,1,j} - a_{k1,j}$

APPENDIX F, TABLE IV

INTERTEMPORAL RANCH MODEL, ANNUAL CONTRIBUTIONS AND PROCESS LEVELS, ALL VARIANTS.

Run No.	Price Levels							
	100	120	125	130	100	70	75	80
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Contribution to Profit and Overhead, from Ranch Enterprises [$]							
1 A	7877	12402	15637	34616	-2264			
B	7877	12402	15637	22186	8709			
C	7366	10613	16436	40501	0			
D	7366	10613	16436	31401	9525			
2 A		8294	15915	28740	25819	-14946		
B		8294	15915	24543	7436	5323		
C		7784	13234	48065	0	0		
D		7129	7952	33800	2525	3075		
3 A			8758	21559	15591	-450	11153	
B			8745	21559	13200	4709	5948	
C			7595	37368	7304	0	0	
D			7589	37295	5566	1729	2961	
4 A				14032	16519	-927	10322	8592
B				14032	17056	-592	9594	6796
C				22603	11813	-2174	6481	2186
D				13299	16451	-1842	5742	3792
5 A	15489				14202	1697	7582	6941
B	9845				14492	1638	7252	9701
C	3629				15436	1819	5900	5752
D	8898				14567	2067	6092	6026
6 A	8192	19872				6639	7546	6565
B	11360	12527				6638	7291	6784
C	6901	-2244				5068	6001	5816
7 A	7376	14748	21534				6755	7917
B	9839	10941	20392				6748	7845
C	6883	6943	-10587				5410	6001
D	7136	7420	9615				1927	5483
8 A	8134	14483	14758	22406				7076
B	8284	15530	19080	13638				7035
C	7010	7469	7235	15617				8592

Appendix F, Table IV continued

(2)

(1)	100 (2)	120 (3)	125 (4)	130 (5)	100 (6)	70 (7)	75 (8)	80 (9)
	k1 Stocker Steers [head]							
1 A		40.5	57.1	52.2	0			
B		40.5	57.1	52.2	0			
C		7.8	58.4	58.5	0			
D		7.8	58.4	58.5	0			
2 A			58.3	52.6	0	0		
B			58.3	52.6	0	0		
C			27.3	58.5	0	0		
D			2.9	51.4	0	0		
3 A				58.3	0	0	38.9	
B				58.3	0	0	0	
C				37.2	0	0	0	
D				36.8	0	0	0	
4 A					0	0	50.7	46.0
B					0	0	45.2	0
C					0	0	45.5	39.1
D					0	0	36.5	0
5 A	49.0					0	25.8	34.2
B	4.5					0	26.1	31.4
C	12.0					0	0	0
D						0	7.6	0
6 A	1.6	51.9					0	0
B	7.4	2.4					0	0
C	0	0					0	0
7 A	19.4	55.2	52.4					1.6
B	19.2	31.1	41.4					1.6
C	0	0	0					0
D	0	0	0					0
8 A	10.9	55.3	52.7	51.2				
B	10.3	54.5	47.7	5.1				
C	0	0	0	31.2				
	k2 Heifers Raised [head]							
1 A	20.0	3.7	20.2	52.2	0			
B	20.0	3.7	20.2	52.2	19.1			
C	20.0	41.3	19.2	58.6	0			
D	20.0	41.3	19.2	58.6	19.1			

Appendix F, Table IV continued

(3)

(1)	100 (2)	120 (3)	125 (4)	130 (5)	100 (6)	70 (7)	75 (8)	80 (9)
2 A		20.0	19.9	52.6	45.2	0		
B		20.0	19.9	52.6	45.2	19.1		
C		20.0	36.7	58.6	0	0		
D		20.0	50.2	51.5	28.9	20.0		
3 A			20.0	20.0	52.6	0	38.9	
B			20.0	20.0	52.6	50.5	21.5	
C			20.0	58.7	0	0	0	
D			20.0	58.7	0	45.6	18.9	
4 A				20.0	52.8	0	50.8	46.0
B				20.0	52.8	22.1	45.2	21.1
C				20.0	0	0	45.5	39.1
D				20.0	53.3	4.0	44.6	20.0
5 A	49.2				20.0	0	55.1	34.5
B	20.0				20.0	8.9	52.6	47.9
C	40.5				20.0	0	49.3	45.2
D	17.5				20.0	0	36.7	47.3
6 A	58.4	51.9				20.0	46.1	22.5
B	50.0	19.1				20.0	46.1	52.6
C	4.2	11.8				12.5	15.2	7.3
7 A	13.8	21.5	52.4				20.0	51.8
B	21.4	35.4	19.1				20.0	51.8
C	0	0	0				0	0
D	33.9	32.0	8.7				20.0	36.0
8 A	30.8	14.0	21.6	51.3				20.0
B	36.0	41.8	47.7	20.0				20.0
C	8.3	30.4	34.3	35.3				0
	k3 Heifers with Calf [head]							
1 A	18.2	14.9	3.5	0	0			
B	18.2	14.9	3.5	0	48.6			
C	18.2	19.0	18.7	0	0			
D	18.2	19.0	18.7	0	34.7			
2 A		18.2	0	0	0	0		
B		18.2	0	0	20.6	43.0		
C		19.0	18.3	0	0	0		
D		19.0	19.0	12.6	0	27.4		
3 A			18.2	0	0	0	0	
B			18.2	0	16.8	0.3	47.9	
C			19.0	0	0	0	0	
D			19.0	0.3	0	0	43.4	

Appendix F, Table IV continued (4)

(1)	100 (2)	120 (3)	125 (4)	130 (5)	100 (6)	70 (7)	75 (8)	80 (9)
4 A				18.2	0	17.9	0	0
B				18.2	0	0	21.0	42.7
C				19.0	0	0	0	0
D				19.0	0	9.9	3.8	42.4
5 A	0				18.2	8.0	0	24.4
B	39.5				19.0	0	8.5	16.2
C	0				18.2	0	0	5.1
D	25.1				19.0	5.3	0	0
6 A	0	0				18.2	0	32.7
B	16.5	35.1				18.2	0	15.3
C	0	0				0	0	0
7 A	32.7	1.9	0				18.2	0
B	28.4	20.4	7.0				18.2	0
C	0	0	0				0	0
D	0	10.4	30.4				0	13.7
8 A	9.0	13.0	13.0	0				18.2
B	6.2	0	14.0	43.8				19.0
C	0	0	18.6	0				0
	k4 Cows							
1 A	120.0	119.5	116.2	103.2	88.7			
B	120.0	119.5	116.2	103.2	88.7			
C	120.0	119.5	119.9	120.0	0			
D	120.0	119.5	119.9	120.0	103.2			
2 A		120.0	119.5	102.8	88.4	0		
B		120.0	119.5	102.8	88.4	94.6		
C		120.0	120.3	120.0	0	0		
D		100.6	103.6	106.2	102.7	88.3		
3 A			120.0	119.5	102.8	88.4	76.0	
B			120.0	119.5	102.8	103.6	89.4	
C			120.0	120.3	103.5	0	0	
D			120.0	120.3	103.7	89.2	76.7	
4 A				120.0	119.5	102.8	104.5	89.9
B				120.0	119.5	102.8	88.4	94.9
C				120.0	120.3	103.5	89.0	76.5
D				107.7	109.7	94.3	90.0	80.9
5 A	103.3				120.0	119.5	110.0	94.6
B	97.2				119.2	119.6	102.8	96.1
C	80.7				120.0	119.5	102.8	88.4
D	79.6				119.2	119.6	107.6	92.5

Appendix F, Table IV continued

(5)

(1)	100 (2)	120 (3)	125 (4)	130 (5)	100 (6)	70 (7)	75 (8)	80 (9)
6 A	117.9	101.3				120.0	119.5	102.8
B	102.2	102.8				120.0	119.5	102.8
C	76.3	65.6				120.0	103.0	88.8
7 A	102.8	117.8	103.0				120.0	119.5
B	102.8	103.3	107.3				120.0	119.5
C	55.4	38.5	22.6				95.0	77.2
D	72.8	62.6	63.2				81.8	70.3
8 A	119.5	110.9	107.0	104.0				120.0
B	119.6	108.4	93.2	97.2				119.2
C	90.5	77.9	67.0	74.4				105.3
	k5 Sell Steer Calves							
1 A	17.8	0	0	45.4	39.0			
B	17.8	0	0	45.4	53.8			
C	50.5	0	0	52.8	0			
D	50.5	0	0	52.8	55.9			
2 A		0	0	45.4	38.9	0		
B		0	0	45.2	45.2	54.7		
C		31.3	0	52.8	0	0		
D		41.7	0	50.6	45.2	47.2		
3 A			0	52.6	45.2	0	33.5	
B			0	52.6	50.3	45.7	53.9	
C			21.3	52.9	45.5	0	0	
D			21.7	53.0	45.6	39.3	46.9	
4 A				58.3	52.6	0	0	39.5
B				58.3	52.6	0	45.3	54.7
C				58.6	52.9	0	0	33.7
D				53.1	48.3	8.0	40.8	48.4
5 A	45.4				58.3	29.2	14.2	0
B	54.8				58.2	26.6	16.5	42.7
C	35.5				58.3	52.6	45.2	28.4
D	42.6				58.2	46.6	47.3	40.7
6 A	0	44.6				58.3	52.6	53.2
B	47.6	55.9				58.3	52.6	42.5
C	33.6	28.9				52.8	45.4	39.1
7 A	0	0	45.3				56.7	33.2
B	26.4	0	51.6				56.7	33.4
C	24.4	16.9	9.9				41.8	33.9
D	32.0	30.7	37.1				36.0	35.1

Appendix F, Table IV continued

(6)

(1)	100 (2)	120 (3)	125 (4)	130 (5)	100 (6)	70 (7)	75 (8)	80 (9)
8 A	0	0	0	45.8				47.3
B	0	0	40.1	54.1				47.9
C	39.8	34.3	3.9	32.7				46.3
k6 Sell Heifer Calves								
1 A	54.7	37.0	0	45.4	39.0			
B	54.7	37.0	0	26.3	34.1			
C	17.2	39.3	0	52.8	0			
D	17.2	39.3	0	33.7	36.2			
2 A		38.5	0	0	38.9	0		
B		38.5	0	0	26.2	35.0		
C		22.0	0	52.8	0	0		
D		0	0	21.8	25.2	27.4		
3 A			38.5	0	45.2	0	33.5	
B			38.5	0	0	24.2	34.3	
C			0	52.9	45.5	0	0	
D			0	53.0	45.6	39.3	46.9	
4 A				5.7	52.6	0	0	39.5
B				5.7	30.5	0	24.4	35.5
C				58.7	52.9	0	0	33.7
D				0	44.2	0	20.8	28.8
5 A	45.4				58.4	0	13.9	0
B	35.1				49.4	0	0	27.3
C	35.5				58.4	3.3	0	0
D	25.3				58.3	17.6	0	23.2
6 A	0	44.6				12.4	30.1	0.6
B	31.0	36.2				12.4	0	0
C	21.7	28.9				37.6	38.1	34.9
7 A	33.9	0	45.3				6.7	38.8
B	43.8	33.6	31.5				6.6	31.2
C	24.4	16.9	9.9				41.8	33.9
D	0	22.1	17.3				0	1.4
8 A	41.4	31.1	0	45.8				27.6
B	12.8	0	25.4	34.4				22.3
C	9.5	0	0	32.7				38.1
k7 Heifers sold								
1 A	4.1	0	19.2	49.6	0			
B	4.1	0	19.2	1.1	0			
C	0	20.4	18.3	55.7	0			
D	0	20.4	18.3	20.9	0			

Appendix F, Table IV continued

(7)

(1)	100 (2)	120 (3)	125 (4)	130 (5)	100 (6)	70 (7)	75 (8)	80 (9)
2 A		19.0	18.9	50.0	43.0	0		
B		19.0	18.9	29.4	0	0		
C		0.7	34.9	55.7	0	0		
D		0	35.1	48.9	0	0		
3 A			19.0	19.0	50.0	0	37.0	
B			19.0	2.2	49.6	0	2.3	
C			19.0	0	0	43.2	37.2	
D			0	53.0	0	20.3	29.7	
4 A				19.0	32.0	0	48.3	43.7
B				19.0	50.1	0	0.3	1.9
C				19.0	55.8	0	0	0
D				19.0	40.7	0	0	0
5 A	46.7				11.0	0	27.9	32.8
B	0				19.0	0	33.7	6.0
C	38.5				19.0	0	41.7	43.0
D	0				13.7	0	34.8	19.9
6 A	52.1	49.3				19.0	11.0	21.4
B	12.4	0				19.0	28.4	33.4
C	4.0	11.2				11.9	14.5	6.9
7 A	11.2	20.4	49.8				19.0	16.6
B	0	6.3	0				19.0	20.8
C	0	0	0				0	0
D	21.8	0	8.3				5.3	34.2
8 A	16.3	0	20.6	48.7				10.0
B	34.2	25.7	1.5	0				12.8
C	7.9	10.2	32.5	33.5				0
k8 Cows sold								
1 A	0	0	0	0	76.3			
B	0	0	0	0	0			
C	0	0	0	103.2	0			
D	0	0	0	0	0			
2 A		0	0	0	0	76.1		
B		0	0	0	0	0		
C		0	0	103.2	0	0		
D		0	0	0	0	0		
3 A			0	0	0	0	65.4	
B			0	0	0	0	0	
C			0	0	89.0	0	0	

Appendix F, Table IV continued

								(8)
	100	120	125	130	100	70	75	80
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
4 A				0	0	0	0	77.3
B				0	0	0	0	0
C				0	0	0	0	65.8
D				0	0	0	0	0
5 A	88.8				0	0	0	0
B	0				0	0	0	0
C	69.4				0	0	0	0
D	13.3				0	0	0	0
6 A	0	87.2				0	0	0
B	0	0				0	0	0
C	0	56.5				0	0	0
7 A	0	0	88.6				0	0
B	0	0	0				0	0
C	9.2	10.5	19.4				4.6	11.0
D	0	0	0				0	0
8 A	0	0	0	89.5				0
B	0	0	0	0				0
C	0	0	0	64.0				0
	k9 Capital Transfer (capital surplus)							
1 A	50	0	4430	12320	39800			
B	50	0	4430	12320	25610			
C	50	0	2620	11800	69430			
D	50	0	2620	11800	35140			
2 A		50	200	9180	30950	45450		
B		50	200	9180	26100	20750		
C		40	0	5920	6470	44790		
D		350	0	0	28760	21330		
3 A			50	670	20170	27540	13290	
B			50	670	16200	19700	12460	
C			50	0	32060	42910	27330	
D			50	0	31990	22000	11630	
4 A				50	7320	15610	3090	6200
B				50	7320	16510	3590	6250
C				50	16380	16540	2020	2240
D				250	6720	13570	4210	0
5 A	0				50	7780	0	0
B	3010				30	8240	0	0
C	0				50	7380	600	0
D	0				30	6270	0	0

Appendix F, Table IV continued

								(9)
	100	120	125	130	100	70	75	80
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
6 A	0	0				50	0	0
B	0	4220				50	0	0
C	0	0				1410	0	0
7 A	0	0	6810				50	0
B	0	0	4320				50	0
C	0	0	0				0	-900
D	0	0	0				0	0
8 A	0	0	6540	13200				50
B	0	0	7480	18680				30
C	0	0	0	0				0
k02 Unused Range								
1 A	0	0	0	0	508			
B	0	0	0	0	12			
C	0	0	0	0	1250			
D	0	0	0	0	6			
2 A		0	0	0	296	1250		
B		0	0	0	124	9		
C		118	0	0	1250	1250		
D		280	135	63	255	0		
3 A			0	0	141	511	326	
B			0	0	0	142	0	
C			149	54	385	1062	1094	
D			149	52	383	100	0	
4 A				0	0	241	0	158
B				0	0	286	0	0
C				180	244	198	12	195
D				284	80	172	0	0
5 A	22				0	184	0	0
B	0				0	208	0	0
C	351				0	63	0	128
D	292				0	19	0	127
6 A	0	18				0	32	10
B	0	0				0	32	13
C	592	770				0	159	348

Appendix F, Table IV continued (10)

(1)	100 (2)	120 (3)	125 (4)	130 (5)	100 (6)	70 (7)	75 (8)	80 (9)
7 A	0	0	0				0	0
B	0	0	0				0	0
C	787	1053	1218				299	480
D	480	612	582				315	252
8 A	0	0	0	0				0
B	0	0	0	0				0
C	454	580	528	565				245

APPENDIX F, TABLE V

INTERTEMPORAL RANCH MODEL; AMOUNTS BY WHICH OPERATING CAPITAL COULD BE INCREASED BEFORE A CHANGE IN RATE OF RETURN OCCURED.

Run No.	Year of Run				
	1	2	3	4	5
normal	-	3390	-	-	-
1 A,B	-	460	-	-	-
C,D	-	650	-	-	-
2 A,B	-	-	-	-	-
C	-	2670	-	-	-
D	-	510	3050	-	-
3 A,B	-	-	-	-	-
C	-	680	-	-	-
D	-	2130	-	-	-
4 A,B,C	-	-	-	-	-
D	-	-	-	-	80
5 A	-	-	1860	1370	1810
B	-	-	1830	2400	-
C	-	-	-	780	1460
D	-	-	550	580	840
6 A	-	40	60	50	100
B	-	720	1220	560	-
C	-	590	650	370	1320
7 A	-	120	1390	1330	-
B	-	120	1440	2700	-
8 A	-	780	570	-	-
B	-	650	330	-	-
C	310	720	2290	830	5670

APPENDIX F, TABLE VI

INTERTEMPORAL RANCH MODEL; SOME ADDITIONAL CHARACTERISTICS OF VARIABLE PRICE RUNS: BEEF PRICE CHANGES ONLY

Run No.	Price Level		Operating Capital Accumulated		Consumption and Fixed Cost	
	Beginning	Average	A	B	A	B
1	100	115	23,990	25,380	18,320	15,480
2	120	111	14,410	18,010	24,160	18,240
3	125	100	10,550	12,110	19,344	16,820
4	130	89	9,818	7,900	13,460	13,740
5	100	85	12,090	8,406	8,570	9,260
6	70	89	15,620	11,882	7,000	7,850
7	75	100	23,713	21,694	8,370	7,870
8	80	111	29,651	24,842	10,960	12,240
Average	100	100	17,480	16,280	13,770	12,790
"Normal"	100	100	20,516	16,930	7,770	8,000

VITA

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Doctor of Philosophy

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