Economics of Size of Cattle Ranches and Wheat Farms and a Comparison of Management Alternatives for Marginal Cropland in Utah

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ECONOMIES OF SIZE OF CATTLE RANCHES AND WHEAT FARMS AND A COMPARISON OF MANAGEMENT ALTERNATIVES FOR MARGINAL CROPLAND IN UTAH

by

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John P. Workman

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF FIGURES

ABSTRACT

Economies of Size of Cattle Ranches and Wheat Farms

And a Comparison of Management Alternatives

For Marginal Cropland in Utah

by

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Five long-run average cost curves were derived from questionnaire and interview data by connecting points corresponding to the per unit production costs and levels of beef output for four cattle ranch sizes (50, 150, 300, and 500 head of breeding cows). Analysis of the long-run average cost curves in combination with the 1968 weighted Utah beef price revealed that all four ranch sizes studied are capable of meeting cash costs. If the goal of the ranch operator is to meet both cash costs and depreciation, a cattle ranch supporting 105 breeding cows is the minimum size necessary. If provision is made to cover cash costs and depreciation in addition to receiving a fair return for operator and family labor, the ranch must support at least 360 breeding cows. None of the four ranch sizes studied were capable of meeting all production costs including five per cent interest on investment. The minimum ranch size necessary to cover all production costs including 1.4 per cent interest on investment is 500 head of breeding cows.

Farmer questionnaires and the machine capacity technique provided data from which five long-run average cost curves were derived by connecting points representing average production costs and levels of wheat output for four sizes of wheat farms (500, 1000, 2000, and 3000 acres). The long-run average cost curves were analyzed in combination with the 1968 Utah wheat price. All four wheat farm sizes studied are capable of meeting cash costs. In order to cover both cash costs and depreciation a wheat farm of at least 940 acres is required. The minimum wheat farm size necessary to meet cash costs and depreciation as well as provide a fair return to operator and family labor is 2430 acres. None of the four sizes of wheat farms studied was large enough to cover all costs including interest on investment at five per cent. In order to cover all production costs including 0.64 per cent interest on investment a wheat farm of at least 3000 acres is required.

Costs and returns to five management alternatives for marginal Utah cropland ((1) wheat production by owner-operator, (2) leasing cropland to tenants for dryland wheat production, (3) leasing forage on an AUM basis, (4) leasing of forage on a livestock gain basis, and (5) stocker cattle production by the land owner) were compared in the short-run, in the long-run assuming that all inputs were variable, and in the long-run assuming that land and operator and family labor were fixed.

For the marginal cropland owner who also owns wheat production factors, wheat production on an owner-operator basis is the most favorable short-run alternative. Wheat production on a tenant basis is the only short-run alternative open to cropland owners who own neither wheat production factors nor the improvements necessary for grazing enterprises. Leasing forage on a livestock gain basis is the most favorable short-run alternative for cropland owners whose holdings are equipped with grazing improvements.

For the long-run situation in which all inputs were considered variable, all five management alternatives yielded negative returns. Under such conditions a rational land owner would refuse to choose from among the five alternatives studied and would instead liquidate his land holdings.

When operator and family labor and land were considered fixed, leasing cropland to tenants for dryland wheat production proved to be the most favorable long-run management alternative. Showing the second highest internal rate of return was leasing forage on a livestock gain basis followed by stocker cattle production by the land owner. Wheat production by the land owner and leasing forage on an AUM basis proved to be the least favorable long-run management alternatives on marginal cropland.

(131 pages)

INTRODUCTION

The General Problem

Since 1956 several hundred thousand acres of marginal Utah cropland (primarily non-irrigated wheat land) have been converted from crop production to a perennial grass cover of primarily crested wheatgrass under the Conservation Reserve Program (CRP) (Parker and Roberts, 1965). Most of the land involved was placed in the soil bank program under ten year contracts which have recently terminated. All of the land under CRP contracts will be released by 1970. Expiration of the contracts will present farmers with the problem of choosing between various alternatives associated with leaving this land in a permanent grass cover or returning it to one of several cropping enterprises (Roberts and Harris, 1961). Little information is currently available to aid farmers and government agency personnel in making rational decisions concerning the economically optimum employment of the marginal croplands of Utah.

Many farmers under contract with the CRP are nearing retirement age and are apparently reluctant to shift from the traditional enterprise of wheat production to other enterprises on the released lands (Parker and Roberts, 1965). Since ownership of wheat machinery has been retained during the contract period, existing farmers compare management alternatives from the viewpoint of the short-run only. Farmer retirement, however, will undoubtedly lead to the transfer of much of the soil bank lands to new owners who will be less reluctant to consider alternative land uses. Prior to committing capital to machinery and improvements, new owners can examine various management alternatives from the viewpoint of the long-run. Thus it is of vital importance to obtain comparisons of costs and returns to potential alternative enterprises. Since the released lands will be transferred to both initial investors in the factors of wheat and beef production and to owners of existing operations interested in enterprise expansion, information is needed concerning the cost-size relationships of beef and wheat production. As pointed out by Faris and Armstrong (1963), reduction in per unit costs as the size of the farm increases is of special concern to policy makers, as well as farm operators. Policy makers require knowledge of economies associated with size to guide them in the formulation of farm programs.

Purpose and Scope of the Study

Knowledge of the effects of economies of size is essential to the determination of the sizes of cropping and grazing operations necessary to justify investment in the factors of production associated with the two types of marginal land use. Such knowledge is also necessary for meaningful comparisons to be made of the various alternative enterprises since such comparisons must be made according to size of operation.

The objectives of the study are the determination of the following for the State of Utah:

(1) Per unit costs of beef production by size of operation.

(2) Per unit costs of wheat production by size of operation.

(3) Minimum sizes of crop and livestock enterprises to justify investment at current prices.

(4) Break-even prices of wheat and beef by size of operation at current production costs.

(5) Comparisons of costs and returns to potential management alternatives on marginal cropland according to size of operation.

Alternatives to be compared in objective number (5) above are:

(a) wheat production (owner-operator basis)

(b) wheat production (rental basis)

(c) leasing of forage (animal unit month basis)

(d) leasing of forage (pounds of livestock gain basis)

(e) use of forage for stocker cattle by owner-operator.

Theoretical Framework for Cost Analysis

Faris and Armstrong (1963) define size of a firm in terms of resources which are fixed in the short-run where the short-run represents a situation where at least one factor of production is fixed in quantity and cannot be varied. Thus the size of the firm cannot be adjusted in the short-run but output per firm can vary within the limits established by the fixed resources associated with a given plant size.

Short-run average cost (SRAC) curves show the effect on the per unit costs of production as more or less of the variable factors are applied to the fixed factors (Figure 1). SRAC curves exhibit the characteristic "U" shape due to the spreading of fixed costs and to the law of variable proportions of inputs. SRAC curves first decrease as fixed costs are spread over more units of output and as increased efficiency in production is brought about as the variable factors of production are intensified on the fixed factors. This region of the SRAC curve is analogous to the rising portion of the average product curve. The average variable cost (AVC) is equal to P_a/AP_a where P_a = price of variable input and AP_a = average product of variable input. AVC also equals TVC/X (by definition) where TVC = total variable cost

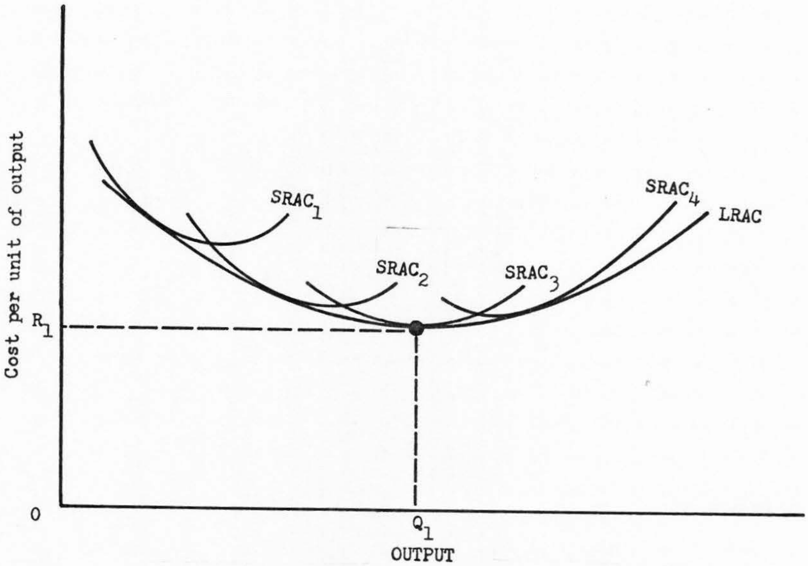

Figure 1. Hypothetical short-run and long-run average cost curves for farms of different sizes.

and X = amount of output. AP_a equals X/a (by definition) where a = amount of variable input and P_a may be written as TVC/a. Thus AVC may also be written $\frac{TVC/a}{X/a}$ or P_a/AP_a. Since P_a is constant under pure competition, AVC must decrease as AP_a increases and vice-versa. The SRAC curve eventually exhibits an increasing portion even though fixed costs are spread over more and more units of output as the level of production increases.

A unique SRAC curve exists for each unique combination of fixed factors (each complement of machinery, buildings, and equipment). Thus SRAC curves exist which lie above those shown in Figure 1. Consequently those shown arise from the most efficient combination of factors which are capable of producing each level of output.

The long-run average cost (LRAC) curve (the long-run situation being one in which all inputs are variable) is formed by drawing an "envelope" curve tangent to the SRAC curves (Figure 1). Each point on the LRAC curve represents a unique combination of buildings, machinery, equipment, land, and labor. As pointed out by Faris and Armstrong (1963), the LRAC curve shows the least-cost combination of inputs required to produce each given level of output. In the long-run, with pure competition, firm size will tend toward the output corresponding to the minimum point on the LRAC curve (Q_1). At this output SRAC = short-run marginal cost = LRAC = long-run marginal cost = marginal revenue (= average revenue = price = R_1 in Figure 1) which defines equilibrium in the purely competitive market situation.

In a classic treatment of the theory of economies of scale (phenomena which cause unit costs to decrease as the size of plant increases), Viner (1950) observed that the point of tangency between the SRAC and LRAC did not correspond to the minimum SRAC except at one level of output, that level being the one where the LRAC was also at a minimum (Figure 1). Viner further observed that economies may be either internal (due to expansion of the individual firm) or external (due to expansion of the entire industry). Internal economies may be pecuniary economies which lower the market price (such as volume buying discounts) or technological economies which shift the production function in an upward direction (such as labor specialization). External economies may also take the form of either pecuniary economies (such as increased demand for raw materials allowing suppliers of raw materials to expand output and ultimately pass on a lower price to buyers) or technological (such as industry growth making it possible to increase efficiency through worker training programs).

In a discussion of cost diseconomies (phenomena which cause unit costs to increase as the size of the plant increases), Heady (1952) distinguishes between internal pecuniary diseconomies (such as the growth in firm size making it necessary for the firm to bid labor away from other uses by paying higher prices) and internal technological diseconomies (such as the ability of management becoming limiting as firm size increases). Distinction is also made between external pecuniary diseconomies (such as the industry expanding to the point where inputs must be bid away from competing industries) and external technological diseconomies (such as irrigation pumping costs increasing due to the lowering of the water table as the number of farms increases).

Heady also is careful to distinguish between scale and proportionality avenues of plant size increase. A scale relationship is one in which all inputs are increased in the same proportion. If product increases by the same, greater, or smaller proportion then returns to scale are termed constant, increasing, or decreasing, respectively. A proportionality relationship is one in which at least one input is intensified upon by an increase in the use of one or more other inputs. Thus farm "size" can be increased by an increase in variable input (an increase in intensity of use of the fixed factor) or an increase in fixed input (an increase in the size of the fixed plant).

Giaever and Seagraves (1960) listed specialization of labor, circumference-area-volume relationships, volume buying and selling, and set up times associated with inputs as the most common sources of economies of scale in agriculture. However, internal technological economies of proportionality adjustment (increased capital:labor ratio) were deemed the most important of all farm cost economies by Heady (1952).

In discussing the use of the LRAC curve as a planning curve, Heady also observed that capital restrictions may prohibit the individual firm from viewing it as such. Also, the LRAC curve is only an approximation of a "practical" planning curve because of the indivisability of machinery and other inputs. Once the set of machinery (fixed factor) has been selected by use of the LRAC (planning) curve, the LRAC curve becomes irrelevant and the operator is restricted to the particular SRAC curve corresponding to the machinery combination selected.

Concerning the question of the "U" shape of LRAC curves, Dean and Carter (1960) noted that there are currently two schools of thought. The first maintains that, since by definition all factors are variable in the long run, the LRAC may approach a constant and never rise. The second states that as firm size increases "red tape" (leading to a lack of communications) increases and the LRAC turns up. Dean and Carter

(1962) also present interesting models showing how the progressive income tax system can cause the LRAC curve to increase at high levels of output.

It was suggested by Dean and Carter (1960) that increased risk would prohibit further expansion in firm size at some maximum production level even if the LRAC decreased indefinitely. Martin and Goss (1963) proposed an additional reason for the failure of ranch firms to expand beyond a certain level of output even though costs were constant. They suggested that ranchers may place higher and higher costs on the required management duties as firm size increases. This is related to the conventional explanation of the rise of long run average cost curves as due to the inability of management to be spread indefinitely.

LITERATURE REVIEW

In a study of the cost-size relationships of Kern County, California cash-crop farms, Faris and Armstrong (1963) derived the LRAC curve by selecting four levels of output (rather than the conventional method of choosing particular plant sizes) and then determining the least cost combination of inputs to produce the chosen levels of output. Thus their LRAC curve represented what was possible rather than what most farmers were doing. In their opinion this method gives nearly the same LRAC curve as is obtained by allowing an envelope curve to come tangent to the various SRAC curves. These investigators subjected machinery costs to particular study because machinery represents a commonly cited source of cost economy (due to the increase in the capital:labor ratio). Machinery was treated as the fixed factor while land, labor, gasoline, etc. became the variable productive factors. The rate of accomplishment technique was employed in which each component part of the operation is specified along with the time and inputs required.

The only short-run source of machinery economies in the Faris and Armstrong study was the spreading of fixed costs since average variable costs of machinery were assumed to be constant over the complete range of production afforded by the four fixed complements of machinery. Although not mentioned by the authors, such an assumption implies that the law of variable proportions is inoperative and that increased labor, land, fuel, etc. can produce output at an increased rate only if combined with a larger complement of machinery. Thus, the total product curves are assumed to be linear and the slopes of the four production functions for each of the four sets of machinery increase in discrete "jumps" giving rise to constant average variable cost curves which also show discrete reductions as the machinery complement becomes larger in a step-wise manner. Basic economic theory would predict that the average variable cost of machinery would decrease as the addition of labor allows machines to be used more intensively. However, this would assume that the production function increases at an increasing rate due to labor specialization and perhaps to the release of the machine operator from such chores as repairing machinery during the critical harvest period. The differences in slope of the four linear production functions might be explained by the avoidance of "bottleneck" situations (i.e., at planting or harvest time) as the size of the machinery complement is increased. The authors do not attempt to justify their unconventional assumptions.

Martin and Goss (1963) approached the problem of the cost-size relationship of southwestern Arizona cattle ranches in a similar manner. Since rangeland has a given grazing capacity, they found it useful to treat land as a variable input along with feed, gasoline, etc. while buildings, equipment, and labor were designated as fixed inputs. Labor was considered the limiting factor in determining the short-run capacity of each operation when land and cattle numbers were varied in constant proportion. The fixed costs included repairs, depreciation, taxes, insurance, labor, and interest (on fixed investment). The variable costs included repairs, depreciation, taxes, insurance, and interest (on variable factors) as well as conventional variable factors such as feed. The values of land, improvements, horses, and cattle varied as output was varied in the development of SRAC curves for each investment group.

It was assumed, however, that average variable costs were constant over the range of output made possible by the fixed complement of labor, buildings, and equipment and that all short-run economies were due to the spreading of fixed costs. This means that the authors assumed that the law of variable proportions was not operating. Thus, in the short-run, two acres of rangeland are capable of supporting exactly twice as many cattle as one acre and the rate of production cannot be increased until the fixed supply of labor, buildings, and equipment is increased. Again the increase in the slopes of the linear production functions as the fixed factors are increased in discrete portions might be explained by bottleneck situations (i.e., labor at calving time). The authors do not attempt to justify their unconventional assumption.

Martin and Goss also hypothesized that the rising portions of SRAC curves for cattle ranches were nearly vertical due to a definite limit to the capacity of the fixed factors. For this reason and also because the rising portion is irrelevant to the derivation of the decreasing range of the LRAC curve, the rising portions of the SRAC curves were ignored in their analysis.

Concerning the question of whether interest on investment should be included as a production cost (in the form of an opportunity cost which may be defined as the rate of return on the best alternative enterprise) Martin and Goss (1963) report that all sizes of Arizona cattle ranches are experiencing losses if all inputs including the opportunity costs of capital are charged for at market prices. The authors point out that since ranchers do remain in business, either they do not recognize opportunity costs of capital or not all returns were recognized in the Arizona study. Some ranchers inherited or purchased property before the recent great increase in land values. These ranchers stay in business by sacrificing their opportunity to sell. The authors also point out that cattle are not the only product of the rancher. He is also a land holder looking for a capital gain. Thus a portion of the opportunity cost should be charged to speculation. Ranches are also excellent tax shelters for investors with other incomes and part of the land investment cost should be charged to the "output" of tax savings which come about through the capital gains method. The value of ranching as a "way of life" is also mentioned as a possible return which is not measured.

For these reasons Martin and Goss (1963) present two sets of cost curves (one which includes interest on investment and one which does not). They conclude that the long-run cost of producing beef is somewhere between these two curves and that the exact position depends upon the combination of goals of the individual rancher. The results of the study reveal that the LRAC curve decreases significantly up to 800 head and then levels off. The rancher must operate at least 325 animal units before positive returns are forthcoming to capital and management.

The cost-size relationships of commercial cattle ranches in Washington were investigated by Mueller (1966) who constructed seven model ranches. These were operated at 60, 75, 90, and 100 per cent of brood cow capacity to derive the SRAC curves. It was assumed that Washington ranches were currently producing at 100 per cent of their short-run capacity. Land, buildings, and improvements were considered to be fixed factors while hired labor, repairs, feed, and veterinary service were treated as variable inputs. It was hypothesized that the rising portions of the SRAC curves were steep due to definite limits of the fixed factors such as legal grazing limits on public range. For this reason the rising portion of the SRAC curves were ignored as irrelevant. The decreasing portions of the SRAC curves which Mueller derived were also steep due to a high proportion of fixed to variable costs at low levels of production. Three sets of SRAC curves were obtained. One set included only cash costs, one included cash costs and depredication, and the third set included cash costs, depreciation, and operator and family labor at a wage rate of $1.50 per hour. Because of land appreciation, tax shelter, and ranching as a "way of life," the opportunity costs of capital were not included in the SRAC curves.

It was not possible to determine from the summary tables presented by Mueller (1966) whether or not average variable costs decreased as the output from each fixed plant increased. Also somewhat confusing was the fact that hay production costs were expressed on a per acre basis and considered constant for all seven ranch sizes. Mueller concluded that the major economies of size were realized by operations up to and including those running from 150 to 200 head of brood cows.

In a study of the economies of size of wheat farms in the Nebraska panhandle, Vollmar, Helmers, and Retzlaff (1968) reported that the LRAC curve derived from four sizes of wheat farms reached a minimum at 482 acres. It then increased slightly at 1006 acres indicating that diseconomies were beginning to outweigh economies.

Morrison and Withers (1959) compared the costs and returns of wheat, barley, and safflower production for typical 700 acre Utah farms. Wheat production was the most profitable enterprise followed by barley production.

A study by Roberts and Harris (1961) compared wheat production, substitution of forage for purchased feeds, stocker cattle production, leasing forage, and substitution of forage for public land grazing on 100 acre units of typical Utah soil bank land. All enterprises except leasing forage and substituting soil bank grazing for grazing on public lands competed favorably with wheat production.

A later report by Parker and Roberts (1965) compared wheat, barley, and forage production for 100 acre units of soil bank land in Utah by the partial budgeting technique. It was concluded that use of land for forage to replace purchased feed yielded a higher return than did wheat production, which was the next best alternative.

METHODS

Cattle Ranch Economies of Size

Although not designed to determine cost-size relationships, a study by Roberts and Gee (1963) yielded considerable data concerning investments, costs, and returns of typical Utah cattle ranches running 50, 150, and 300 head of breeding cows. These data, which were collected through interviews, were updated to 1968 prices through the use of agricultural price indexes (U.S.D.A. 1968, Christensen and Richards 1969). Following a review of grazing permittee records (U.S. Forest Service 1968) one additional size of Utah cattle ranch (500 breeding cows) was designated for study. This particular size of ranch appeared to be the most common size of cattle operation running more than 300 head which agrees with the frequency distribution presented by Roberts and Gee (1963). Rancher interviews and questionnaires provided data which allowed a model ranch to be synthesized which included the typical complement of machinery, equipment, and improvements and typical variable costs associated with Utah cattle ranches operating 500 breeding cows.

Since land productivity (and hence land values) and marketing conditions vary widely throughout the diverse areas of the State of Utah, it would have been desirable to confine the study to a small homogeneous area of the State. However, the fact that few ranches running 500 head of cattle exist, coupled with a low percentage of questionnaire responses, made it necessary to treat the entire state as the sample area.

Buildings, improvements, machinery, and equipment were treated as fixed factors of production while land, cattle, labor, feed, gasoline, veterinarian services, etc. were considered variable factors. The fixed factor complements associated with each of the four models correspond to those typically found in connection with levels of beef output dictated by 50, 150, 300, or 500 cows. Once the typical fixed factor makeup was identified, both cattle numbers and land acreage could have been allowed to vary along with other variable factors.

It was assumed that existing cattle operations are producing at output levels corresponding to the low points of their SRAC curves. This assumption is similar to those made by Mueller (1966) and Faris and Armstrong (1963). Such an assumption is inconsistent with marginal price theory in some situations. Since the firm attempts to maximize profits by equating marginal cost and marginal revenue, the desired level of output will be less than the level of output corresponding to the minimum point on the SRAC curve for all firm sizes except the optimum long-run firm size (whose minimum SRAC position corresponds to the minimum point on the LRAC curve). In the long-run situation price tends toward the minimum point on the LRAC curve and will lie below the minimum points of SRAC curves of all but the optimum sized firm. The detrimental effect of this assumption on the derivation of the LRAC curve is slight, however, as is further explained below.

Since it is commonly hypothesized (Martin and Goss 1963, Mueller 1966) that cattle ranch SRAC curves rise very steeply due to definite limits of the fixed factors, and since the rising portions of the SRAC curves are irrelevant to the derivation of the decreasing portion of the LRAC curve, the increasing portions were ignored. Thus if the variable factors cattle and land and consequently beef output had been allowed to vary over the range made possible by the fixed factors, the resulting SRAC curves would be decreasing throughout and would represent production stage I and a portion of stage II. However, if as has been assumed, cattle operations do produce at the minimum points on their SRAC curves (which lie in stage II), it is not likely that the fixed factors would ever be used less intensively. The derivation of the decreasing portions of the SRAC curves would become little more, then, than an exercise in geometry (unless, of course, institutional restraints limit output). Thus the SRAC "curves" for each set of fixed factors consist of single points and the derivation of the LRAC curve is accomplished by drawing a curve through these points. This technique does result in a LRAC curve which lies slightly above the one which would be derived by allowing the envelope curve to come tangent to the decreasing portions of the SRAC curve.

Regression analysis could have been used to fit a LRAC curve through all sample points (each representing a unique combination of output level, fixed inputs, and per unit costs. However, the data utilized from the study by Roberts and Gee (1963) were available only in "lumped" form. Fixed inputs were expressed as the typical set corresponding to breeding herds of 50, 150, and 300 cows. The same was true for variable production costs. Even though individual combinations of per unit costs and output were available for the 500 cow ranch, there was no point in attempting to analyze these data in more detail than was possible for the three smaller ranch sizes. Thus the 500 cow ranch data were also reduced to a typical set of fixed inputs and a typical level of variable costs.

If more detailed information (similar to the 500 cow ranch data) had been available for the 50, 150, and 300 cow ranches, four SRAC curves could have been traced out by drawing lines between points representing the various combinations of average cost and output level. For such curves to correctly be called SRAC curves one critical condition would have to be met. All points on a given curve would have to represent ranches being operated with an identical set of fixed factors. If this condition were not met, the lines connecting the points representing combinations of average cost and output would not trace out SRAC curves but, instead, would be merely lines connecting single points on numerous SRAC curves. This is due to the fact that if fixed inputs are not identical, the complement of machinery, buildings, and improvements varies as output varies. Since it is unlikely that any two ranchers operate with an identical set of fixed inputs, the alternative was to choose the typical complement of machinery and improvements associated with each of the four herd sizes and reduce the four SRAC curves to single points.

Interest on cash costs was computed for six months at an annual rate of 8 per cent. Interest on investment was set at 5 per cent for reasons which are explained in the methods section for wheat farm models below.

Interest on investment for depreciable items was computed on the basis of average investment. Machinery, equipment, improvements, horses, and cattle were assumed to have one-half of their useful lives remaining and interest on investment was figured on one-half of the sum of replacement cost and salvage value. This procedure avoids the problem of assigning life expectancies to diverse collections of new and old, large and small investment items. However, it was necessary to assign life expectancies in order to compute depreciation. Depreciation on buildings and improvements was computed by the straight line method assuming a twenty year life and no salvage value. Machinery and equipment depreciation was computed in the same manner assuming a five year life and a salvage value of 20 per cent.

One difference in basic management practices was apparent between the large ranch and the three smaller ranches. Typically ranches in the three smaller size classes offered a portion of their home grown crops for sale, while the large ranches fed all crops grown. To further complicate matters, there was no way to separate the production costs of crops used on the smaller ranches and the costs of those sold. There was also no clear indication of the proportion of crops sold to those used. The identification of beef production costs on the smaller ranches would have been a relatively simple matter if the production costs of crops sold could have been isolated (beef production costs = total costs - production costs of crops sold). Since this was impossible, the only alternative was to subtract the market value of the crops sold from total ranch costs to obtain the production costs of beef. Thus all crops produced on the large ranch and a portion of those produced on the smaller ranches were treated as inputs and valued at their costs of production while crops sold by the smaller ranches were valued at their market price. The net effect of this procedure was to bias beef production costs on the smaller ranches in a downward direction.

The bias could have been avoided by valuing all crops used by both the large and the smaller ranches at their opportunity costs (market value) rather than their production costs. However, such a procedure would introduce a double counting problem. This becomes apparent when one considers what is included in the market value of the crops sold. The value includes return to land, machinery, equipment, labor, management, and (perhaps) pure profit. An opportunity cost is included in total ranch costs for each of these items except profit. If crops used on the ranches were charged for at their market values, an opportunity cost which had already been partially covered elsewhere (depending on the magnitude of profit) would be counted twice.

For the purpose of determining net return the above procedure presents no problems. Since net return is the difference between total revenue and total costs, the same result is obtained whether the value of the crops sold is added to total revenue or subtracted from total costs.

Since ranch operators often view production costs differently than do economists, unit costs are expressed in five different ways for the purpose of deriving five distinct LRAC curves. The first includes only cash costs (which must be covered even in the short-run). The second includes cash costs plus depreciation. Depreciation is considered a real production cost since capital goods must be replaced as they wear out even though the operator may for short time periods choose to ignore the wearing out process and "live on depreciation." The third LRAC curve includes cash costs, depreciation, and the opportunity costs of operator and family labor. The fourth and fifth LRAC curves include cash costs, depreciation, opportunity costs of labor, and interest on investment. If he so chooses the operator may ignore the opportunity costs of both labor and capital and concern himself only with covering cash costs and replacing capital as it is used up.

For the purpose of providing information to existing ranch operators or potential investors in beef production factors, it is probably more important to present all five curves (letting the rancher choose the one he considers relevant) than it is to attempt to justify one of the five as the correct curve. From the viewpoint of society, $LRAC_4$ (which includes all costs including a normal return on investment) is the relevant curve. Even though the opportunity costs of operator and family labor and interest on investment may be ignored by private operators, they are social costs which society cannot ignore.

Wheat Farm Economies of Size

Box Elder County, Utah represented the population sampled for the purpose of constructing models of typical dryland wheat farm organization for the State of Utah. This large Utah county was chosen as the wheat farm study area for two reasons. First, Box Elder County lies close to the Utah State University campus allowing a large amount of data to be collected for a given expenditure of time and travel costs. Second, Box Elder County includes a sufficiently wide variety of soils, precipitation, and marketing situations so as to be representative of the dryland wheat farming areas throughout the state.

A survey of data compiled by the Agricultural Stabilization and Conservation Service (1968) revealed that the average acreage planted by Box Elder County wheat farmers is about 250 acres. Due to the common practice of summer fallowing this means that the average Box Elder County wheat farm contains about 500 acres. The 500 acre farm was used as the minimum size for dry farm units producing wheat exclusively. The three additional sizes chosen for study were 1000, 2000, and 3000 acres.

Typical machinery and equipment complements associated with each farm size were obtained through interviews with farm machinery dealers serving Box Elder County farmers. Questionnaires sent to Box Elder County farmers provided additional data on machinery and equipment and served as a check on the information furnished by the machinery dealers.

Depreciation was computed by the straight line method. Tractors, combines, etc. were assumed to have a five year life and a salvage value of 20 per cent. Trucks and tillage and shop equipment were assumed to have a 10 year life ad 10 per cent salvage value. Granaries, machine sheds, and fences were given no salvage value and life expectancies were set at 20 years for fences and 30 years for buildings.

Labor costs (both cash costs of hired labor and opportunity costs of operator and family labor) were determined through the use of the machine capacity technique explained below with farmer questionnaires providing a check.

Repairs and maintenance costs of machinery were determined using the method of Fenton and Fairbanks (1954) in which annual repair costs were computed as a percentage of the original cost of the machines. Repairs and maintenance costs of buildings and improvements were furnished by farmer questionnaires. It is interesting to note that these annual costs amounted to about 2 per cent of the cost of these items new.

Property taxes (both personal and real) were computed using a mill levy of 65 mills and an assessment of 20 per cent of the average fair market value (Kerr, 1968). Land values assigned corresponded to those expressed as typical in farmer interviews. Fertilizer and seed costs were determined on the basis of the application and seeding rates listed as typical by seed dealers serving the Box Elder area. The rates used were 80 lbs. of urea per acre (amounting to about 34 lbs. of N per acre) at a cost of $4.25 per hundred pounds of urea and 0.64 bushels of wheat seed per acre at a cost of $2.80 per bushel.

Machine operating costs were determined by the machine capacity technique (American Society of Agricultural Engineers, 1966; Michalson, 1964) in which field capacity in acres per hour equals speed in miles per hour x width of machine x efficiency expressed as a percentage ÷ 825. Fuel costs per acre were computed by combining machine capacity in acres per hour with fuel use per hour. Fuel consumption per hour was assumed to be 0.06 gallons x maximum horsepower for gasoline engines and 0.06 gallons x maximum horsepower x 0.73 for diesel engines following Stevens and Agee (1967). Lubrication and oil costs were set at 1/6 of fuel costs (Urilden and Benrud, 1956).

Operating costs were computed at $0.035 per mile for 3/4 ton pickups and $0.07 per mile for two ton trucks. Annual mileage for pickups was assumed to 1500 miles plus 12 miles x number of work days for the 500 acre farm, 3000 miles plus 16 miles x number of work days for the 1000 acre farm, 6000 miles plus 20 miles x number of work days for the 2000 acres farm, and 9000 miles plus 24 miles x number of work days for the 3000 acre farm following Stipler and Castle (1961). Annual mileage for trucks was assumed to be 12 trips x 60 miles (the typical round trip distance to a seed and fertilizer dealer) equal to 720 miles for all four farm sizes plus 60 miles x the number of necessary grain hauling trips. The necessary trips amounted to 20 for the 500 acre farm, 40 for the 1000 acre farm, 80 for the 2000 acre farm, and 120 for the 3000 acre farm.

Machine hire was represented by the costs of air contract herbicide application at $1.50 per acre which included the cost of the herbicide. Insurance costs were computed as 0.006 x the average value of machinery, equipment, and improvements (Stevens and Agee 1967). Interest on cash costs was computed at an annual interest rate of 8 per cent (which was the 1968 rate paid by farmers for production credit) and six months was set as the average length of production loans.

Interest on investment was computed at a rate of 5 per cent. Interest on investment ideally would represent the rate of return on the best alternative investment which had been foregone due to investment in the factors of wheat production (land, machinery, equipment, and improvements). Since the rate of return on the best alternative would differ for each individual and would be extremely difficult to identify, the current rate paid on time certificates was allowed to represent the true rate. Interest on investment in depreciable items was computed on the basis of average investment. Machinery, equipment and improvements were assumed to have one-half of their useful lives remaining and average investment was calculated as one-half of the sum of replacement cost and salvage value.

All categories of wheat production costs (both cash costs and opportunity costs) appeared on the farmer questionnaires. The questionnaires were the primary source of data for some categories as mentioned above and also served as a check on those data which were derived from the machine capacity technique, from seed and machinery dealers, and from various published materials.

Machinery and improvements were designated as fixed factors of production while land, labor, fuel, oil, repairs, etc. were treated as variable factors. The fixed factor complements associated with each of the four farm sizes correspond to those typically found in connection with levels of wheat production dictated by 500, 1000, 2000, or 3000 acres. For reasons explained in the section on cattle ranch methods above, the rising portions of the four SRAC curves were ignored. Assuming that existing wheat operations are operated at the minimum points of their SRAC curves, it is not likely that the fixed factors would ever be used less intensively (since wheat allotments have been in effect for an amount of time sufficient for fixed factor complements to be adjusted to the acreages in allotments). Thus the SRAC "curves" for each set of fixed factors were reduced to single points and a curve drawn through these points formed the LRAC curve. As pointed out above, the resulting LRAC curve is biased slightly in an upward direction.

The LRAC curve could have been derived by fitting a regression line through all sample points (each representing a unique combination of output level, per unit production costs, and fixed inputs). The machine capacity technique would have been necessary for determination of variable costs with this procedure also. Use of this technique would have been required due to the general inadequacy of farm records and the fact that many of the farmers answering questionnaires proved to be involved in the production of at least one other crop requiring the use of wheat machinery. Considerable time would have been involved in the derivation of variable costs for each individual sample. The alternative was to carefully choose four sets of fixed inputs which typically corresponded to the four levels of output and to apply the machine capacity technique to these four complements of machinery to determine variable costs.

Four SRAC curves could also have been derived by connecting points representing the various combinations of output level and per unit costs. Again, due to inadequate farmer data and multiple enterprises, great amounts of time would have been necessary to determine variable costs for each sample by the machine capacity technique. A more serious problem was presented by the fact that few, if any, Utah wheat farmers operate with the same set of fixed factors (see section on cattle ranches above). Thus if output is allowed to vary, the machinery and equipment complement also changes. A curve drawn through points derived in such a manner would not trace out a SRAC curve for a set of fixed factors. Instead it would be a line connecting individual points on many SRAC curves. The alternative was to choose four typical machinery complements as mentioned above, and to allow the four SRAC curves to be reduced to single points.

As with the beef production LRAC curves described above, five distinct LRAC curves of wheat production were derived. The first includes only the cash costs which the operator must pay even in the short-run. The second includes cash costs plus depreciation which must be covered eventually as capital items are used up in the production process. The third LRAC curve includes the opportunity costs of operator and family labor as well as cash costs and depreciation. The fourth and fifth LRAC curves include the three items represented in the third LRAC curve plus interest on investment.

Again, for the purpose of providing information to potential investors in wheat production factors or to existing wheat farmers it would seem more important to present all five curves and let the farmer choose the curve which is relevant to his situation than to attempt to justify one of the curves as representative of the true wheat production costs. From the viewpoint of society, $LRAC_4$ is the relevant curve since it alone accounts for all social costs of wheat production.

Management Alternatives

In order to obtain wheat production and forage production data for important soil bank areas in the State of Utah four sources of information were used. These included Agriculture Stabilization and Conservation records of wheat production, farmer records of carrying capacity and wheat production, published results of forage production research and unpublished results of forage production research. Various combinations of data sources provided paired observations for the two land uses on fifteen Utah sites (Table 6, p. 65).

The relationship between wheat production and forage production was established by regression analysis. This allows potential forage production on marginal cropland to be estimated from records of actual wheat production which are readily available from ASCS records. The regression equation provides what is essentially the two end points (the horizontal and vertical intercepts) of a production-possibility (iso-resource) curve. Since the production data were obtained from acreages devoted exclusively to wheat productionor exclusively to forage production, the production-possibility "curve" consisted of a straight line drawn between the two end points. Such a curve implies that the two products act as substitutes in production at a constant rate. This further implies that the production functions for the two products are either both linear or that one is an increasing function while the other is a decreasing function of the necessary magnitudes so as to just cancel one another and yield a linear substitution relationship. When a price (iso-revenue) line is imposed on such a production-possibility curve, the dictated optimum allocation of resources will be a "corner solution" where resources are devoted to either exclusive wheat production or exclusive forage production.

Linear programming analysis (a technique by which several resource restrictions are handled simultaneously) might provide a means of estimating a production-possibility curve with an increasing marginal rate of substitution. Such a relationship would identify an optimum resource allocation which was more stable in the face of price fluctuation, and long range recommendations could be made. However, for linear programming to be valid, reliable estimates of the productivity of other resources such as labor and capital must be available. Since the requirements of forage and wheat production for land are more reliably determined from farmer records than are those for capital and labor (especially when several crops are grown and family labor is involved) it was decided to treat land as the single limiting resource.

The five management alternatives for marginal Utah cropland studied using partial budgeting techniques were (1) wheat production by owner-operator, (2) leasing of cropland by owner for wheat production by leasee, (3) leasing of forage on AUM basis, (4) leasing of forage on pounds of livestock gain basis, and (5) use of forage by owner for spring stocker cattle production.

Alternatives were compared according to plots of land of four sizes (corresponding to the 500, 1000, 2000, and 3000 acre dryland wheat farms examined in the LRAC study). Any wheat farm is capable of forage production and ultimate beef production through investment in establishment of grass stands, cross fences, corrals, loading chutes, and water facilities. However, not all ranches are capable of dryland wheat production and the cropland typically associated with Utah cattle ranch operations is irrigated land rather than dryland. Thus the management alternatives were compared on the basis of wheat farm sizes rather than cattle ranch sizes.

Alternative 1 was the enterprise described above in the Wheat Farm Economies of Size methods. Alternative 2 combined current Utah lease agreements (in which the landlord receives one-third of the wheat crop) with the costs and returns of alternative 1. The 1968 Utah wheat price of $1.32 per bushel (Christensen and Richards, 1969) was used in the calculation of revenue figures. This price represents a weighted average price for all wheat sold in Utah during 1968. Since it is an average of the price paid for both wheat sold on the open market and wheat sold subject to federal price supports, it provides a better indication of the price a farmer could expect to receive than does the federally supported price taken alone.

In view of the current wheat surpluses in both the United States and Canada (Bank of Nova Scotia Monthly Review, 1969) it would be desirable to also compare the management alternatives with wheat being priced according to what society believes a bushel of wheat is worth. One such measure of marginal social value might be the price of wheat exported from the United States for sale abroad. However, this price averages somewhat higher than does the United States domestic price (Economic Research Service, 1969). This is probably due to the selection of high quality wheat for export and because the export price is a function of the costs of transporting wheat to exporting ports.

Another possible measure of marginal social value is the price paid for wheat traded on the open market in Utah. However, the price of the wheat exchanged in this manner is not independent of the price of wheat sold under the federal price support program (Hubbard, 1970). Another difficulty arises because wheat is seldom sold on the open market in Utah except as feed grain. Such wheat is typically the softer, poorer quality wheat which will not meet the standards for premium prices under the federal price support program. Since no reliable estimate was obtained of the value placed on wheat by society, no attempt was made to rank the alternatives with wheat being valued at anything other than the weighted 1968 price.

In order to compare the management alternatives from the viewpoint of society, it would also be necessary to calculate the social costs of production (if the social costs differed from the private costs). It may be that wheat production yields a higher soil loss and a less desirable upland game bird habitat than does forage production. If this is true, the social costs of wheat production are higher than the private costs. Because of the difficulties involved in evaluating these intangible features of the various land uses, no attempt was made to compare the management alternatives from a viewpoint other than that of the land owner.

Alternative 3 assumed a price per AUM of forage of $3.50 (Hooper, 1968; Roberts and Harris, 1961). Grazing capacity was calculated using the regression equation described below in the Results and Discussion. The grazing season was the two month period from April 20 to June 20. Four hundred pounds of total digestible nutrients (TDN) were required per AUM where each AUM equalled two 500 pound steers, each gaining one and one-half pounds per day for 30 days. Wheatgrass forage was assumed to be 40 per cent TDN which meant that 1000 pounds of forage were required per AUM. Wheat yield for use in the regression equation was assumed to be 20 bushels per acre which corresponded to the yield assumed for wheat production alternatives 1 and 2. The cost of establishing grass stands was charged against alternative 3 as were other necessary improvements (cross fences, corrals, loading chutes and stock water developments). The cost of grass stand establishment was set at $6.97 per acre. Broken down into component parts grass stand establishment on marginal cropland was as follows: tandem disking, $2.32 per acre, drilling, $1.44 per acre (Gardner, 1961; Christensen and Richards, 1969), seed, $2.58 per acre (Cook, 1960) and non-use, $.63 per acre (Nielsen, 1967). It is likely that cost-size economies exist in the establishment of grass stands. However, in order to present a flexible analysis applicable to both farmers who own machinery and ranchers who do not own machinery, costs were calculated on the basis of average costs of grass stand establishment reported in reseeding studies. These results were modified to fit marginal cropland seeding conditions since some operations (brush removal and pest control) are not necessary on cropland seedings.

Cross fences necessary for proper livestock distribution on the four sizes of marginal land plots were assumed to be as follows: 500 acres, no cross fences necessary, 1000 acres, one cross fence (1.25 miles), 2000 acres, two cross fences (3.54 miles), and 3000 acres, two cross fences (4.34 miles). Such facilities would also allow cattle rotation between pastures. For example, alternate halves of the 1000 acre plot could be deferred during the first month of the grazing period or one-third of the 2000 and 3000 acre plots could be deferred during the first month of the grazing period. Due to the smaller size of the 500 acre plot, no distribution problems would be expected. Fencing costs were assumed to be $1000 per mile.

Necessary water developments for the four plot sizes were 500 acres, one water trough ($50), one well ($1000), and one electric pump ($260); 1000 acres, two water troughs ($100), one well ($1000), and one electric pump ($260); 2000 acres, four water troughs ($200), two wells ($2000), and two electric pumps ($520); and 3000 acres, four water troughs ($200), two wells ($2000), and two electric pumps ($520). Pump operating costs were of a fixed variety in the short-run. Power companies providing electric service to pump installations typically require the land owner to pay an annual minimum of $100 per installation for the electricity used. Such an agreement entitles the land owner to a number of kilowatt hours of electricity in excess of the amounts necessary for the pumping requirements of the grazing enterprises.

It should be pointed out that the use of the 1968 price ($3.50 per AUM) in the calculation of total revenue for the alternative of leasing forage on an AUM basis may be somewhat unrealistic. Since the price per AUM is established in local markets, the increased supply of forage available for leasing created by shifts in land use from wheat production to forage production could depress the lease fee. The amount of decrease in price per AUM caused by the increase in supply would depend upon the elasticity of demand for lease forage. If the shift from wheat production to forage production were sufficiently widespread there would be an additional source of downward pressure on the price of forage. The market demand for lease forage is the sum of the products of the marginal physical product of forage for each firm in the market and the price of beef. The decrease in demand for forage resulting from the decrease in the price of beef (caused by an increase in supply of beef) would tend to lower the price of lease forage. However, the demand for lease forage may be perfectly elastic due to the fact that insufficient spring-fall range is the limiting factor in many range cattle operations. A perfectly elastic demand for lease forage implies a constant marginal physical product for forage which further implies that the total product curve for forage is linear. Both of these implications appear reasonable if spring-fall forage is the limiting factor in terms of total livestock carrying capacity. If the demand for lease forage is perfectly elastic, an increase in forage supply cannot directly lower the price of lease forage. However, the decrease in beef price brought about by the increase in beef supply (due to the increased forage supply) can decrease the price of lease forage.

Government cost sharing was ignored in this analysis. If the improvements necessary for the grazing alternatives (grass stands, cross fences, loading chutes, and water developments) are already owned by the land owner, he is in the short-run situation as far as the grazing alternatives are concerned. Since these improvements are fixed in the short-run their costs do not enter into the decision making process and it does not matter whether the federal government shared in their original cost. If the land owner does not already own the improvements necessary for the grazing alternatives he is in the long-run situation with regard to grazing enterprises and government cost sharing does enter into his decision as to which enterprise to pursue. However, cost sharing programs change substantially over time and in the interests of presenting a flexible analysis, the costs of grazing improvements have been treated as if they were paid entirely by the land owner. Also, the social costs of land conversion to permanent forage are the same whether the land owner pays all conversion costs or whether the government shares in these costs.

Alternative 4 assumed an average daily steer gain per animal unit of three pounds (Cook, 1966; Roberts and Harris, 1961; Anonymous, 1964). Steers were assumed to go on pasture at 500 pounds and come off weighing 590 pounds two months later. Thus the average steer weight for the two month period was 545 pounds which meant that corresponding to the definition of an AUM as two 500 pound steers gaining one and one-half pounds per day, each steer represented 1.09 AUMs during the two month grazing season. Livestock gain was priced at $.10 per pound. Grazing capacity and investment in improvements necessary for grazing operations were calculated by the methods of alternative 3 above.

Alternative 5 was subjected to the assumptions imposed upon alternative 4. Utah stocker cattle prices during 1968 were set at $24.00 per cwt. for 500 pound steers and $23.00 per cwt. for 590 pound steers (Christensen and Richards, 1969). Trucking costs were calculated on the basis of hauling each steer 60 miles (30 miles from market to the pastures at the beginning of the grazing season and 30 miles back at the end of the grazing season). Sales commission costs were set at $2.85 per steer. This price corresponds to that typically paid by sellers to local livestock commission companies. Salt costs were calculated at 1968 prices assuming that two pounds of salt were required per AUM.

Depreciation of buildings and the improvements necessary for the grazing alternatives (grass stands, cross fences, corrals, loading chutes, and water developments) was computed by the straight line method assuming a life expectancy of twenty years and no salvage value. Depreciation of machinery and equipment followed the methods described above for the economies of size studies as did the calculation of the costs of repairs, maintenance, taxes and insurance.

Short-run alternatives

In the short-run situation some inputs, by definition, cannot be varied. Thus (explicitly) machinery, equipment, and improvements and (implicitly) land (since acreages studied corresponded to those typically associated with wheat farm fixed factor complements) were fixed. Operator and family labor (in the amounts required for each of the five alternatives) were also treated as if they were fixed. It was assumed that in the short-run, owners of marginal Utah farmland will retain their land holdings, will remain on the farm, and will continue to supply the necessary amounts of operator and family labor despite the costs of foregone alternative investments and employment.

Comparisons of the five short-run alternatives were made on the basis of the differences between total revenue and total variable costs through the use of partial budgeting. Because of the above assumptions only the return to fixed factors (land, investment in machinery and improvements, depreciation of machinery and improvements, operator labor, and family labor) was relevant to the decision as to which of the five short-run enterprises to pursue. Alternatives were compared according to the absolute difference between total revenue and total variable costs since a "rate of return on investment" (total revenue - total variable costs ÷ average investment in land, machinery, and improvements) would not be meaningful. To be consistent with the assumption that land, machinery, improvements, and operator and family labor are fixed in the short-run, investment should be given no more importance than the other fixed factors and should not be used to calculate a rate of return. None of the fixed factors should enter into calculations leading to short-run comparisons of alternatives.

The assumption that machinery and improvements are fixed in the short-run imposes certain limitations on the interpretation of short-run comparisons of the five management alternatives. The owner-operator wheat operation is open only to farmers who currently own wheat machinery and improvements. The grazing alternatives are available only on farms currently equipped with cross fences, corrals, loading chutes, water developments, and stands of perennial grass.

Long-run alternatives

In the long-run situation all factors of production are variable by definition. All five management alternatives are available to all owners of marginal Utah cropland. Machinery, equipment, and improvements can be acquired or disposed of and grass stands can be established as well as plowed up and returned to crop production.

It should be recognized that for the land owner who owns land resources in addition to marginal cropland and who currently operates a beef cattle operation, the increase in the size of this operation made possible by the additional forage produced on marginal cropland also exists as a long-run alternative to those mentioned. In the same manner, for a land owner who owns additional land resources and who currently operates a wheat production enterprise, the increase in the size of this enterprise made possible by bringing marginal cropland into production offers a long-run alternative in addition to those studied. The latter alternative could be analyzed by referring to the wheat production long-run average cost curve described in the Results and Discussion below. The same technique would permit the analysis of increases in the size of the beef cattle operation through the use of the beef production long-run average cost curve described below in the Results and Discussion. However, such analyses should be tailored to the situations facing individual owners of marginal cropland. It is likely that few actual operators possess combinations of land resources which include one of the four sizes of cattle ranches or wheat farms investigated in the economies of size studies and one of the four sizes of additional marginal cropland acreage.

In keeping with the traditional definition of the long-run, the five management alternatives were first compared by partial budgeting procedures under the assumption that all inputs were variable. It was assumed that land ownership and operator and family labor were completely mobile in the long-run and that market pressures would push land and labor inputs into their best use. Accordingly, the opportunity costs of operator and family labor and investment were considered.

Since farming and ranching are looked upon as "ways of life" by many owners of marginal Utah cropland, the five management alternatives were next subjected to long-run budget comparison where all factors were assumed to be variable except land ownership and operator and family labor. Thus it was assumed that land ownership and operator and family labor were not mobile, even in the long-run. This assumption was based on the idea that owners of marginal cropland who view farming or ranching enterprises as "ways of life" will retain their land holdings and they and their families will continue to live and work on the land despite the opportunity costs of alternative investment and employment.

Economic literature contains many works which discuss the merits of various mathematical techniques for choosing between alternative investments (Dean, 1954; Alchian, 1955; Lorie and Savage, 1955; Solomon, 1956; Hirshleifer, 1958; Gardner, 1963; LeBaron, 1963; Gardner and LeBaron, 1966). Although economists usually assume that the goal of the farm operator is to maximize profits or minimize losses, the literature does not discuss the situation where a choice must be made between investment alternatives which yield losses. None of the four ranking techniques discussed below are capable of providing a rational decision under such conditions.

Comparisons might have been made on the basis of the rate of return on investment in land and improvements. This technique is often applied by farm appraisers when they capitalize net revenue into perpetuity to calculate land values. The following formula may be used to calculate the rate of return on investment: $\frac{R - (C + D + O)}{I}$ where R = total annual revenue, C = cash costs, D = depreciation, O = opportunity costs of operator and family labor, and I = average investment in land and improvements. In the long-run situation where all resources are free to move, comparison of alternatives on the basis of the rate of return gives full weight to the investment necessary to bring forth the revenue streams. For this reason this technique is superior to comparison on the basis of the absolute difference between revenues and expenditures. However, this technique not only assumes that the various alternatives are practiced perpetually, but serious problems also arise when negative returns are encountered. Comparison on the basis of the rate of return on investment seems quite logical as long as returns are positive (situation A, Table 1). Alternative 1 would obviously be chosen over alternative 2 even though alternative 2 yields a higher absolute return on investment. Due to the smaller investment required for alternative 1, the rate of return on investment is higher for alternative 1 than for alternative 2. Alternative 1 is chosen because it is better to receive a somewhat smaller return by investing considerably less.

However, when returns are negative (as in situation B, Table 1) rate of return on investment would choose alternative 2 over alternative 1 even though alternative 1 yields a smaller absolute negative return on investment. Due to the larger investment required by for alternative 2, the rate of negative return on investment is lower for alternative 2 than for alternative 1. Thus, in effect, the choice of alternative 2 is like saying that it is better to receive a larger loss by investing more. It seems unlikely that a land owner would actually choose one enterprise over another on this basis.

In view of the short comings of the rate of return on investment approach, a second method was considered for comparison of the five management alternatives. This was the internal rate of return calculated by the following formula (Gardner, 1963; Nielsen, 1967):

$I = R\left[\frac{1-(1+i)^{-n}}{i}\right]$ where I = present value of investment, R = net annual returns, n = number of years returns are received, and i = the internal rate of return. The internal rate of return is the interest rate which will discount the stream of net annual returns so as to just equal the present cost of the investment. Transposing terms we obtain

Table 1. Comparison of positive and negative returns to two hypothetical alternatives under three situations by rate of return on investment, internal rate of return, present net worth, and benefit-cost ratio.

	Situation A		Situation B		Situation C	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Life of investment project (n)	20 yrs.	20 yrs.	10 yrs.	10 yrs.	5 yrs.	5 yrs.
Investment (I)	1000	1500	1000	2000	1000	1300
Total annual revenue	150	200	100	100	100	170
Total annual costs	50	55	200	250	200	400
Return on investment (R)	100	145	-100	-150	-100	-230
Rate of return on investment (R/I)	10%	9.67%	- 10%	- 7.5%	- 10%	-17.7%
Inwood coefficient (I/R)	10	10.34	10	- 13.3	10	5.65
Internal rate of return	8%	7.4%	- 0.5%	- 5%	- 20%	- 4%
Present value of annual revenue stream (B)	1869	2492	772	772	433	736
Present value of annual cost stream (C)	623	685	1544	1931	866	1732
Present net worth B - (C+I)	246	307	-1772	-3159	-1433	-2296
Benefit-cost ratio	1.15	1.14	0.303	0.196	0.232	0.242

$\frac{I}{R} = \frac{1 - (1+i)^{-n}}{i}$ which is identical to the Inwood coefficient listed in Inwood tables (American Institute of Real Estate Appraisers, 1967). The approximate internal rate of return is found by simply locating the calculated Inwood coefficient corresponding to the appropriate year in the years column of the Inwood table. The correct internal rate of return is the corresponding interest rate appearing in the interest rate row of the Inwood table.

As long as the annual net revenue stream is positive the internal rate of return is completely analogous to the annual compound interest rate paid on money borrowed for capital investment. This technique has been recommended for ranking investment alternatives when capital is limited (Gardner and LeBaron, 1966). However, serious problems arise when this technique is used to compare alternatives yielding negative net annual returns. Negative returns produce negative Inwood coefficients (Table 1). Negative coefficients are not listed in published Inwood tables and solution of the formula to obtain such coefficients is possible only by an iterative computer process. The negative coefficients used to compare the negative income streams in Table 1 were provided by Gardner (1970) and appear in Table 49, Appendix C. The internal rate of return method selects the correct alternative in situations A and B (Table 1). The choice of alternative 1 over alternative 2 in situation B (where both alternatives yield negative returns) is rational since an investor would prefer a small loss from a small investment to a large loss from a large investment. However, the choice of alternative 2 over alternative 1 in situation C (where both alternatives again yield negative returns) is not rational. The selection of alternative 2 in this situation implies that an investor would prefer a large loss from a large investment to a small loss from a small investment.

The value of the Inwood coefficient is a function of the annual net revenue (R) and investment (I). If I is held constant and R is positive, an increase in R will decrease the value of the coefficient which will, in turn, increase the internal rate of return as would be expected. If R is negative and is held constant, an increase in I will increase the absolute value of the negative coefficient which leads to an increase in the absolute value of the negative internal rate of return. This relationship would also be expected. The selection of the incorrect alternative by the internal rate of return technique (as in situation C, Table 1) is caused by the fact that when I is held constant and R is negative, an increase in the absolute value of the negative R decreases the absolute value of the negative coefficient which produces a decrease in the absolute value of the negative internal rate of return. Such a relationship is not rational.

Ranking of investment alternatives by the negative internal rate of return involves another flaw in logic. The generation of negative Inwood coefficients (Table 49, Appendix C) is based upon the concept that losses should be compounded rather than discounted. The table of negative coefficients implies then, that an individual with an opportunity cost of five percent would be indifferent between losing $1.05 today and losing $1 one year from today. Rational individuals do not think this way.

To avoid the compounding of losses, negative coefficients might be treated as absolute values and positive Inwood tables might be referred to in order to obtain the corresponding internal rates of return.

If alternative investments were ranked according to internal rates of return calculated in this manner (and treated as internal rates of loss rather than return) discounting of losses would be implied. This approach would depend implicitly on the assumption that an individual with an opportunity cost of five percent would be indifferent between losing \$.95 today and losing \$1 one year from today. As pointed out by Gardner (1963), such an assumption seems reasonable. However, one should remember that for any given annual revenue stream life (n), the coefficients in a positive Inwood table decrease as the interest rate increases while the coefficients in a negative Inwood table increases as the absolute value of the interest rate increases. Thus whenever the comparison of negative revenue streams by the negative internal rate of return yields the correct choice, comparison by the positive internal rate of return gives the wrong choice and vice-versa.

It is also interesting to note that comparison of alternatives yielding negative returns by the negative internal rate of return will always select an alternative which differs from the one chosen by the rate of return on investment approach (situations B and C, Table 1). This is because the Inwood coefficient is the reciprocal of the rate of return on investment (as calculated in Table 1). In any situation, then, where the negative internal rate of return technique dictates the correct choice, the rate of return on investment method will choose the wrong alternative and vice-versa.

The present net worth technique was next considered as a means of comparing alternatives. Present net worth is calculated by the following formula: B - (C+I), where B = present value of the gross annual revenue stream, C = present value of the annual cost stream, and I =

present value of investment. Present values of annual revenue and cost streams are calculated by discounting at an interest rate corresponding to the firm's cost of borrowing (or, ideally, at the internal rate of return on the best alternative investment). If land rent (calculated as an opportunity cost) is included in the annual cost stream, the present net worth method accounts for all investment necessary to produce the revenue streams. However, this method tends to rank large investment alternatives higher than small investments (Table 1, situation A) while saying nothing about average profitability (Gardner, 1963). The technique has been described as appropriate for investment comparisons when funds are not limited (Gardner and LeBaron, 1966). It is better suited for choosing the correct scale of project than for choosing between projects.

With regard to ranking investment projects yielding only negative returns, the present net worth method is superior to the other three methods discussed. Since this technique looks only at the absolute difference between the present values of benefits and costs, it cannot select the alternative yielding the largest loss as can the other three methods (Table 1). This technique does, however, base its choice on faulty logic in some situations. By looking only at the absolute amount of net loss, this method implies that a loss of $99 from a $1000 investment is superior to a loss of $100 from a $500 investment. If these are the only alternatives open, the rational choice is the $500 investment since the extra $500 required for the $1000 investment could be placed in a savings account. The interest earned would more than make up for losing $100 instead of $99.

Benefit-cost analysis was also examined as a possible method of choosing between management alternatives. The benefit-cost ratio is calculated by the following formula: B/(C+I), where B = present value of the gross annual revenue stream, C = present value of the annual cost stream, and I = present value of investment. This technique has been described as appropriate for choosing between alternatives when funds are limited (Gardner and LeBaron, 1966). Benefit-cost analysis may dictate the wrong choice when alternatives yielding negative returns are compared (situation C, Table 1).

For the comparison of alternatives yielding positive returns the internal rate of return technique was used. This method provides a rate completely analogous to the annual compound interest rate paid on borrowed money.

As mentioned above, none of the four methods considered is capable of making the correct choice from among alternatives yielding only negative returns. The problem of loss minimization for the long-run (even when land and operator and family labor are assumed fixed) may be a difficult one only because at least one alternative has not been considered. If faced with choosing between five alternatives yielding net losses, the land owner (even though determined to retain his land ownership) can always refuse to engage in any of the alternatives. The land owner can reduce his losses to zero by not borrowing the funds necessary to put one of the alternatives into practice. This is analogous to the short-run situation in which operations cease if variable costs cannot be covered. It is only when the land owner refuses to consider leaving the land idle as an alternative that the choice of alternatives yielding losses presents a problem which cannot be solved. With this in mind it is not surprising that the literature of economics has not dealt with the problem of long-run loss minimization. If management alternatives are being considered subject to the assumption that all inputs are variable, the inability of the four methods of comparison to make correct choices is irrelevant. If all inputs are variable the land owner will not retain ownership of his land if confronted only with management alternatives yielding negative returns.

For the long-run situation in which all inputs were considered variable, the opportunity costs of operator and family labor (fair market value of similar services) were charged against the revenues accruing to each of the five alternatives. Figures concerning the amounts of operator and family labor required for alternative 1 were available from the wheat farm economies of size study. Necessary labor for alternative 2 consisted of that necessary for repairs and maintenance of boundary fences. Labor requirements of alternative 3 included the repair and maintenance of boundary fences, cross fences, and water developments. The same was true for alternative 4. In addition to these items, alternative 5 required operator and family labor for maintaining salt supplies and livestock loading and unloading. Labor costs were computed at $10 per 10 hour man day. Labor needs for fence maintenance and repair were assumed to be two man days per mile of fence. Two man days per well and pump installation were set as the required amount of maintenance labor for these items. Salting was assumed to require one man day for each 1360 pounds of salt distributed. Required labor for unloading and loading of steers associated with trucking was set at four man days per 312 steers.

Land rent was calculated by solving for r in the equation $V = \frac{r}{i}$ where V = land value and i = 7 per cent. This rate is lower than the

10 per cent currently charged on twenty year farm land mortgages, but 7 per cent is more consistent with 1968 prices and perhaps better suited to long-run analysis.

Since all five alternatives yielded negative net revenues there was no suitable means of comparing them nor was there any reason to attempt to do so. In the long-run situation in which all inputs are variable, a land owner confronted with such a choice would not retain his land holdings.

For the long-run situation in which land and operator and family labor were considered fixed (it being assumed that owners of marginal Utah cropland will retain their land holdings and that they and their families will continue to live and work on the land despite opportunity costs) neither the costs of operator and family labor nor the opportunity cost of land investment entered into the decision as to which of the five management alternatives to pursue. Alternatives were compared on the basis of the internal rate of return (i) from the formula $I = \frac{R[1-(1+i)^{-n}]}{i}$ where I = present value of investment in machinery, equipment, buildings, and improvements and R = total revenue minus cash costs and depreciation. Alternative comparison by this method requires that R be received for a definite time period (n). All necessary investment items, whether short lived or long lived, must be present during the entire time period. The time period was set at twenty years which corresponded to the life of long lived inputs (buildings, fences, grass seedings, and other improvements). In order to provide required services for the entire twenty year period, investment items with a life of five years (tractors, combines, etc.) required one initial investment and three periodic reinvestments. Investment items with a life of 10 years (trucks, disks, etc.) required one reinvestment in addition to the initial investment. All investment expenditures were discounted to the base period at an interest rate of 7 per cent which is considerably lower than the 10 per cent currently associated with three year farm machinery loans. However, 7 per cent is not only more in line with the rates charged during 1968 (the base year to which all other prices were adjusted), but is also an interest rate more applicable to long-run decisions since the current interest rates are unusually high.

RESULTS AND DISCUSSION

Cattle Ranch Economies of Size

Of the five LRAC curves derived, only $LRAC_1$ (which represents only cash costs) exhibits a shape different from what microeconomic theory would predict (Figure 2). Average cash costs of beef production decrease as the size of cattle ranch increases from 50 to 150 head of breeding cows. $LRAC_1$ then turns up at 300 head only to again decrease at 500 head. The size economies evident as ranch size is expanded from 50 to 150 head are due to intensification of cattle numbers on the cash costs associated with taxes and insurance. Intensification on these items brings about size economies due to the spreading of their costs and to the increased productivity resulting from the law of variable proportions. The "hump" in $LRAC_1$ at 300 head is due to basic differences in management practices. Even though the intensification of herd size on the costs of insurance is still in effect, there is little intensification on taxes and the average costs of production for the 300 cow ranch rise due to a more than proportionate increase in purchased feeds and veterinary services and supplies (Table 2). Further cattle number intensification on taxes and insurance is responsible for the decrease in average cash costs of beef production as ranch size is increased from 300 to 500 head. The "hump" in $LRAC_1$ at 300 head does not present any problems from the standpoint of long-run planning since it is doubtful that long-run decisions are made entirely on the basis of information provided by $LRAC_1$. It is not likely that a ranch operator would choose

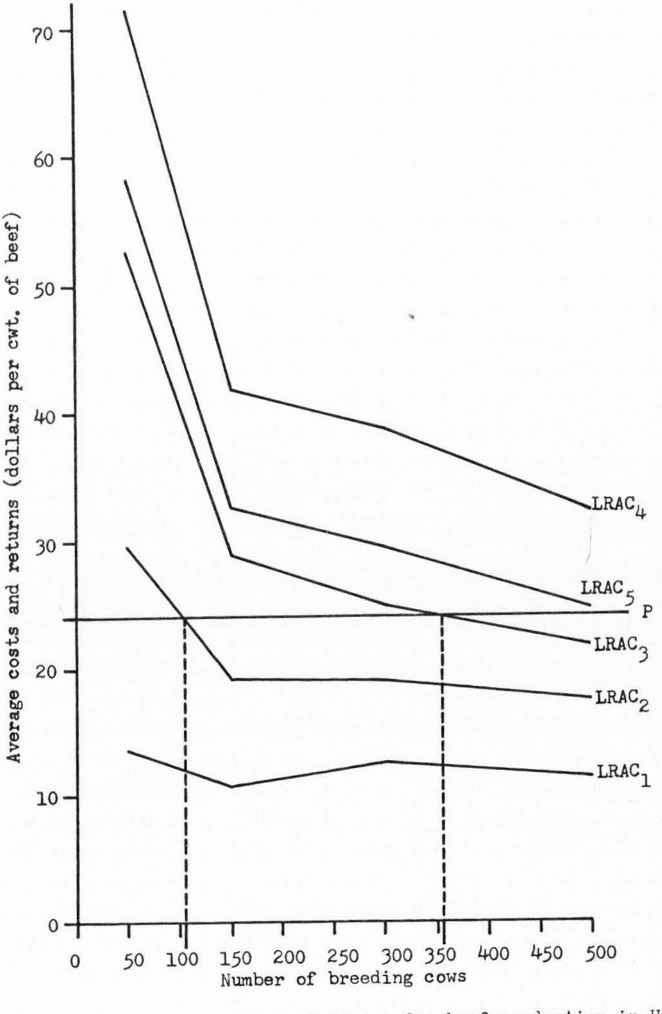

Figure 2. Long-run average cost curves for beef production in Utah, 1968.

Table 2. Total and average (per cwt. beef) costs of beef production on typical ranches, Utah, 1968.

	Size of breeding herd 50	150	300	500
Cash costs				
Grazing fees				
BLM	88	365	771	825
FS	131	350	545	792
Labor hired	150	360	3200	6600
Feed purchased	161	307	2244	1100
Repairs and maintenance				
Buildings and improvements	175	458	831	1200
Machinery and equipment	922	1074	1541	2062
Veterinary services and supplies	41	59	439	500
Taxes	719	1351	2616	2900
Seed and fertilizer	236	590	1210	1322
Machine operating costs	625	1294	1659	2500
Machine hire	207	309	620	750
Insurance	101	133	133	200
Utilities	41	283	400	500
Irrigation water	224	389	873	1200
Miscellaneous	345	476	637	850
Interest on cash costs	166	312	664	932
Total cash costs	4332	8110	18383	24233
Total cash costs-value crops sold	2782	6631	14664	24233
Average cash costs	13.37	10.78	12.44	11.27
Non-cash costs				
Depreciation				
Buildings and improvements	365	843	1508	2681
Machinery and equipment	2892	3798	5044	8309
Bulls	120	460	1150	1918
Horses	30	45	75	105
Total operating costs	6189	11777	22441	37246
Average operating costs	29.75	19.15	19.03	17.32
Operator and family labor	4800	6000	8000	9600
Total operating and labor costs	10989	17777	30441	46845
Average operating and labor costs	52.83	28.90	24.82	21.79
Interest on investment (5%)	3847	7960	15244	22715
Total operating and opportunity costs	14836	25737	45685	69560
Average operating and opportunity costs	71.33	41.85	38.75	32.35
Interest on investment (1.4%)	1095	2181	4177	6224
Total operating and opportunity costs	12084	19958	34618	53069
Average operating and opportunity costs	58.10	32.45	29.36	24.68

to ignore all opportunity costs (interest on investment, operator and family labor, and depreciation) and recognize only the cash costs represented in $LRAC_1$. Depreciation cannot be ignored in the long-run since the wearing out of machinery, equipment, buildings, and improvements is a continuous process and these items must be replaced. All four ranch sizes studied are capable of covering the cash costs involved in beef production.

Each of the other four LRAC curves derived decreases throughout the range of cattle ranch sizes studied (Figure 2) indicating that cost economies are continually realized as ranch size increases from 50 to 500 head. As mentioned above, an important source of cost economies is the intensification of cattle numbers on cash costs (taxes and insurance). A related source of cost economies for $LRAC_2$ (which includes cash costs and depreciation), $LRAC_3$ (which includes cash costs, depreciation, and operator and family labor), $LRAC_4$ (which includes cash costs, depreciation, operator and family labor, and interest on investment at 5.0 per cent), and $LRAC_5$ (which includes cash costs, depreciation, operator and family labor, and interest on investment at 1.4 per cent) is the spreading of the implicit cost of depreciation of machinery, equipment, buildings, and improvements (Table 2). Spreading of the costs of operator and family labor contributes to the economies represented in $LRAC_3$, $LRAC_4$, and $LRAC_5$. In both $LRAC_4$ and $LRAC_5$ spreading of costs of interest on investment (brought about by intensification of cattle numbers on buildings, improvements, machinery, and equipment) is an important source of cost economies.

For purposes of long-run planning, Figure 2 provides considerable information. Setting the weighted average beef price at $24 per cwt.

(Christensen and Richards, 1969) (Table 3) and given the combination of cash and implicit costs which the operator recognizes as true costs, the LRAC curve can be used to answer the question "how large must a cattle ranch enterprise be to just break even?". This question might be asked by existing cattle ranch operators or by persons considering cattle ranches as an investment opportunity. As mentioned above, if the ranch operator recognizes only the cash costs of production ($LRAC_1$), any one of the four ranch sizes studied is of sufficient size to meet these costs since the price line (P) lies above $LRAC_1$ throughout the range of ranch sizes studied.

It is likely that the goal of the ranch operator is to at least maintain long-run solvency. In this case both cash costs and depreciation must be provided for from the cash returns to beef production ($LRAC_2$). A cattle operation of about 105 head is the minimum necessary to pay cash costs and depreciation. The ability of operators of 50 cow ranches to remain in business even though cash costs and depreciation cannot both be covered is probably due to the willingness of the operator to subsidize his beef operation with part time or even full time off-the-ranch employment.

If the goal of the ranch operator is to receive the market wage for his labor and that of his family as well as paying all cash costs and providing for replacement of worn out capital ($LRAC_3$), the minimum size of cattle ranch necessary is about 360 head.

Assuming that the operator's goal includes providing a fair return (5 per cent) to investment in land and capital as well as covering cash costs, depreciation and the opportunity costs of labor ($LRAC_4$), none of the four ranch sizes studied is of sufficient size. If beef revenue is

Table 3. Production and sales of cattle on typical ranches, Utah, 1968.

Ranch size	No. sold	Average weight	Total weight (cwt)	Price $/cwt	Value $
50 breeding cows					
cows	7	1000	70	16.60	1162
heifer calves	9	380	34	26.98	917
steer calves	8	400	32	28.62	916
yearling steers	12	600	72	24.00	1728
Total sales			208	22.71	4723
150 breeding cows					
cows	21	1000	210	16.60	3486
heifer calves	35	380	133	26.98	3588
steer calves	41	400	164	28.62	4694
yearling steers	18	600	108	24.00	2592
Total sales			615	23.35	14360
300 breeding cows					
cows	34	1000	340	16.60	5362
heifer calves	73	380	277	26.98	7473
steer calves	85	400	340	28.62	9731
yearling steers	37	600	222	24.00	5328
Total sales			1179	24.01	27894
500 breeding cows					
cows	50	1000	500	16.60	8300
heifer calves	171	380	650	26.98	17537
steer calves	175	400	700	28.62	20034
yearling steers	50	600	300	24.00	7200
Total sales			2150	24.68	53071

Bulls are treated as capital items and accounted for in depreciation.

considered to be the only source of income (values not being assigned to other ranch "products" such as tax shelter, land appreciation, and ranching as a "way of life"), the minimum size of cattle ranch consistent with operator goals is somewhat larger than 500 head of breeding cows. However, if an investor in cattle ranch property expected a return of only 1.4 per cent on his investment ($LRAC_5$) and saw this particular rate as the true opportunity cost of land and capital, the minimum size of cattle ranch consistent with operator goals would be 500 head.

Given the size of cattle ranch currently operated by an existing rancher and the combination of cash and implicit costs which he believes must be covered, Figure 2 may be used to answer the question "what must the weighted average price of beef be in order to just break even?". For instance an operator of a 200 head cattle ranch who sees only cash costs and depreciation as real costs ($LRAC_2$) would have to receive a weighted average price of $19 per cwt. for the beef he produced. An operator of a 400 head cattle ranch who intended to cover all costs including a rate of return on investment of 5 per cent would require a weighted average price slightly greater than $35 per cwt.

Wheat Farm Economies of Size

Average costs of wheat production were calculated on the basis of the production figures shown in Table 4. All five LRAC curves derived exhibit the same shape (Figure 3). $LRAC_1$ includes only cash costs while $LRAC_2$ includes cash costs and depreciation. $LRAC_3$ includes cash costs, depreciation and operator and family labor. $LRAC_4$ includes these three items plus interest on investment at five per cent. In addition to cash costs, depreciation, and operator and family labor, $LRAC_5$ includes

Table 4. Production and sales of wheat on typical dryland wheat farms, Utah, 1968.

Farm size (acres)	Bu./Acre	Total yield (bu.)	Price	Value
500	20	5000	1.32	6600
1000	20	10000	1.32	13200
2000	20	20000	1.32	26400
3000	20	30000	1.32	39600

interest on investment at 0.64 per cent. Size economies are evident as the size of operation is expanded from 500 to 1000 acres but diseconomies are present as size is further expanded to 2000 acres. Economies are again in effect as wheat farm size grows from 2000 to 3000 acres. The strange shape of the curves which include the costs of depreciation or both depreciation and interest on investment ($LRAC_2$, $LRAC_3$, $LRAC_4$ and $LRAC_5$) is probably due to machinery being added in a large "lump" as farm size increases from 1000 to 2000 acres. A wheat farm of 1000 acres is typically operated with a machinery complement which differs little from the one found on 500 acre farms. Thus, for example, the shift from a 75 horsepower tractor to a 100 horsepower tractor creates a proportionality adjustment (machinery being intensified upon by land) which causes a spreading of depreciation and interest on investment in machinery over more acres (Table 35 and 36, Appendix B). This effect is evidenced by the decrease in the LRAC curve between 500 and 1000 acres. However, as farm size increases from 1000 to 2000 acres, the machinery complement

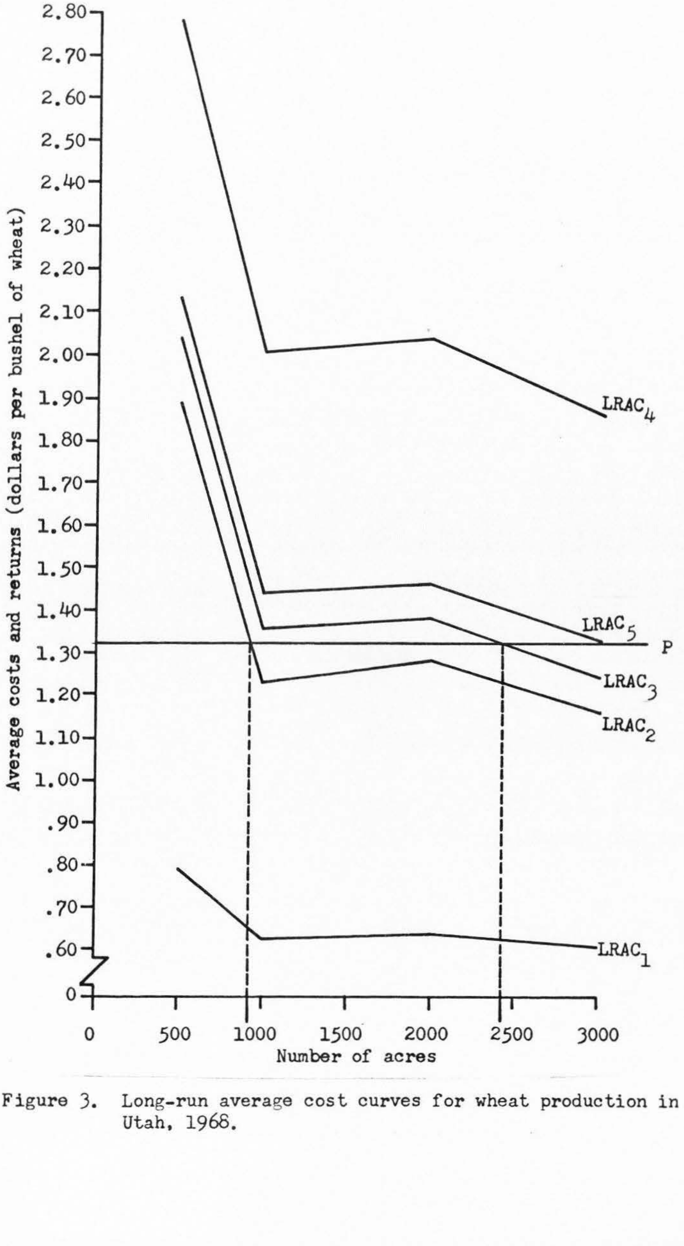

Figure 3. Long-run average cost curves for wheat production in Utah, 1968.

is greatly increased. For instance, both a 100 horsepower tractor and a 120 horsepower tractor are typically found on the 2000 acre farms (Table 37, Appendix B). This causes a proportionality adjustment, but one in which land is intensified upon by machinery. This has an effect which is precisely the opposite of spreading of machinery costs and is apparent in the increase in the LRAC curve between 1000 and 2000 acres. As farm size increases from 2000 to 3000 acres there is again little change in machinery complement. The 100 horsepower tractor is typically absent and in its place a second 120 horsepower tractor is found (Table 38, Appendix B). This proportionality adjustment causes an intensification of land on machinery which is evidenced by the decrease in the LRAC curve between 2000 and 3000 acres.

When one considers that the $LRAC_1$ curve, which includes only cash costs (Table 5), contains such costs as personal property taxes and insurance, it is not surprising that this curve exhibits the same shape as those discussed above, even though the costs of depreciation and interest on investment are not represented.

As mentioned in the Methods section, it was assumed that existing wheat farm operators are operating at the minimum points on their SRAC curves (that is they operate their acreages with the most efficient complements of machinery possible). The "hump" in the LRAC curves at 2000 acres might be caused by farmers in the 2000 acre category operating with something other than the most efficient complement of machinery and equipment. Such action might be dictated by goals for the wheat production enterprise differing from the traditionally assumed goal of profit maximization. If fármers operating 2000 acres have outside sources of income which smaller operators do not have, their goals may

Table 5. Total and average (per bushel) costs of wheat production on typical dryland wheat farms, Utah, 1968.

	Size of farm (acres)			
	500	1000	2000	3000
Cash costs				
Labor hired			300	600
Repairs and maintenance				
Buildings and improvements	98	217	353	459
Machinery and equipment	1320	1389	2951	3635
Taxes	967	1683	3387	4880
Fertilizer	85	170	340	510
Seed	448	896	1792	2688
Machine operating costs	392	748	1335	1936
Machine hire (including herbicide)	375	750	1500	2250
Insurance	136	162	342	426
Interest on cash costs	153	250	492	695
Total cash costs	3974	6265	12792	18079
Average cash costs	.795	.627	.640	.603
Non-cash costs				
Depreciation				
Buildings and improvements	222	446	707	1884
Machinery and equipment	5256	5594	12234	15026
Total operating costs	9452	12305	25733	34989
Average operating costs	1.890	1.231	1.287	1.166
Operator and family labor	750	1260	1900	2200
Total operating and labor costs	10202	13565	27633	37189
Average operating and labor costs	2.040	1.357	1.382	1.240
Interest on investment (5%)	3720	6571	13027	18765
Total operating and opportunity costs	13922	20036	40660	55954
Average operating and opportunity costs	2.784	2.004	2.033	1.865
Interest on investment (0.64%)	476	828	1667	2402
Total operating and opportunity costs	10678	14393	29300	39591
Average operating and opportunity costs	2.136	1.439	1.465	1.320

include tax advantages gained by possessing large amounts of machinery for write-off at tax time. Thus an over-investment in machinery by farmers in this size category would be expected and would be consistent with overall profit maximization even though less than maximum profit would be received from the wheat enterprise itself. If this is the case, it is difficult to explain the decrease in the LRAC between 2000 and 3000 acres. Such a decrease indicates a more efficient complement of machinery and an actual intensification of land on capital as mentioned above. But less over-investment in machinery on the 3000 acre farms may indicate that wheat enterprise profit maximization rather than tax advantages is the goal of farmers in this size category. Such a shift in operator goals would be rational only if outside sources of income are less common on the 3000 acre farm than on the 2000 acre size. Such a situation is possible since the 3000 acre farms may be large enough for wheat enterprise profit maximization to become the dominant operator goal.

If there actually is a difference in the goals of operators of 2000 acre farms and those of operators of the other three farm sizes, the situation may be as represented in Figure 4. The actual LRAC curve (which includes only cash costs) derived from budgeting procedures is represented by $LRAC_1$ while $LRAC_1'$ represents what the LRAC might be if operator goals were identical for all four farm sizes. The curve labeled $LRAC_1'$ is merely a trend line drawn through the four points yielded by budgeting and does possess the shape characteristic of theoretical LRAC curves. Since the problem of differences in goals of operators of different farm sizes was not foreseen, questions concerning operator goals were absent on questionnaires sent to wheat farmers.

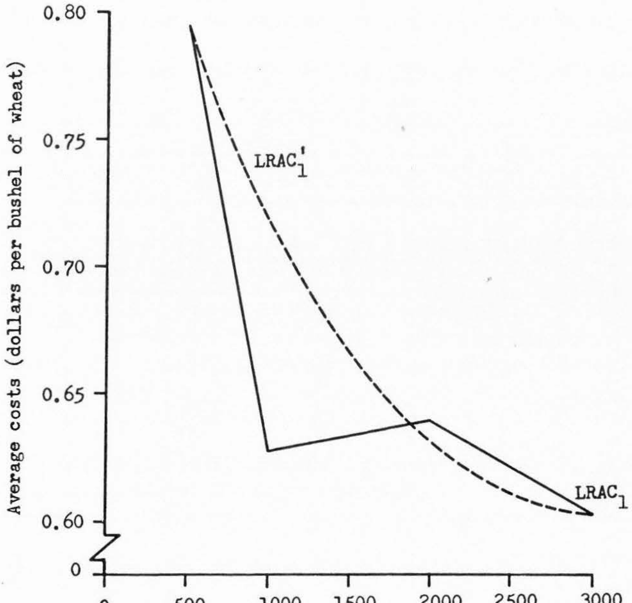

Figure 4. Actual and hypothetical long-run average cost curves for wheat production in Utah, 1968.

With reference to the trend line labeled $LRAC_1'$, one additional possibility exists. If all data had been derived from questionnaires sent to wheat farmers rather than partially from machine capacity techniques, the LRAC curve resulting from regression analysis and representing the "best fit" of many sample points might have looked more like $LRAC_1'$ than $LRAC_1$. This would indicate that the goals of wheat farmers were similar throughout the range of production investigated and that size economies did exist throughout this range. As mentioned in the Methods section, low percentage response from farmers receiving questionnaires made it necessary to rely on the machine capacity technique as an important source of data. This technique does not readily lend itself to regression analysis since the explanatory power of a regression equation must come from the best fit through many points. The sample size provided by the machine capacity technique was not sufficient to justify more sophisticated analyses employing regression techniques.

Considerable information for decision making purposes is provided by Figure 3. Inspection of Figure 3 can be used to answer the question "how large must a wheat farm operation be in order to just break even?". This question might be asked by either potential investors in wheat enterprises or by existing wheat farmers. Given the 1968 price of wheat of $1.32 per bushel (Christensen and Richards, 1969) and the combination of cash and implicit costs which the operator believes must be covered, the necessary size of wheat farm may be determined directly from the LRAC curves. None of the four sizes of wheat farms studied were large enough to cover all costs. If $LRAC_4$ is considered the relevant curve (that is, provision is made to cover all costs including interest on investment at a rate of 5 per cent), the minimum sized wheat farm is something greater than 3000 acres (the price line (P) lies below $LRAC_4$ throughout the range of farm sizes studied). Thus none of the four wheat farm sizes studied are capable of covering all costs without assigning values to other wheat farm "products" such as tax shelter, land appreciation, and farming as a "way of life." However, the situation can be analyzed from another viewpoint. If wheat farm operators expect a return of only 0.16 per cent and see this particular rate of return as the opportunity cost of capital and land ($LRAC_5$), the necessary minimum size of wheat farm is 3000 acres.

The minimum size of wheat farm necessary to meet all costs except interest on investment is 2430 acres ($LRAC_3$). If the operator chooses to ignore all opportunity costs except depreciation, $LRAC_2$ becomes the relevant curve and about 940 acres is the minimum farm size consistent with operator goals. For short periods of time the operator may choose to ignore even depreciation ($LRAC_1$). In this case all four wheat farm sizes are capable of satisfying the goals of the operator. It is doubtful that $LRAC_1$ is really a planning curve since to be viable in any long-run situation the operator would have to at least account for the wearing out of capital.

Figure 3 can also be used by existing wheat farm operators to answer the question "what must the price of wheat be in order to just break even on a wheat farm of a given size?". If provision is made to cover all costs including five per cent interest on investment, the necessary wheat prices are 2.78, 2.00, 2.03 and 1.87 for 500, 1000, 2000, and 3000 acre wheat farms, respectively. To cover all costs on a wheat farm of say 2500 acres, the price of wheat would have to be \$1.95 per bushel. If the operator of such a farm chose to ignore interest on investment, the necessary wheat price would drop to about \$1.30 per bushel. If the same operator saw only depreciation and cash costs as real costs, the price of wheat necessary to satisfy his goals would be about \$1.22 per bushel.

It is not likely that any wheat farm operator will choose to ignore both the opportunity costs of operator and family labor and those of interest on investment. In addition to the goal of long-run solvency (which could be satisfied by meeting only cash costs and depreciation), most operators are also concerned with providing their families with an acceptable standard of living. The latter requirement can be financed in the long-run in the form of either the returns to operator and family labor or interest on investment. The operator and his family can "live on depreciation" only for short periods of time since the wearing out of machinery and equipment is a continuous process. With this in mind, perhaps $LRAC_2$ (accounting only for cash costs and depreciation) should not be considered as a genuine long-run planning curve.

Management Alternatives

The regression equation with AUMs of forage per acre expressed as a function of bushels of wheat per acre (Table 6) took the form AUM = -0.383 + 0.054 (bushels). The R^2 value was 0.87 indicating that 87 per cent of the variability in forage production is explained by the variability in wheat production. The t value for the beta coefficient for wheat as the explanatory variable was 9.16 which was significant at the 0.001 level with n-k = 13 degrees of freedom. This may be interpreted

Table 6. Forage and wheat production at fifteen locations.

Location	Forage production (AUM per acre)	Wheat production (bushels per acre)	Data source Forage	Wheat
Benmore	0.36	15	Cook (1966)	ASCS
Eureka	0.37	18	Cook (1966)	ASCS
Oneida County, Idaho	0.40	15	Hull (1966)	ASCS
Benmore	0.42	15	Anonymous (1964)	ASCS
Curlew Junction	0.43	14	Grumbles (1966)	ASCS
Curlew Nat'l Grassland	0.60	19	Kimber (1966)	ASCS
Fairview	0.59	18	Farmer A	Farmer A
Snowville	0.56	16	Farmer B	Farmer B
North Curlew Valley	0.80	20	Farmer C	ASCS
Blue Creek	0.60	18	Farmer D	Farmer D
Fairview	1.20	30	Farmer E	Farmer E
Nephi	0.75	20	Farmer F	Farmer F
Fairview	0.80	20	Farmer G	Farmer G
Howell	0.54	16	Farmer H	Farmer H
Fairview	0.43	15	Farmer I	Farmer I

to mean that if the sample were repeated the probability of a Type I error (rejecting a null hypothesis which was true) is 0.1 per cent. The null hypothesis in this case is that the beta coefficient for wheat production as the independent variable is zero which would mean that AUM production and wheat production were not related.

Despite the "goodness of fit" indicated by the high R^2 value, the negative intercept value is somewhat disturbing. Obviously negative forage production at low wheat production levels is not realistic although the negative intercept may be a reflection of nothing more than the units chosen to express productivity. To avoid obtaining negative forage production values at low levels of wheat production a second regression was run which minimized the sum of squares of deviation subject to the constraint that the vertical intercept equal zero. This regression equation took the form AUM = 0.034 (bushels), with an R^2 value of 0.74 and t of 20.34 which was significant at the 0.001 level with $n-k = 14$ degrees of freedom. Although it has a lower R^2 value, the second regression equation more closely fits the a priori knowledge of the biological relationship between wheat and forage production. In terms of prediction of forage yield, given wheat yield, the two equations do not differ greatly. For instance if wheat production is twenty bushels per acre, the first equation predicts that 0.697 AUMs of forage can be produced per acre while the second regression equation predicts a forage yield of 0.680 AUMs per acre.

Concerning the question of model misspecification, it is obvious that forage production is a function of many variables in addition to wheat production. Total precipitation, time of precipitation, length of growing season, soil texture, soil fertility, soil salinity, wheat grass species, source of seed, and previous land use history are other possible explanatory variables. Many of these would be difficult to quantify for regression purposes and the use of dummy variables would be necessary. Also by allowing the above variables to "run wild" considerable simplicity and generality is gained over a regression equation which includes all variables. As is indicated by the R^2 values, the predictive power of the equations is quite high. If the equations were to be used to explain variability in forage production, a valid argument could be made for including all possible explanatory variables. However, since the equations are to be used to predict forage production from wheat production, use of the more simple model can be justified.

The regression equations serve another purpose. The high R^2 values indicate that forage production and wheat production are biological substitutes on various qualities of dryland in Utah. Thus the problem of choosing between management alternatives is an economic rather than a biological problem.

Short-run alternatives

Short-run costs, returns, and returns to fixed factors for the five management alternatives are shown in Tables 7 through 11. The returns to fixed factors also appear in summary form in Table 12. Comparisons of the short-run alternatives should be interpreted as predictions of what course of action marginal cropland owners are apt to take. The short-run comparisons of management alternatives are not to be viewed as management recommendations for owners of marginal cropland.

Table 7. Short-run costs and returns to wheat production by owner-operator (short-run alternative 1).

	Acreage			
	500	1000	2000	3000
Returns				
Wheat at $1.32 per bushel	6600	13200	26400	39600
Costs				
Labor hired			300	600
Repairs and maintenance				
Buildings and improvements	98	217	353	459
Machinery and equipment	1320	1389	2951	3635
Fertilizer	85	170	340	510
Seed	448	896	1792	2688
Machine operating costs	392	748	1335	1936
Machine hire (including herbicide)	375	750	1500	2250
Interest on variable costs	109	167	343	483
Total variable costs	2827	4337	8914	12561
Return to fixed factors	3773	8863	17486	27039

Table 8. Short-run costs and returns to owner leasing cropland to leasee producing dryland wheat (short-run alternative 2).

	Acreage			
	500	1000	2000	3000
Returns				
One-third wheat crop at $1.32 per bushel	2200	4400	8800	13200
Costs				
Repairs and maintenance				
Boundary fences	70	100	141	173
Interests on variable costs	3	4	6	7
Total variable costs	73	104	147	180
Return to fixed factors	2127	4296	8653	13020

Table 9. Short-run costs and returns to owner leasing forage on AUM basis (short-run alternative 3).

	Acreage			
	500	1000	2000	3000
Returns				
Lease forage at $3.50 per AUM	1190	2380	4760	7140
Costs				
Repairs and maintenance				
Improvements	108	164	279	327
Interest on variable costs	4	7	11	13
Total variable costs	112	171	290	340
Return to fixed factors	1078	2209	4470	6800

Table 10. Short-run costs and returns to owner leasing forage on livestock gain basis (short-run alternative 4).

	Acreage			
	500	1000	2000	3000
Returns				
Lease forage at $.10 per lb. gain	2808	5616	11232	16848
Costs				
Repairs and maintenance				
Improvements	108	164	279	327
Interest on variable costs	4	7	11	13
Total variable costs	112	171	290	340
Return to fixed factors	2696	5445	10942	16508

Table 11. Short-run costs and returns to stocker cattle production (short-run alternative 5).

	Acreage			
	500	1000	2000	3000
Returns				
590 lb. steers at $.23 per lb.	42338	84677	169353	254030
Costs				
500 lb. steers at .24 per lb.	37440	74880	149760	224640
Repairs and maintenance				
Improvements	108	164	279	327
Trucking	1248	2496	4368	6552
Sales commission costs	889	1778	3557	5335
Salt	10	19	38	57
Interest on variable costs[1]	577	1151	2276	3410
Total variable costs	40272	80488	160279	240322
Return to fixed factors	2066	4189	9074	13708

[1]Includes interest on cattle investment at 1.33% (8% annual interest for two month period).

Table 12. Return to fixed factors for five short-run management alternatives on four sizes of marginal cropland acreages, Utah, 1968.

	Acreage			
Alternative	500	1000	2000	3000
1	3773	8863	17486	27039
2	2127	4296	8653	13020
3	1078	2209	4470	6800
4	2696	5445	10942	16508
5	2066	4189	9074	13708

In the short-run all five management alternatives are open only to marginal cropland owners who also own all factors of wheat production (machinery, equipment and buildings) and all improvements necessary for the grazing enterprises (cross fences, corrals, loading chutes, grass seedings, and water developments). It is possible, but not likely, that a land owner would find himself in this situation. These conditions could arise if a wheat farmer had entered into soil bank contracts, established a permanent cover on his cropland, retained his ownership of wheat production factors, and had during the contract period, invested in grazing improvements. Referring to Table 12, it is apparent that owners of all four marginal cropland acreages faced with choosing between all five alternatives, would choose alternative 1 (wheat production on owner-operator basis).

For marginal cropland owners who own all factors of wheat production but do not own the improvements necessary for the grazing enterprises, the decision is reduced to choosing between alternatives 1 and 2. Alternative 1 would again by chosen by the owners of each of the four acreages.

Alternative 2 (leasing cropland to tenant producing dryland wheat) is the only course of action open to marginal cropland owners who own neither wheat production factors nor grazing improvements.

Owners of cropland equipped with the improvements necessary for grazing enterprises must choose between alternatives 2, 3, 4, and 5. Owners of all four acreage sizes would choose alternative 4 (leasing of forage on livestock gain basis). Leasees may prefer the leasing agreement of alternative 4 to that of alternative 3 since the farmer allows the cattleman to pay on the basis of benefits actually obtained.

However, it is likely that if lease forage were available to cattle owners on the basis of alternative 3, land owners would encounter difficulty in attempting to lease their forage on the basis of alternative 4. If alternative 4 were, for these reasons, not available to land owners the decision would be between alternatives 2, 3, and 5. In this case owners of 500 and 1000 acre units of marginal cropland would choose alternative 2 while owners of 2000 and 3000 acre units would choose alternative 5.

As mentioned in the Methods section, interpretation of the results of short-run comparisons of costs and returns to management alternatives is subject to certain assumptions. In the short-run situation some inputs are, by definition, fixed. It was assumed, then, that machinery, equipment, buildings, and improvements could be neither acquired nor disposed of and the fixed costs attributable to these factors (insurance, taxes, and depreciation) were not allowed to enter into the decision as to which of the five management alternatives to pursue. It was also assumed that in the short-run land ownership would be retained and that both the operator and his family would continue to live and work on the land. Thus the opportunity costs of alternative investment and employment were not allowed to affect the decision either.

Long-run alternatives assuming all factors variable

When it is assumed that all inputs are variable (and the opportunity costs of operator and family labor and land are accounted for accordingly), each of the five long-run management alternatives yields a net loss (Tables 13-17). None of the mathematical techniques of alternative comparison encountered in economic literature provide a means of ranking

Table 13. Long-run costs and returns to wheat production by owner-operator (long-run alternative 1) when all inputs are considered variable.

	Acreage			
	500	1000	2000	3000
Returns				
Wheat at $1.32 per bushel	6600	13200	26400	39600
Costs				
Cash costs				
Labor hired			300	600
Repairs and maintenance				
Buildings and improvements	98	217	353	459
Machinery and equipment	1320	1389	2951	3635
Taxes	967	1683	3387	4880
Fertilizer	85	170	340	510
Seed	448	896	1792	2688
Machine operating costs	392	748	1335	1936
Machine hire (including herbicide)	375	750	1500	2250
Insurance	136	162	342	326
Interest on cash costs	153	250	492	695
Total cash costs	3974	6265	12792	18079
Non-cash costs				
Depreciation				
Buildings and improvements	245	544	884	2177
Machinery and equipment	5256	5594	12234	15026
Operator and family labor	750	1260	1900	2200
Land rent (7% of land value)	3500	7000	14000	21000
Total operating costs	13725	20663	41810	58482
Net annual revenue (R)	- 7125	- 7463	-15410	-18882
Present value of investment (I)	79630	90456	189740	236360

Table 14. Long-run costs and returns to owner leasing cropland to tenant producing dryland wheat (long-run alternative 2) when all inputs are considered variable.

	Acreage			
	500	1000	2000	3000
Returns				
One-third wheat crop at $1.32 per bushel	2200	4400	8800	13200
Costs				
Cash costs				
Repairs and maintenance				
Boundary fences	70	100	141	173
Taxes	673	1333	2646	3956
Interest on cash costs	30	57	111	165
Total cash costs	773	1500	2898	4294
Non-cash costs				
Depreciation				
Boundary fences	175	250	354	444
Operator and family labor	70	100	140	170
Land rent	3500	7000	14000	21000
Total operating costs	4518	8850	17392	25908
Net annual revenue (R)	-2318	-4450	-8592	-12708
Present value of investment (I)	3500	5000	7070	8670

Table 15. Long-run costs and returns to owner leasing forage on AUM basis (long-run alternative 3) when all inputs are considered variable.

	Acreage			
	500	1000	2000	3000
Returns				
Lease forage at $3.50 per AUM	1190	2380	4760	7140
Costs				
Cash costs				
Repairs and maintenance				
Improvements	108	164	279	327
Taxes	685	1353	2691	4006
Pump operating costs	100	100	200	200
Interest on cash costs	36	65	127	181
Total cash costs	929	1682	3297	4714
Non-cash costs				
Depreciation				
Improvements	271	411	697	817
Operator and family labor	90	145	252	300
Land rent	3500	7000	14000	21000
Total operating costs	4790	9238	18246	26831
Net annual revenue (R)	-3600	-6858	-13486	-19691
Present value of investment (I)	8895	15180	27860	37240

Table 16. Long-run costs and returns to owner leasing forage on livestock gain basis (long-run alternative 4) when all inputs are considered variable.

	Acreage			
	500	1000	2000	3000
Returns				
Lease forage at $.10 per lb. gain	2808	5616	11232	16848
Costs				
Cash costs				
Repairs and maintenance				
Improvements	108	164	279	327
Taxes	685	1353	2691	4006
Pump operating costs	100	100	200	200
Interests on cash costs	36	65	127	181
Total cash costs	929	1682	3297	4714
Non-cash costs				
Depreciation				
Improvements	271	411	697	817
Operator and family labor	90	145	252	300
Land rent	3500	7000	14000	21000
Total operating costs	4790	9238	18246	26831
Net annual revenue (R)	-1982	-3622	-7014	-9983
Present value of investment (I)	8895	15180	27860	37240

Table 17. Long-run costs and returns to stocker cattle production (long-run alternative 5) when all inputs are considered variable.

	Acreage			
	500	1000	2000	3000
Returns				
590 lb. steers at $.23 per lb.	42338	84677	169353	254030
Costs				
Cash costs				
500 lb. steers at $.24 per lb.	37440	74880	149760	224640
Repairs and maintenance				
Improvements	108	164	279	327
Trucking	1248	2496	4368	6552
Sales commission costs	889	1778	3557	5335
Salt	10	19	38	57
Taxes	685	1353	2691	4006
Pump operating costs	100	100	200	200
Interest on cash costs[1]	609	1209	2392	3579
Total cash costs	41089	81999	163285	244696
Non-cash costs				
Depreciation				
Improvements	271	411	697	817
Operator and family labor	135	265	462	600
Land rent	3500	7000	14000	21000
Total operating costs	44985	89675	178444	267113
Net annual revenue (R)	-2647	-4998	-9091	-13083
Present value of investment (I)	8895	15180	27860	37240

[1]Includes interest on cattle investment at 1.33% (8% annual interest for two month period).

alternatives which yield negative returns (see Methods section). However, the comparison of alternatives providing net losses is necessary only when the decision maker has no alternate course of action and must choose from among these alternatives. Such a situation might arise if a farmer facing such a choice was not only determined to retain his land ownership, but also refused to allow his land to lie idle.

The lack of criteria suitable for ranking such alternatives is irrelevant when all factors of production are variable. Since all resources are free to move, the market will tend to push each input into its best use. A land owner faced with choosing between the five alternatives will turn to still another option. He will dispose of his marginal cropland, thus refusing to engage in any one of the management alternatives studied.

The fact that farmers do retain ownership of their land for long periods of time and do practice the five alternatives analyzed indicates that (1) some farm products are not included in the analysis or (2) the land owners choose to ignore some costs. Other farm "products" not attributed to the alternatives studied include such things as tax advantages for land owners with additional sources of income, land appreciation, and the value of farming as a "way of life." Such costs as the opportunity costs of operator and family labor and land ownership may not be looked upon by land owners as real costs.

In view of the likelihood that some land owners do view farming as a "way of life" and do ignore some costs of production, the alternatives were compared below subject to the assumption that operator and family labor and land are fixed even in the long-run.

Long-run alternatives assuming operator and family labor and land fixed

Alternative 2 (leasing cropland to tenants producing dryland wheat) proved to be the most profitable for all four sizes of marginal cropland acreage (Tables 18-23). In absolute terms the net revenue provided by alternative 2 was less than that yielded by alternative 4. However, the modest investment required to put alternative 2 into practice allowed its internal rate of return on investment to be higher than that for any of the other four alternatives.

The internal rate of return on investment in alternative 4 (leasing forage on a pounds gained basis) ranked second for all four marginal cropland acreages. It should be pointed out that if forage were available under the terms of alternative 3 (leasing forage on an AUM basis) that owners of marginal cropland might have difficulty finding stockmen willing to enter into the leasing agreement of alternative 4.

Ranking third for all four acreages studied was alternative 5 (use of forage by owner for stocker cattle production). The absolute returns yielded by this alternative were similar to those provided by alternative 2 but alternative 5 required much larger capital outlays.

Alternatives 1 (wheat production by the land owner) and 3 (leasing forage on an AUM basis) ranked least favorably. These two alternatives both yielded an internal rate of return of less than one-fourth of one per cent for the three larger acreages. Alternatives 1 and 3 cannot be compared by the internal rate of return technique on the 500 acre farms since for this acreage both yield negative returns (see Methods section).

It should be pointed out that alternative 2, while appearing to be the most favorable management alternative from the viewpoint of the land

Table 18. Long-run costs, returns, and internal rate of return to wheat production by owner-operator (long-run alternative 1) when operator and family labor and land are considered fixed.

	Acreage			
	500	1000	2000	3000
Returns				
Wheat at $1.32 per bushel	6600	13200	26400	39600
Costs				
Cash costs				
Labor hired			300	600
Repairs and maintenance				
Buildings and improvements	98	217	353	459
Machinery and equipment	1320	1389	2951	3635
Taxes	967	1683	3387	4880
Fertilizer	85	170	340	510
Seed	448	896	1792	2688
Machine operating costs	392	748	1335	1936
Machine hire (including herbicide)	375	750	1500	2250
Insurance	136	162	342	426
Interest on cash costs	153	250	492	695
Total cash costs	3974	6265	12792	18079
Non-cash costs				
Depreciation				
Buildings and improvements	245	544	884	2177
Machinery and equipment	5256	5594	12234	15026
Total operating costs	9475	12403	25910	35282
Net annual revenue (R)	-2875	797	490	4318
Present value of investment (I)	79630	90456	189740	236360
Inwood coefficient	-2.77	113.50	387.22	54.74
Internal rate of return (%)	-0.50	<0.25	<0.25	<0.25

Table 19. Long-run costs, returns, and internal rate of return to owner leasing cropland to tenant producing dryland wheat (long-run alternative 2) when operator and family labor and land are considered fixed.

	Acreage			
	500	1000	2000	3000
Returns				
One-third wheat crop at $1.32 per bushel	2200	4400	8800	13200
Costs				
Cash costs				
Repairs and maintenance				
Boundary fences	70	100	141	173
Taxes	673	1333	2646	3956
Interest on cash costs	30	57	111	165
Total cash costs	773	1500	2898	4294
Non-cash costs				
Depreciation				
Boundary fences	175	250	354	444
Total operating costs	948	1750	3252	4738
Net annual revenue (R)	1252	2650	5548	8462
Present value of investment (I)	3500	5000	7070	8670
Inwood coefficient	2.80	1.89	1.27	1.02
Internal rate of return (%)	35	>50	>50	>50

Table 20. Long-run costs, returns, and internal rate of return to owner leasing forage on AUM basis (long-run alternative 3) when operator and family labor and land are considered fixed.

	Acreage			
	500	1000	2000	3000
Returns				
Lease forage at $3.50 per AUM	1190	2380	4760	7140
Costs				
Cash costs				
Repairs and maintenance				
Improvements	108	164	279	327
Taxes	685	1353	2691	4006
Pump operating costs	100	100	200	200
Interest on cash costs	36	65	127	181
Total cash costs	929	1682	3297	4714
Non-cash costs				
Depreciation				
Improvements	271	411	697	817
Total operating costs	1200	2093	3994	5531
Net annual revenue (R)	- 10	287	826	1609
Present value of investment (I)	8895	15180	27860	37240
Inwood coefficient	-889.60	52.89	33.73	23.14
Internal rate of return (%)	- 23	<0.25	<0.25	<0.25

Table 21. Long-run costs, returns, and internal rate of return to owner leasing forage on livestock gain basis (long-run alternative 4) when operator and family labor and land are considered fixed.

	Acreage			
	500	1000	2000	3000
Returns				
Lease forage at $.10 per lb. gain	2808	5616	11232	16848
Costs				
Cash costs				
Repairs and maintenance				
Improvements	108	164	279	327
Taxes	685	1353	2691	4006
Pump operating costs	100	100	200	200
Interest on cash costs	36	65	127	181
Total cash costs	929	1682	3297	4714
Non-cash costs				
Depreciation				
Improvements	271	411	697	817
Total operating costs	1200	2093	3994	5531
Net annual revenue (R)	1608	3523	7238	11317
Present value of investment (I)	8895	15180	27860	37240
Inwood coefficient	5.53	4.31	3.85	3.29
Internal rate of return (%)	17	22	26	30

Table 22. Long-run costs, returns, and internal rate of return to stocker cattle production (long-run alternative 5) when operator and family labor and land are considered fixed.

	Acreage			
	500	1000	2000	3000
Returns				
590 lb. steers at $.23 per lb.	42338	84677	169353	254030
Costs				
Cash costs				
500 lb. steers at $.24 per lb.	37440	74880	149760	224640
Repairs and maintenance				
Improvements	108	164	279	327
Trucking	1248	2496	4368	6552
Sales commission costs	889	1778	3557	5335
Salt	10	19	38	57
Taxes	685	1353	2691	4006
Pump operating costs	100	100	200	200
Interest on cash costs[1]	609	1209	2392	3579
Total cash costs	41089	81999	163285	244696
Non-cash costs				
Depreciation				
Improvements	271	411	697	817
Total operating costs	41360	82410	163982	245513
Net annual revenue (R)	978	2267	5371	8517
Present value of investment (I)	8895	15180	27860	37240
Inwood coefficient	9.10	6.70	5.17	4.37
Internal rate of return (%)	9	14	18	22

[1]Includes interest on cattle investment at 1.33% (8% annual interest for two month period).

Table 23. Internal rates of return (%) to five long-run management alternatives on four acreages of marginal cropland when operator and family labor and land are considered fixed.

Alternative	Acreage 500	1000	2000	3000
1	-0.5	<0.25	<0.25	<0.25
2	35.00	>50.00	>50.00	>50.00
3	23.0	<0.25	<0.25	<0.25
4	17.0	22.00	26.00	30.00
5	9.0	14.00	18.00	22.00

owner, may not be the most favorable land use from the viewpoint of society. This is true for three reasons. First, wheat was valued at the weighted average price received for wheat in Utah during 1968. This value reflects the price received for wheat sold under the federal price support program as well as the price for wheat sold on the open market. Current wheat surpluses indicate that the marginal value of a bushel of wheat to society is less than the price supported by federal programs.

Second, the private costs of wheat production may be less than the social costs. Wheat production as a land use may involve greater soil losses and less productive upland game bird habitats than does forage production. Such costs may be ignored by private land owners but are real costs to society.

Third, the consolidation associated with alternative 2 (as well as alternatives 3 and 4) and the resulting decrease in the number of farm operators may produce adverse effects from the viewpoint of society. Even though such consolidation can be justified on efficiency grounds, the increased efficiency may be outweighed by income distribution effects and the detrimental effects on local economies.

SUMMARY AND CONCLUSIONS

Cattle Ranch Economies of Size

Five long-run average cost curves were derived from questionnaire and interview data by connecting points corresponding to the per unit production costs and levels of beef output for four cattle ranch sizes (50, 150, 300, and 500 head of breeding cows). Analysis of the long-run average cost curves in combination with the 1968 weighted Utah beef price revealed that all four ranch sizes studied are capable of meeting cash costs. If the goal of the ranch operator is to meet both cash costs and depreciation, a cattle ranch supporting 105 breeding cows is the minimum size necessary. If provision is made to cover cash costs and depreciation in addition to receiving a fair return for operator and family labor, the ranch must support at least 360 breeding cows. None of the four ranch sizes studied were capable of meeting all production costs including five per cent interest on investment. The minimum ranch size necessary to cover all production costs including 1.4 per cent interest on investment is 500 head of breeding cows.

If existing ranch operators recognize all production costs including five per cent interest on investment, the beef price necessary to break even are $71.33, $41.85, $38.75 and $32.35 per cwt. for cattle ranches supporting 50, 150, 300, and 500 head of breeding cows, respectively.

Wheat Farm Economies of Size

Farmer questionnaires and the machine capacity technique provided data from which five long-run average cost curves were derived by connecting points representing average production costs and levels of wheat output for four sizes of wheat farms (500, 1000, 2000, and 3000 acres). The long-run average cost curves were analyzed in combination with the 1968 Utah wheat price. All four wheat farm sizes studied are capable of meeting cash costs. In order to cover both cash costs and depreciation a wheat farm of at least 940 acres is required. The minimum wheat farm size necessary to meet cash costs and depreciation as well as provide a fair return to operator and family labor is 2430 acres. None of the four sizes of wheat farms studied was large enough to cover all costs including interest on investment at five per cent. In order to cover all production costs including 0.64 per cent interest on investment a wheat farm of at least 3000 acres is required.

If all production costs including five per cent interest on investment are recognized by existing wheat farm operators, the wheat prices necessary to break even are $2.78, $2.00, $2.03, and $1.87 for 500, 1000, 2000, and 3000 acre wheat farms, respectively.

Management Alternatives

To facilitate the conversion of potential wheat production to potential forage production regression analysis was used. The regression equation took the form AUM per acre = 0.034 (bushels per acre).

Costs and returns to five management alternatives for marginal Utah cropland ((1) wheat production by owner-operator, (2) leasing cropland to tenants for dryland wheat production, (3) leasing forage on an

AUM basis, (4) leasing of forage on a livestock gain basis, and (5) stocker cattle production by the land owner) were compared in the short-run, in the long-run assuming that all inputs were variable, and in the long-run assuming that land and operator and family labor were fixed.

For the marginal cropland owner who also owns wheat production factors, wheat production on an owner-operator basis is the most favorable short-run alternative. Wheat production on a tenant basis is the only short-run alternative open to cropland owners who own neither wheat production factors nor the improvements necessary for grazing enterprises. Leasing forage on a livestock gain basis is the most favorable short-run alternative for cropland owners whose holdings are equipped with grazing improvements.

For the long-run situation in which all inputs were considered variable, all five management alternatives yielded negative returns. Under such conditions a rational land owner would refuse to choose from among the five alternatives studied and would instead liquidate his land holdings.

When operator and family labor and land were considered fixed, leasing cropland to tenants for dryland wheat production proved to be the most favorable long-run management alternative. Showing the second highest internal rate of return was leasing forage on a livestock gain basis followed by stocker cattle production by the land owner. Wheat production by the land owner and leasing forage on an AUM basis proved to be the least favorable long-run management alternatives on marginal cropland.

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APPENDIXES

Appendix A

Input and Production Data for Utah Cattle Ranches

Table 24. Summary of investment for typical ranches, Utah, 1968.

	Size of breeding herd			
	50	150	300	500
Land	40,500	72,250	148,250	218,100
Federal grazing permits	7,176	23,816	44,520	54,000
Buildings and improvements	7,300	16,865	30,160	53,620
Machinery and equipment	18,075	23,739	29,022	51,930
Livestock				
Cattle	15,280	41,860	83,900	131,760
Horses	300	450	750	1,050
Total investment	88,581	178,980	336,602	510,460

Table 25. Livestock inventories and investment for typical ranches, Utah, 1968.

Class	Size of breeding herd							
	50		150		300		500	
	Number	Dollars	Number	Dollars	Number	Dollars	Number	Dollars
Cows	50	10,000	150	30,000	300	6,000	500	100,000
Bulls	2	1,000	6	3,000	15	7,500	25	12,500
Yearling heifers	11	1,760	25	4,000	45	7,200	52	8,320
Heifer calves	12	1,320	26	2,860	50	5,500	54	5,940
Steer calves	12	1,200	20	2,000	37	3,700	50	5,000
Horses	2	300	3	450	5	750	7	1,050
Totals		15,580		42,310		84,650		132,810

Table 26. Land inventories and investment for typical ranches, Utah, 1968.

	Size of breeding herd							
	50		150		300		500	
Class	Acres	Investment	Acres	Investment	Acres	Investment	Acres	Investment
Irrigated land								
Native and improved grassland	90	18,000	160	32,000	420	84,000	200	40,000
Native hay							200	45,000
Alfalfa	30	10,500	55	19,250	100	35,000	166	58,100
Barley	20	6,000	30	9,000	60	18,000	50	15,000
Non-federal rangeland	400	6,000	800	12,000	750	11,250	4,000	60,000
Federal range permits	AUMs	Investment	AUMs	Investment	AUMs	Investment	AUMs	Investment
BLM	268	3,216	1,105	13,216	2,335	28,020	2,500	30,000
FS	198	3,960	530	10,600	825	16,500	1,200	24,000
Totals		40,476		96,066		192,770		272,100

Table 27. Investment in buildings and improvements for typical ranches, Utah, 1968.

Class	Size of breeding herd							
	50		150		300		500	
	No.	Investment	No.	Investment	No.	Investment	No.	Investment
Sheds	1	1,600	1	1,575	1	1,600	3	6,000
Corrals	2	400	2	600	3	1,100	4	2,000
Feed mangers	1	260	1	780	1	1,230	5	1,000
Water facilities								
Troughs	1	50	2	100	4	200	6	300
Wells	1	1,000	1	1,000	1	1,000	2	2,000
Electric pumps	1	260	1	260	1	260	2	520
Granary	1	680	1	800	2	860	1	1,500
Stackyards	1	50	4	200	2	100	6	300
Machine sheds			1	2,400	1	3,660	1	2,000
House (for hired labor)							1	12,000
Shop			1	2,150	1	2,150	1	2,000
Fences	3 mi.	3,000	7 mi.	7,000	18 mi.	18,000	24 mi.	24,000
Totals		7,300		16,865		30,160		53,620

Table 28. Investment in machinery and equipment for typical ranches, Utah, 1968.

	Size of breeding herd							
	50		150		300		500	
Item	No.	Investment	No.	Investment	No.	Investment	No.	Investment
Tractors	1	3,000	2	6,000	2	8,000		
Gasoline							2	10,000
Diesel							1	8,000
Trucks	1	4,000	2	8,000	2	8,000	2	10,000
Pickup	1	3,000					1	3,000
Auto (ranch share)	1	1,500	1	1,500	1	1,500	1	1,500
Haying equipment		4,433		4,391		5,727		
Swather							1	4,000
Mower							1	500
Rake							1	500
Baler							1	4,000
Bale loader							1	400
Bale elevator							1	300
Tillage equipment		440		1,010		1,769		
Leveler							1	500
Plow							2	1,000
Disk							1	1,000
Harrow							1	200
Drill							1	1,500

Table 28. Continued.

Item	Size of breeding herd							
	50		150		300		500	
	No.	Investment	No.	Investment	No.	Investment	No.	Investment
Other crop equipment		1,040		1,040		1,632		
Ditcher							1	500
Manure spreader							1	500
Wagon							2	800
Other equipment				208		416		
Gas tank							2	800
Post hole auger							1	200
Gas pumps							2	600
Livestock equipment		529		1,265		1,619		
Squeeze chute							2	800
Spray rig							1	300
Branding irons							10	30
Shop equipment		133		325		359		1,000
Totals		18,075		23,739		29,022		51,930

More detailed information of machinery and equipment on the three smaller ranches is given by Gee (1962).

Table 29. Labor use and costs for typical ranches, Utah, 1968.

		Size of breeding herd							
		50		150		300		500	
Worker	Wage/mo.	Man mos.	Cost	Man mos.	Cost	Man mos.	Cost	Man mos.	Cost
Operator	400	8	3,200	12	4,800	12	4,800	12	4,800
Family	400	4	1,600	3	1,200	8	3,200	12	4,800
Full-time hired	400					8	3,200	12	4,800
Part-time hired	300	.5	150	1.2	360		____	6	1,800
Totals			4,950		6,360		11,200		16,200

Table 30. Forage and feed use and costs for typical 50 cow ranch, Utah, 1968.

Kind	Unit	Amount fed	Purchases	Price	Total cost
Alfalfa hay	ton	60			
Barley	cwt	68			
Protein supplements	cwt	25	25	4.95	124
Salt	cwt	26	26	1.42	37
Owned land					
Irrigated pasture	AUM	102			
Rangeland	AUM	73			
Aftermath	AUM	197			
Federal permits					
BLM	AUM	268	268	.33	88
FS	AUM	198	198	.66	131

Table 31. Forage and feed use and costs for typical 150 cow ranch, Utah, 1968.

Kind	Unit	Amount fed	Purchases	Price	Total cost
Alfalfa hay	ton	146			
Barley	cwt	234.6			
Protein supplements	cwt	42.5	42.5	4.95	210
Salt	cwt	68.1	68.1	1.42	97
Owned land					
Irrigated pasture	AUM	160			
Rangeland	AUM	200			
Aftermath	AUM	100			
Federal permits					
BLM	AUM	1105	1105	.33	365
FS	AUM	530	530	.66	350

Table 32. Forage and feed use and costs for typical 300 cow ranch, Utah, 1968.

Kind	Unit	Amount fed	Purchases	Price	Total cost
Alfalfa hay	ton	204			
Barley	cwt	720			
Protein supplements	cwt	190	190	4.95	941
Salt	cwt	123	123	1.42	175
Owned land					
Irrigated pasture	AUM	525			
Rangeland	AUM	300			
Aftermath	AUM	200			
Leased rangeland	AUM	376	376	3.00	1128
Federal permits					
BLM	AUM	2335	2335	.33	771
FS	AUM	825	825	.66	545

Table 33. Forage and feed use and costs for typical 500 cow ranch, Utah, 1968.

Kind	Unit	Amount fed	Purchases	Price	Total cost
Alfalfa hay	ton	500			
Native hay	ton	200			
Barley	cwt	1250			
Protein supplements	ton	12	12	80	960
Salt	ton	7	7	20	140
Owned land					
Irrigated pasture	AUM	600			
Rangeland	AUM	800			
Aftermath	AUM	420			
Federal permits					
BLM	AUM	2500	2500	.33	825
FS	AUM	1200	1200	.66	792

Table 34. Crop production and sales for typical ranches, Utah, 1968.

Ranch size	Unit	Acres	Average yield	Total yield	Sales	Price	Value
50 breeding cows							
Alfalfa	ton	30	3	90	30	22.00	660
Barley	cwt	20	25	500	432	2.06	890
Total sales							1550
150 breeding cows							
Alfalfa	ton	55	3	165	19	22.00	418
Barley	cwt	30	25	750	515	2.06	1061
Total sales							1479
300 breeding cows							
Alfalfa	ton	100	3	300	96	22.00	2112
Barley	cwt	60	25	1500	780	2.06	1607
Total sales							3719
500 breeding cows							
Alfalfa	ton	170	3	510	0		
Native hay	ton	200	1	200	0		
Barley	cwt	50	25	1250	0		

Appendix B

Input and Production Data for Utah Wheat Farms

Table 35. Investment in machinery and equipment for typical 500 acre dryland wheat farm, Utah, 1968.

Item	Description	Investment
Tractor	1 75 hp	9,000
Chisle plow	1 12 ft.	1,200
Offset disk	1 12 ft.	1,200
Rod weeder	2 10 ft.	1,150
Grain drill	2 8 ft.	2,400
Combine (self propelled)	1 14 ft.	12,000
Grain auger	1 32 ft.	500
Truck	1 2 ton	6,500
Pickup	1 3/4 ton	3,000
Fertilizer spreader	1 drill attachment	225
Shop equipment, tools		300
Total		37,475

Table 36. Investment in machinery and equipment for typical 1000 acre dryland wheat farm, Utah, 1968.

Item	Description	Investment
Tractor	1 100 hp	10,000
Chisle plow	1 16 ft.	1,400
Offset disk	1 14 ft.	1,400
Rod weeder	1 24 ft.	1,300
Grain drill	2 12 ft.	3,000
Combine (self propelled)	1 14 ft.	12,000
Grain auger	1 32 ft.	500
Truck	1 2 ton	6,500
Pickup	1 3/4 ton	3,000
Fertilizer spreader	1 drill attachment	390
Shop equipment, tools		500
Total		39,990

Table 37. Investment in machinery and equipment for typical 2000 acre dryland wheat farm, Utah, 1968.

Item	Description	Investment
Tractor	1 100 hp	10,000
	1 120 hp 4-W	20,000
Chisle plow	1 24 ft.	2,400
Offset disk	1 24 ft.	3,000
Rod weeder	1 36 ft.	2,000
Grain drill	4 12 ft.	6,000
Combine (self propelled)	2 14 ft.	24,000
Grain auger	2 32 ft.	1,000
Truck	2 2 ton	13,000
Pickup	1 3/4 ton	3,000
Fertilizer spreader	1 drill attachment	760
Shop equipment, tools	includes welders, drill press	1,000
Total		86,160

Table 38. Investment in machinery and equipment for typical 3000 acre dryland wheat farm, Utah, 1968.

Item	Description	Investment
Tractor	2 120 hp 4-W	40,000
Chisle plow	2 24 ft.	4,800
Offset disk	2 24 ft.	4,800
Rod weeder	2 36 ft.	4,000
Grain drill	4 12 ft.	6,000
Combine (self propelled)	2 16 ft.	28,000
Grain auger	2 32 ft.	1,000
Truck	2 2 ton	13,000
Pickup	1 3/4 ton	3,000
Fertilizer spreader	1 drill attachment	760
Shop equipment, tools	includes welders, drill press	1,000
Total		106,360

Table 39. Investment in land, buildings, and improvements for typical dryland wheat farms, Utah, 1968.

Farm size	Item	Description	Investment
500 acres	land[1]	500 acres dryland	50,000
	granaries	1 2000 bu.	870
		1 1000 bu.	530
	machine shed	none	
	boundary fences	3.5 mi.	3,500
	Total		54,900
1000 acres	land[1]	1000 acres dryland	100,000
	granaries	1 3000 bu.	1,000
		1 2000 bu.	870
	machine shed	40'x48' steel (14'-16' eve ht.)	4,000
	boundary fences	5 mi.	5,000
	Total		110,870
2000 acres	land[1]	2000 acres dryland	200,000
	granaries	2 5000 bu.	3,400
	machine shed	50'x72' steel (14'-16' eve ht.)	7,200
	boundary fences	7.07 mi.	7,070
	Total		211,190
3000 acres	land[1]	3000 acres dryland	300,000
	granaries	3 5000 bu.	5,100
	machine shed	50'x92' steel (14'-16' eve ht.)	9,200
	boundary fences	8.67 mi.	8,670
	Total		322,970

[1]Assuming land capable of producing 20 bushels of wheat per acre.

Table 40. Summary of investment for typical dryland wheat farms, Utah, 1968.

Item	Size of farm (acres)			
	500	1000	2000	3000
Land	50,000	100,000	200,000	300,000
Buildings and improvements	4,900	10,870	17,670	22,970
Machinery and equipment	37,475	39,990	86,160	106,360
Total investment	92,375	150,860	303,830	429,330

Table 41. Production and sales of wheat on typical dryland wheat farms, Utah, 1968.

Farm size (acres)	Bu./acre	Total yield (bu.)	Price	Value
500	20	5,000	1.32	6,600
1000	20	10,000	1.32	13,200
2000	20	20,000	1.32	26,400
3000	20	30,000	1.32	39,600

Table 42. Labor use and costs for typical dryland wheat farms, Utah, 1968.

		Size of farm (acres)							
		500		1000		2000		3000	
Worker	Wage/mo.	Man mos.	Cost	Man mos.	Cost	Man mos.	Cost	Man mos.	Cost
Operator	400	1.5	600	2.4	960	4.0	1600	4.0	1600
Family	300	0.5	150	1.0	300	1.0	300	2.0	600
Part-time hired	300					1.0	300	2.0	600

Typically each farm has one family worker available during the busy season.

Table 43. Labor use by operation for typical dryland wheat farms, Utah, 1968.

Operation	Time required by size of farm			
	500 acres	1000 acres	2000 acres	3000 acres
Plowing	40 hours	60 hours	81 hours	122 hours
Disking	40 hours	70 hours	101 hours	122 hours
Summer fallowing	49 hours	81 hours	108 hours	162 hours
Drilling	46 hours	61 hours	61 hours	92 hours
Combining	70 hours	140 hours	281 hours	369 hours
Grain hauling	122 hours	252 hours	504 hours	666 hours
Repairing	63 hours	76 hours	156 hours	199 hours
Total[1]	2.0 man mos.	3.4 man mos.	6 man mos.	8 man mos.

[1]9 man hours = 1 work day and 24 work days = 1 man month.

Table 44. Machinery operating costs on 500 acre dryland wheat farm, Utah, 1968.

Machine	Capacity acres/hr.	Tractor	Acres covered	Fuel gal./hr.	Fuel gal./acre	Fuel cost/acre	Lubrication cost/acre	Total cost
Chisle plow 12'	6.18	75 hp	250	3.29	.53	.095	.016	27.75
Offset disk 12'	6.18	75 hp	250	3.29	.53	.095	.016	27.75
Rod weeder 20'	10.30	75 hp	500	3.29	.32	.058	.010	34.00
Grain drill 16'	5.43	75 hp	250	3.29	.61	.110	.018	32.00
		Engine						
Combine	4.75	60 hp	250	3.60	.76	.224	.037	65.25
	Bu./hr.		Hours used			Cost/hr.	Cost/hr.	
Grain auger 6"	1500	12 hp	5	.72		.21	.040	1.25
			Miles			Cost/mi.	Cost/mi.	
Truck 2 ton			1920			.06	.010	134.40
Pickup			1992			.03	.005	69.72
Total								392.12

Tires, brake linings, etc. are included in repairs.

Table 45. Machinery operating costs on 1000 acre dryland wheat farm, Utah, 1968.

Machine	Capacity acres/hr.	Tractor	Acres covered	Fuel gal./hr.	Fuel gal./acre	Fuel Cost/acre	Lubrication cost/acre	Total cost
Chisle plow 16'	8.28	100 hp	500	4.38	.53	.095	.016	55.50
Offset disk 14'	7.21	100 hp	500	4.38	.61	.110	.018	64.00
Rod weeder 24'	12.36	100 hp	1000	4.38	.35	.063	.011	74.00
Grain drill 24'	8.15	100 hp	500	4.38	.54	.097	.016	56.50
		Engine						
Combine SP 14'	4.75	60 hp	500	3.60	.76	.224	.037	130.50
	Bu./hr.		Hours used			Cost/hr.	Cost.hr.	
Grain auger 6"	1500	12 hp	10	.72		.210	.040	2.50
			Miles			Cost/mi.	Cost/mi.	
Truck 2 ton			3120			.060	.010	218.40
Pickup			4184			.030	.005	146.44
Total								747.84

Tires, brake linings, etc. are included in repairs.

Table 46. Machinery operating costs on 2000 acre dryland wheat farm, Utah, 1968.

Machine	Capacity acres/hr.	Tractor	Acres covered	Fuel gal./hr.	Fuel gal./acre	Fuel cost/acre	Lubrication cost/acre	Total cost
Chisle plow 24'	12.36	120 hp	1000	5.26	.43	.077	.013	90.00
Offset disk 24'	9.88	100 hp	1000	4.38	.45	.079	.013	92.00
Rod weeder 36'	18.55	120 hp	2000	5.26	.28	.050	.008	116.00
Grain drill 48'	16.30	120 hp	1000	5.26	.32	.058	.010	68.00
		Engine						
Combine SP 14'	4.75	60 hp	1000	3.60	.76	.224	.037	261.00
	Bu./hr.		Hours used			Cost/hr.	Cost/hr.	
Grain auger 6"	1500	12 hp	20			.210	.040	5.00
			Miles			Cost/mi.	Cost/mi.	
Truck 2 ton			5520			.060	.010	404.67
Pickup			8520			.030	.005	298.20
Total								1334.87

Tires, brake linings, etc. are included in repairs.

Table 47. Machinery operating costs on 3000 acre dryland wheat farm, Utah, 1968.

Machine	Capacity acres/hr.	Tractor	Acres covered	Fuel gal./hr.	Fuel gal./acre	Fuel cost/acre	Lubrication cost/acre	Total cost
Chisle plow 24'	12.36	120 hp	1500	5.26	.43	.077	.013	135.00
Offset disk 24'	12.36	120 hp	1500	5.26	.43	.077	.013	135.00
Rod weeder 36'	18.55	120 hp	3000	5.26	.28	.050	.008	174.00
Grain drill 48'	16.30	120 hp	1500	5.26	.32	.058	.010	102.00
		Engine						
Combine SP 16'	5.43	65 hp	1500	3.90	.72	.212	.035	370.50
	Bu./hr.		Hours used			Cost/hr.	Cost/hr.	
Grain auger 6"	1500		30			.210	.040	7.50
			Miles			Cost/mi.	Cost/mi.	
Truck 2 ton			7920			.060	.010	554.40
Pickup			13080			.030	.005	457.80
Total								1936.20

Tires, brake linings, etc. are included in repairs.

Table 48. Field capacity and fuel use of machinery on dryland wheat farms, Utah, 1968.

Machine	Capacity acres/hr.	Fuel gal./hr.	Fuel gal./acre
Chisle plow 12' 75 hp tractor	$\frac{5x12x85}{825} = 6.18$	.73x.06x75 = 3.29	$\frac{3.29}{6.18} = .53$
Chisle plow 16' 100 hp tractor	$\frac{5x16x85}{825} = 8.28$	.73x.06x100 = 4.38	$\frac{4.38}{8.28} = .53$
Chisle plow 24' 120 hp tractor	$\frac{5x24x85}{825} = 12.36$	.73x.06x120 = 5.26	$\frac{5.26}{12.36} = .43$
Disk 12' 75 hp tractor	$\frac{5x12x85}{825} = 6.19$	.73x.06x75 = 3.29	$\frac{3.29}{6.19} = .53$
Disk 14' 100 hp tractor	$\frac{5x14x85}{825} = 7.21$	.73x.06x100 = 4.38	$\frac{4.38}{7.21} = .61$
Disk 24' 100 hp tractor	$\frac{5x24x85}{825} = 9.88$	.73x.06x100 = 4.38	$\frac{4.38}{9.88} = .45$
Disk 24' 120 hp tractor	$\frac{5x24x85}{825} = 12.36$	.73x.06x120 = 5.26	$\frac{5.26}{12.36} = .43$
Rod weeder 20' 75 hp tractor	$\frac{5x20x85}{825} = 10.30$	.73x.06x75 = 3.29	$\frac{3.29}{10.30} = .32$
Rod weeder 24' 100 hp tractor	$\frac{5x24x85}{825} = 12.36$	.73x.06x100 = 4.38	$\frac{4.38}{12.36} = .35$
Rod weeder 36' 120 hp tractor	$\frac{5x36x85}{825} = 18.55$	.73x.06x120 = 5.26	$\frac{5.26}{18.55} = .28$
Grain drill 16' 75 hp tractor	$\frac{5x16x70}{825} = 5.43$	.73x.06x75 = 3.29	$\frac{3.29}{5.43} = .61$
Grain drill 24' 100 hp tractor	$\frac{5x24x70}{825} = 8.15$	.73x.06x100 = 4.38	$\frac{4.38}{8.15} = .54$
Grain drill 48' 120 hp tractor	$\frac{5x48x70}{825} = 16.30$	.73x.06x120 = 5.26	$\frac{5.26}{16.30} = .32$

Table 48. Continued.

Machine	Capacity acres/hr.	Fuel gal./hr.	Fuel gal./acre
Combine SP 14' 60 hp tractor	$\frac{4x14x70}{825} = 4.75$	.06x60 = 3.60	$\frac{3.60}{4.75} = .76$
Combine SP 16' 65 hp tractor	$\frac{4x16x70}{825} = 5.43$	.06x65 = 3.90	$\frac{3.90}{5.43} = .72$
Auger (bu./hr.) 6", 12 hp engine	1500	.06x12 = .72	

Travel time to field is reflected in percent efficiency.

Appendix C

Table of Negative Inwood Coefficients

Table 49. Negative Inwood coefficients and corresponding negative internal rates of return.

Internal rate of return	Year			
	5	10	15	20
-.005	5.07589	10.28059	15.61740	21.08965
-.010	5.15357	10.57274	16.27118	22.26331
-.020	5.31458	11.19406	17.69848	24.89426
-.030	5.48349	11.86905	19.30507	27.96435
-.040	5.66082	12.60345	21.11811	31.56077
-.050	5.84710	13.40365	23.16939	35.79019
-.060	6.04293	14.27688	25.49628	40.78355
-.070	6.24893	15.23130	28.14279	46.70209
-.080	6.46578	16.27608	31.16089	53.74506

Appendix D

Investment Items for Management Alternatives

Table 50. Investment items and total present value for twenty year investment period for alternative 1 on four marginal cropland acreages. (See Tables 35-39.)

Item	Acreage 500	1000	2000	3000
Granaries (20 years)	1400	1870	3400	5100
Machine sheds (20 years)		4000	7200	9200
Boundary fences (20 years)	3500	5000	7070	8670
Tractors, etc. (5 years)				
Year 1-5	23064	24436	54874	66877
Year 6-10	16445	17423	39125	47683
Year 11-15	11723	12421	27892	33994
Year 16-20	8358	8856	19886	24236
Truck, etc. (10 years)				
Year 1-10	10038	10906	20084	26918
Year 11-20	5102	5544	10209	13682
Present value of investment	79630	90456	189740	236360

Table 51. Investment items and total present value for twenty year investment period for alternative 2 on four marginal cropland acreages.

Item	Acreage 500	1000	2000	3000
Boundary fences (20 years)	3500	5000	7070	8670
Present value of investment	3500	5000	7070	8670

Table 52. Investment items and total present value for twenty year investment period for alternatives 3, 4, and 5 on four marginal cropland acreages.

Item	Acreage 500	1000	2000	3000
Fences (20 years)	3500	6250	10610	13010
Corrals, loading chute (20 years)	600	600	600	600
Wells (20 years)	1000	1000	2000	2000
Pumps (20 years)	260	260	520	520
Troughs (20 years)	50	100	200	200
Seedings (20 years)	3485	6970	13940	20910
Total present value of investment	8895	15180	27870	37240

VITA

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Doctor of Philosophy

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