An Economic Study of Adjustment Possibilities in Farm Organization and Resource Allocation in the Sevier River Valley in Piute County, Utah, 1961

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AN ECONOMIC STUDY OF ADJUSTMENT POSSIBILITIES IN FARM ORGANIZATION AND RESOURCE ALLOCATION IN THE SEVIER RIVER VALLEY IN PIUTE COUNTY, UTAH, 1961

by

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INTRODUCTION

Problems that confront the farmer are varied, but one of the most important is the combination of his possible enterprises so that maximum financial return from farming is obtained. This problem has been made more important in the last decade by the severity of the agricultural price-cost squeeze.

Farmers' total net income, on a national basis, has declined from more than 16 billion dollars to about 13 billion dollars. In Utah, total net farm income has dropped from 91.3 million dollars in 1951 to 36.5 million dollars in 1961. Average net income of Utah farm operators dropped from $5.89 per acre in 1950 to $3.64 per acre in 1959, while farm size increased during the same period from 449 acres to 713 acres (2). Farmers of the Sevier River Valley have felt this decline in net income.

Many factors affect the allocation of the farmer's resources, which in turn determine the profit to the farmer and to an area. Supplies of various resources vary, prices fluctuate, and technology changes causing different amounts of some resources to be used.

Water supply is of particular importance to the farmers in the Sevier River Basin. For the years 1959, 1960, and 1961 primary water delivered to the farmers in the Kingston-Circleville-Junction area has averaged 42 percent, 40 percent, and 56 percent respectively, of decreed primary water rights for the months April through September (14).

This study has particular reference to the Kingston-Circleville-Junction area of the Sevier River Basin. This area has an altitude of about 6,000 feet with a growing season of about 125 days and an average rainfall of 8.14 inches. It is removed from main marketing centers, being approximately 174 miles south of Salt Lake City and 27 miles from Panguitch on the south and 55 miles from Richfield on the north. Cattle, small grains, and alfalfa with some corn silage and potatoes are the main products of the area. This investigation has studied existing conditions in an effort to determine adjustments of farm and area resource uses which would increase incomes of individual farmers and the area as a whole.

OBJECTIVES

Objectives of this study were:

1. to determine optimum resource allocation and adjustment possibilities for representative individual farms in the Kingston-Junction-Circleville area of the Sevier River Valley, and

2. to determine optimum resource allocation for the Kingston-Junction-Circleville area as a whole assuming present resource levels.

REVIEW OF LITERATURE

To this time no published work has been completed on the determination of enterprise combinations for Piute County farms. Other areas have been studied and recommendations made regarding maximum profit combinations using available resources. A Master's thesis study by Mitts (7) was conducted for farms in Sevier County, Utah, and a similar study of the Delta, Utah area was made by Sumsion (17). Both of these studies have determined optimum enterprise combinations for representative farms and have used budgeting and linear programming techniques similar to those used in Objective 1 of this study.

Other studies have been completed in other areas of the country. Strickland and Parlenhum (16) studied optimum farm organization and aggregate production in the Limestone Valley areas in Alabama. Their work determined the most profitable combinations for several selected resource situations under a range of product prices and also determined aggregate production for the area under these price and resource situations.

A similar study was made by Wysong and Porter (23) on the allocation of resources for an area in eastern Maryland. White and others (20) analyzed dryland crop farms on loam soils in southwestern Oklahoma. This study considered effects of alternative prices of cotton, rates of interest on capital, tenure of the farm operator, level of machinery cost, and the level of technology on the optimum combination of enterprises for representative situations.

The northern coastal plain in North Carolina was studied indicating farm adjustments for changes in resource levels, product prices, and allotments by T. K. White and others (21). Other areas of North Carolina farming adjustment opportunities have been considered by Sutherland (18). In the study by Sutherland emphasis was placed on aggregate possibilities of an entire area to optimum possibilities.

METHOD AND RESULTS

The purpose of this section is to give the assumptions, reasoning, and procedures used in this study. Procedures and results of each objective are presented separately.

Procedure for Objective 1

Description of area

This study is concerned with farms on the upper Sevier River drainage in south central Utah. Operators of these farms are faced with particular problems as well as many of the problems confronting farmers in general.

Farms considered were located within a five mile radius of each of the towns of Circleville, Kingston, and Junction, which includes most of the farming area near these communities. The model farm which was assumed to represent the entire area included 150 acres of irrigated cropland.

Source of data

A list of commercial farms in the area was prepared in consultation with County Extension Agents, local S.C.S. offices, and individual farmers. From the list a sample of farms was selected, and operators of these farms were interviewed to obtain cost and return data for crop enterprises.

The data were recorded on a schedule prepared and designed for this purpose. Information on labor, yield of enterprise, acreages, water availability and use, and other necessary related information was collected.

Commercial farmers in each of the communities of Circleville, Junction, and Kingston, Utah, were interviewed although no effort was made to select farms or enterprises of a particular size level or income category. A total of 53 enterprise schedules were completed. Twenty-seven farms were represented.

Five crops were considered. Twenty-five alfalfa enterprises, three corn silage, fourteen potato, five oat, and fourteen barley enterprise schedules were taken. Secondary sources were used to supplement data from the oat and corn silage crops.

Livestock information was determined on an enterprise basis. Secondary sources were also used to supplement the survey data.

Lack of rotation of crops

Indications of the survey were that no specific rotation was being followed. Therefore, rather than follow a rotation plan, an enterprise approach on a single year basis was used for all crops except alfalfa. This approach simplifies the calculation of input-output coefficients in that one enterprise need be considered for only one year.

From information obtained in a survey of the general area, it was determined that small grains were generally not produced on the same land for more than three years before seeding the land back to alfalfa. For this study it was assumed that not more than 46 of the 150 acres would be plowed up at one time.

Crop budgets

A budget was prepared for each crop enterprise from data obtained during the interviews. These budgets were prepared to show average costs and the average returns based on actual prices received or anticipated by the farmer. Two of these enterprises, alfalfa and potatoes, showed a net profit. Budgets for the five crop enterprises are shown in tables 1 through 5.

Adjustments were made in each original budget to prepare a budget for each crop at different yield levels. Four yield levels were considered in preparing the adjusted enterprise budgets. These levels were selected from the range of yields reported in the survey. One level was chosen below the survey average. The survey average was chosen as one level of yield and two above average levels were chosen. These yield levels are shown in table 6.

Budgets for each of these modified yield levels were adjusted to account for costs which changed as yields changed. For example, as barley yields increased by 5 percent, costs such as combining, hauling, straw baling and hauling, were increased by 5 percent. All crop budgets that showed an increase in yield were adjusted in this manner. This procedure was reversed to show decreased costs for the lower yield level.

Although original budgets for corn silage and oats showed a negative return above variable costs, subsequent budgets

Table 1. Average receipts, costs, and net return per acre from alfalfa hay production, Piute County, Utah, 1961

Item	Unit	Quantity	Price per unit dollars	Value or cost dollars
Receipts:				
Alfalfa	ton	2.77	21.91	60.69
Barley	bushel	11.31	1.14	12.90
Straw				.08
Total receipts				77.85
Costs:				
Labor	hours	8.59	1.25	10.76
Power		3.65	1.03	3.74
Material:				
Barley seed	lbs.	16.43	.0375	.64
Alfalfa seed	lbs.	2.50	.38	.98
Fertilizer				.83
Manure				.08
Water				1.81
Spray				.80
Twine				1.19
Machine hire				2.83
Other				.70
Total material costs				9.86
Overhead:				
Interest on money in crop				.33
Interest on capital investment				21.12
Building depreciation				.38
Other				7.99
Taxes:				
Land				4.32
Drainage				--
Equipment				3.71
Total overhead costs				37.85
Total costs				62.21
Net return				15.64

Table 2. Average receipts, costs, and net revenue per acre from barley production, Piute County, Utah, 1961

Item	Unit	Quantity	Price per unit dollars	Value or cost dollars
Receipts:				
Barley	bushel	67.91	1.02	69.28
Straw	cwt.			.48
Total receipts				69.76
Costs:				
Labor	hours	10.77	1.25	13.46
Power	hours	6.20	2.38	14.76
Material:				
Fertilizer				.55
Seed	lbs.	98.56	.0375/lb.	3.66
Water	ac. in.			1.33
Spray				.18
Other				--
Machine hire				8.14
Total material costs				13.86
Overhead:				
Interest on money in crop				.44
Interest on capital investment				23.20
Building depreciation and repair				1.23
Taxes				10.52
Other				2.39
Total overhead costs				37.78
Total cost				79.86
Net return				-10.10

Table 3. Average receipts, costs, and net revenue per acre from oat production, Piute County, Utah, 1961

Item	Unit	Quantity	Price per unit dollars	Value or cost collars
Receipts:				
Oats	bushel	51.22	.82	42.00
Straw				--
Total receipts				42.00
Costs:				
Labor	hours	13.06	1.25	16.32
Power	hours	6.04	2.13	12.86
Material:				
Fertilizer				--
Seed	cwt.	1.02	4.08	4.30
Water				1.67
Twine				--
Other				.29
Machine hire				3.14
Total material costs				9.40
Overhead:				
Interest on money in crop				.39
Interest on capital investment				22.27
Building depreciation and repair				.48
Taxes				9.48
Other				2.13
Total overhead costs				34.75
Total cost				73.33
Net return				-31.33

Table 4. Average receipts, costs, and net revenue per acre from potato production, Piute County, Utah, 1961

Item	Unit	Quantity	Price per unit dollars	Value or cost dollars
Receipts:				
Potatoes	cwt.	113.05	1.89	213.66
Costs:				
Labor		47.94	1.25	59.92
Power		11.41	2.07	23.62
Material:				
Fertilizer				2.79
Seed				42.53
Water				4.10
Twine				.25
Other				9.28
Machine hire				4.46
Total material costs				63.41
Overhead:				
Interest on money in crop				1.80
Interest on capital investment				23.92
Building depreciation and repair				.39
Taxes				10.15
Other				4.74
Total overhead costs				41.00
Total cost				187.95
Net return				25.71

Table 5. Average receipts, costs, and net revenue per acre from corn silage production, Piute County, Utah, 1961

Item	Unit	Quantity	Price per unit dollars	Value or cost dollars
Receipts:				
Corn silage	ton	9.93	7.30	72.49
Costs:				
Labor	hours	15.15	1.25	18.94
Power	hours	12.29	2.17	26.68
Material:				
Commercial fertilizer				--
Manure				--
Seed	lbs.	12.80		2.78
Water				1.19
Spray				--
Machine hire				5.93
Other				--
Total material costs				9.90
Overhead:				
Interest on money in crop				.51
Interest on capital investment				26.23
Other				8.00
Taxes:				
Land and drainage				4.32
Equipment tax				5.94
Total overhead costs				45.00
Total cost				100.52
Net return				-28.03

Table 6. Production at various yield levels for Piute County, Utah, 1961

Crop	Product	Yield level 1	2	3	4
Alfalfa	Hay (ton)	1.6	2.8	3.8	4.6
	Barley (bu.)	8.0	11.0	13.0	15.0
	Straw (cwt.)	2.4	4.1	4.6	5.0
Barley	Barley (bu.)	45.0	68.0	80.0	90.0
	Straw (cwt.)	17.2	24.4	31.0	33.0
Potatoes	Potatoes (cwt.)	80.0	113.0	130.0	150.0
Oats	Oats (bu.)	45.0	51.0	60.0	75.0
	Straw (cwt.)	17.3	19.6	23.0	28.8
Corn silage	Corn silage (ton)	8.0	10.0	15.0	20.0

which included adjusted yields and prices resulted in positive returns above variable costs. This was primarily due to the increase in yield which resulted in an increase in total return. Although costs increased at the same time, they did not increase at the same rate which resulted in an increase in return above variable costs.

Alfalfa stands were assumed to have an average life of six years. Life of stand was highly dependent upon water availability. Since high water supply is necessary for re-establishment of stand, dry years tend to lengthen stand life even though yields drop.

The adjusted alfalfa budget was based on a six-year crop period. First year crop was assumed to be a barley nurse crop. Costs and returns associated with alfalfa were spread evenly over the six year life of the stand. For example, costs of planting growing and harvesting the nurse crop barley were divided by six. At the same time, the costs for the alfalfa crops for the remaining five years were added together, then divided by six to obtain an average annual cost. The cost of a single year's alfalfa crop was added to the cost of one-sixth of the barley nurse crop which equaled the average total cost of one year of alfalfa crop. Returns for a single year of alfalfa were calculated using the same method.

Prices and costs. Prices used in the original budgets were representative of what farmers received for products sold or paid for products purchased. Average prices as reported in the survey were used where applicable. These prices were supplemented where information was lacking in the survey by average prices as reported in Utah Agricultural Statistics, Utah Crop Reports, and unpublished reports compiled from Livestock Division, Agricultural Marketing Service, United States Department of Agriculture. Prices farmers received were adjusted to account for location of the market, grade of the product, and time of year.

These original budgets were later adjusted by considering a weighted average of the prices over the last ten years. It was felt that greater emphasis should be placed on the recent years. Concepts in price projections were utilized from Agricultural Price and Cost Projections (1). The weighting was accomplished as follows: Prices of the first year of the ten year period were given the weight of one, the second year's prices received the weight of two, the third year the weight of three, and so on until the eighth year. Prices of the eighty, ninth, and tenth years were each given the weight of eight. In this manner, some consideration was given to prices of the more distant years, but more weight was given to the prices of the latest three years. This procedure was tested using historical price data and showed quite accurate predictions of prices as they actually did occur.

Livestock sale and purchase prices were taken from unpublished data obtained from the Ogden Office of Agricultural Marketing Service, United States Department of Agriculture. These prices were also adjusted using the method discussed above.

Labor. Labor requirements for each enterprise were ascertained from the field survey. Average labor requirements for each operation were used for original budgets. Where necessary, labor requirements used in programming were adjusted for different yield levels. Only operations such as harvesting, hauling, etc., which required different amounts of labor when yield levels changed were adjusted in this manner.

Total labor available for operation of the model farm was assumed to be supplied by the operator and his family. The labor supply was assumed to consist of one man available year round plus one 16-year old boy available during the summer months. From data assembled at Utah State University, Department of Agricultural Economics, it was assumed that labor of a 16-year-old boy is equivalent to that of a man. Hired labor was made available for harvesting and irrigating.

Three labor periods were considered. Labor I included the months of April and May during which 572 man hours were available. Labor II consisted of the months of June and July and included 1,040 man hours. Labor III also included 1,040 man hours during the months of August and September.

The survey showed that some hired labor was utilized by a few operators. Since no data were available to indicate how much hired labor was available, it was assumed that services of a hired nature would be readily available when needed. The original budgets include costs for the average amount of hired labor involved in the operation of each enterprise. Operators who do not hire any labor will be able to lower costs to the extent of that average hired cost indicated in the enterprise budget.

Water. Water requirement information for the area was limited. The original budgets used data obtained from farmers in determining how much water was applied. Average rainfall in the area is 8.14 inches. Rainfall in 1960 was 5.72 inches, considerably lower than the average for the last 30 years. Water use levels in the adjusted budgets were determined on the basis of how water needs were met according to present supplies.

To ascertain whether or not different input-output coefficients were necessary for water at each yield level, statistical analysis was employed. Multiple regression was used to test the relationship between yield and amounts of applied water as reported in the survey in the presence of the other variables of capital and the three different categories of labor. Variables included Water, Labor I, Labor II, Labor III, and Capital I.

Table 7 shows the results of the analysis in terms of standard partial regression coefficients, correlation elements, and partial regression coefficients. The standard partial coefficient for water is .2152 which is, with one exception, smaller than that for the other four variables. These standard partial regression coefficients are "...the partial regression coefficients when each variable is in standard measure that is, is a deviation from the mean in units of its standard deviation." (15) This is evidence of a lack of relative importance of the water variable on yield.

Examination of the coefficients of determination for the individual elements as found in table 7 also shows a lack of high correlation between water and yield. For the water variable, the coefficient of determination was 1.21 percent. Table 8 shows that the "T-test" for significance indicates that water is not a significant factor affecting yield differences.

Shown in figure 1 is a scatter diagram plotting water application against yield of alfalfa. The lack of correlation between these two variables is visually apparent. In view of this evidence, it was felt that input coefficients for water should remain unchanged over the range of yields considered in the study.

Three levels of water availability were used. These levels were 12 acre inches, 24 acre inches, and 36 acre inches of water and were selected to represent water supplies presently received (24 acre inches) as well as two hypothetical levels. The hypothetical levels were used to yield insights regarding changes in enterprise combination which would come if water availability were to change.

Capital. Capital was divided into investment capital and operating capital. Investment capital is defined as the funds

Table 7. Multiple regression results for specified variables affecting alfalfa production in Piute County, Utah, 1961

Variable	Partial regression coefficient (B)	Standard partial regression coefficient	Correlation element	Coefficient of determination
Water	.2112	.2152	.1112	.0124
Labor I	-.3680	-.1590	.0359	.0012
Labor II	-.4329	-.7136	.0850	.0072
Labor III	.1661	.3086	.2080	.0433
Capital I	.0995	.5649	.3478	.1210

Table 8. Regression equations for alfalfa production in Piute County, Utah, 1961

DF = 19 Y = Yield/acre X_1 = Water acre/feet/acre

Tabular T = 2.093 X_2 = Labor I/acre X_3 = Labor II/acre

X_4 = Labor III/acre X_5 = Capital/acre

$$Y = 2.0846X + .2112X_1 - .3680X_2 - .4329X_3 + .1661X_4 + .0995X_5$$

S_b =	.2154	.2078	.1695	.1259	.1249
T =	.9805	.8070	2.5540	1.3193	.7966

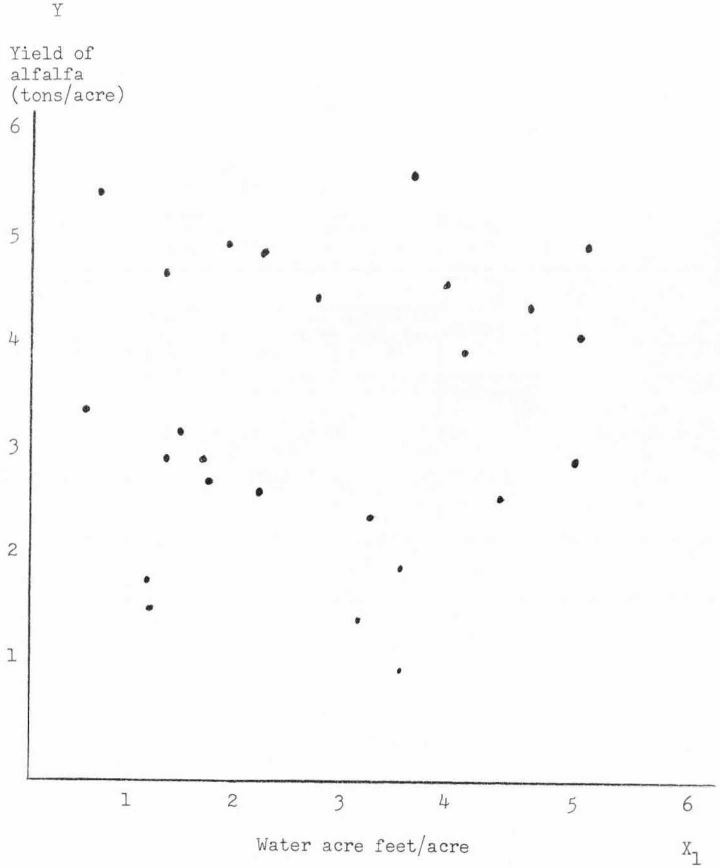

Figure 1. Scatter diagram of applied water and yield of alfalfa

invested in resources which are used for more than one production period and closely allied with fixed costs. Examples of investment capital items would be breeding herds, land, machinery, and buildings. Resources which have a "carry over" effect from year to year such as fertilizer may be considered as part investment capital and part operating capital. The amount of each considered could be determined by an estimate of known value of the amount applicable to the year in question. The remainder could be considered as investment capital. Since very little fertilizer was reported applied in the survey, it was considered as operating capital.

Operating capital is the money which is invested in resources that are normally used in one production period and are akin to variable costs, and for purposes of this study were assumed to be the same. It was assumed that each dollar was available only once during each production period. Because linear programming techniques do not consider fixed costs, investment capital was not considered in this study. However, both could be used in a similar study either separately or in a combination method, considering all costs as variable costs, but over a longer period of time.

Two periods of use of operating capital were assumed. Spring capital was assumed available for and used by field crops and range cattle. Fall capital was used for livestock feeding enterprises (Cattle I, II) and range livestock enterprises (Cattle III). In general, crop enterprises used only spring capital. Of the three cattle enterprises considered, Cattle I and Cattle II used only fall capital. Cattle III was assumed to use spring and fall capital in equal amounts.

Two restricting levels of capital were considered: $4,000 and $5,000. In one part of the analysis, capital was assumed available in unlimited quantities. The unlimited capital case indicates how much capital would be necessary to obtain maximum return to fixed factors from the enterprises considered.

It was assumed that the capital be either totally or partially operator owned. Although it does not make any difference to procedure whether capital is owned or not, it does to the operator since return to owned capital comes to himself.

Livestock budgets

Information about farms in the study area indicated that a variety of livestock enterprises were present. Enterprises varied both as to size and type. Livestock budgets developed for this study depended heavily on data from secondary sources. The budget for farm flock sheep was based largely on a study by Morrison and Nielson (9). A Grade C milk enterprise budget was prepared using data from a study by Morrison (8). A Grade A milk budget was prepared but was excluded from the study because of Grade A milk base restrictions. Budgets were prepared for two beef feeding enterprises using data from a feed lot fattening study by Davis (4). Studies by Roberts and Gee (13), Myles (11), and data from the 1959 Census of Agriculture (19) were used to prepare a range beef enterprise budget. All three beef operations showed a positive return to fixed factors. These budgets are presented in tables 9 through 11.

Three rations were developed using feeds raised or readily available in the area. The lowest cost of these three rations was employed in the livestock budgets. Different rations which would have some effect on the net return to fixed factors could be readily utilized. Feeds used were alfalfa and barley with salt, minerals, and other miscellaneous feeds. Nutritional requirements as published in Morrison's Feeds and Feeding (11) were met in every ration.

Cattle I consisted of weaned 380 pound beef calves purchased in October and fed for 180 days to an average weight of 680 pounds. These animals were sold as Good Grade cattle, table 9.

Cattle II consisted of fattening 700 pound feeder cattle for a period of 150 days from October to March, table 10. The ration fed to these cattle was composed of alfalfa and barley with salt and other additives. Corn silage could be substituted for some hay with little change in costs. Rate of gain for these animals was an average of two and two-tenths pounds per day. They were fed to be sold as Choice cattle. Other rations were computed utilizing other feeds available in the area, but the feeds included in the study had the lowest cost of those considered. The other rations could be utilized but not without compensating decreases in net return.

Cattle III was a range beef enterprise in which steers and heifers were sold as yearlings at 700 to 800 pounds. Receipts and costs were based on the weight of animal units sold per year rather than on an individual animal basis, table 11.

Table 9. Average receipts and costs for fattening 380 pound calves for 180 days with 2 pounds daily gain, (Cattle I), Piute County, Utah, 1961

Item	Amount/head
	dollars
Receipts:	
Sale of animal avg. wt. 740 lbs. @ 22.26/cwt. (includes .55 transportation costs)	164.71
Less allowance for death loss 2 percent	3.63
	161.09
Manure credits 3 percent	5.34
Net receipts	166.43
Costs:	
Feed costs:	
Alfalfa 1080 lbs. @ 19.60/ton	10.58
Barley 1800 lbs. @ 2.12/cwt.	38.16
Salt 6 lbs. @ 1.63/cwt.	.10
Misc. feed cost	1.54
Total feed cost	48.74
Cost of feeder animal 380 lbs. @ 21.10 (Includes .55 transportation costs)	80.18
Material cost	3.57
Fixed costs	9.31
Labor cost	9.51
Power cost	2.52
Total cost	153.83
Total variable cost	144.52
Return above variable costs (Return to fixed factors)	21.91
Net return	12.60

Table 10. Average receipts and costs for fattening 700 pound feeder cattle for 150 days with 2.2 pounds daily gain, (Cattle II), Piute County, Utah, 1961

Item	Amount/head
	dollars
Receipts:	
Sale of animal avg. wt. 1030 lbs. @ 22.11/cwt. (Includes .55 transportation costs)	227.73
Less allowance for death loss 2 percent	4.14
	229.26
Manure credits	6.09
Net receipts	229.69
Costs:	
Feed costs:	
Alfalfa 1350 lbs. @ 19.60/ton	13.23
Barley 1500 lbs. @ 2.12/cwt.	31.80
Corn silage 1650 lbs. @ 7.30/ton	6.02
Salt 7.5 lbs. @ 1.63/cwt.	.12
Misc. feed cost	1.70
Total feed cost	52.87
Cost of feeder animal 700 lbs. @ 21.26/cwt. (Includes .55 transportation costs)	148.82
Material cost	2.98
Fixed costs	7.76
Labor cost	7.93
Power cost	2.10
Total cost	222.46
Total variable costs	214.70
Return above variable costs (Return to fixed factors)	14.99
Net return	7.23

Table 11. Average receipts and costs for range beef cattle, (Cattle III), Piute County, Utah, 1961. Animal Unit Basis

Receipts per animal unit	Unit	No.	Price/cwt.	Amount/ dollars
Cows	lbs.	50.8	13.75	6.98
Heifers	lbs.	87.7	20.26	17.77
Steers	lbs.	165.4	21.26	35.16
Bulls	lbs.	15.1	16.50	2.49
Total				62.40
Inventory change				4.05
Total income				66.45
Costs per animal unit:				
Variable costs:				
Operator and family labor	hrs.	12.6	1.25	15.79
Hired labor	hrs.	5.7	1.25	7.18
Grazing fees				
USFS				.62
BLM				.40
Insurance				1.08
Seed and fertilizer				.67
Feed and pasture				4.79
Veterinary and medicine				.57
Gas, oil, and lubrication				5.62
Equipment repair				3.78
Utilities				.80
Accounting and legal fees				.28
Business travel				.41
Other				2.55
Depreciation				7.34
Livestock purchases				5.10
Total				57.15
Fixed costs:				
Interest				
Operating capital				.29
Investment				24.33
Taxes				2.56
Total				27.18
Total expense				84.33
Return above variable costs				9.30
Net return				-17.88

Linear programming

Linear programming was used as a tool in this study. "The complete mathematical statement of a linear programming problem includes a set of simultaneous linear equations which represent the conditions of the problem and a linear function which expresses the objective of the problem" (6). This process is used to obtain the maximum profit combination of the various inputs. It may also be used to determine the minimum cost combination of various factors of input.

This technique can be used to select the optimum combination of farm enterprises or the optimum combination of area resources. It is particularly appropriate when large numbers of combinations are possible. The technique is about the same as budgeting except different computational methods are used. Budgeting is often used to find an optimum combination of several enterprises but becomes too cumbersome and time consuming to be used with many alternative enterprises. However, the same data are used in both procedures, and the same care must be observed in obtaining accurate data. Programming has an additional advantage over budgeting in that the former may indicate automatically the marginal value of limiting resources. This is important to the farmer in that it indicates how much he can afford to pay for additional resources.

The simplex method of programming was used in this study. Input-output coefficients for each enterprise were calculated from the adjusted budgets described earlier and placed in matrix form for calculation purposes. The matrix for Yield Level III, Water Level I is presented in tables 12 and 12a. This particular yield level was selected for illustrative purposes only and has no other particular significance. In the P_o column is found the supply of resources available after the resources to produce 25 acres of alfalfa have been deducted. This procedure was chosen to insure that the minimum of 25 acres of alfalfa was produced on each farm.

The O row shows the returns to fixed factors of one unit of an enterprise or "activity". It is found by subtracting the variable costs of one unit of output from the gross returns for that unit. Computations are simplified if consideration is given only to those costs which change with production plans. Fixed costs are not altered by changes in production in the short run. They must be incurred regardless of production and can be subtracted after programming has been completed. Results of this study are presented in terms of return to fixed factors.

Each activity is represented by a column in the table. These columns are arranged in two groups: disposal activities (P_1 to P_{11}) and real activities (P_{12} to P_{21}). Disposal activities allow resources to go unused, and since an unused resource produces no returns, a zero is entered in the C row for those activities.

Each real activity has entered in the C row the return to fixed factors for one unit of the activity. Purchasing activities are real activities which make additional resources available to the farm operator. They do not directly produce returns to fixed factors and, therefore have a zero entered in the O row. As these purchased resources are used in production their costs are reflected in the returns to the real activities. Minimum alfalfa and barley entries in the P_o column indicate the amount of these resource supplies available at the outset of the programming. These supplies of alfalfa and barley are produced by the minimum 25 acres of alfalfa mentioned earlier. Negative input-output coefficients such as those in the P_{14} column indicate that resource supplies (P_o) are increased by production of that P_{14} crop. For example, producing alfalfa adds to the supply of barley and alfalfa available on the farm.

The Z row represents the opportunity cost of or value of other activities sacrificed for a particular activity. In the initial matrix or tableau shown, these values are zero since nothing is produced and hence nothing is sacrificed. In subsequent tableaus, non-zero entries appear in this row.

Of particular interest is the Z - C row which, in the final tableau or matrix, indicates the total returns to fixed factors in in the P_o column, while in the disposal columns are found the marginal value products of the scarce resources. The latter are of importance to the farmer as they can be used to determine how much he can afford to pay for additional resources. A negative value in the Z - C row under the real activities columns indicates that total return to fixed factors will be increased by including an additional unit of the activity into the program. When no more negative numbers appear in the Z - C row, the solution has been reached.

Table 12. First matrix of simplex solution with input-output coefficients for Yield Level III

			Disposal Activities										
		C	0	0	0	0	0	0	0	0	0	0	0
Yield level	Resource	Supply P_0	Land P_1	Bar. min. P_2	Alf. min. P_3	Pot. land P_4	Spr. cap. P_5	Fall cap. P_6	Range permit P_7	Water P_8	Labor I P_9	Labor II P_{10}	Labor III P_{11}
III	Land	125	1	0	0	0	0	0	0	0	0	0	0
	Barley minimum	325	0	1	0	0	0	0	0	0	0	0	0
	Alfalfa minimum	95	0	0	1	0	0	0	0	0	0	0	0
	Potato land	25	0	0	0	1	0	0	0	0	0	0	0
	Spring capital	3360.5	0	0	0	0	1	0	0	0	0	0	0
	Fall capital	4000	0	0	0	0	0	1	0	0	0	0	0
	Range permits a.u.m.	82	0	0	0	0	0	0	1	0	0	0	0
	Water	1035	0	0	0	0	0	0	0	1	0	0	0
	Labor I	549.25	0	0	0	0	0	0	0	0	1	0	0
	Labor II	962	0	0	0	0	0	0	0	0	0	1	0
	Labor III	923	0	0	0	0	0	0	0	0	0	0	1
	Z		0	0	0	0	0	0	0	0	0	0	0
	Z - C		0	0	0	0	0	0	0	0	0	0	0

Table 12a. First matrix of simplex solution with input-output coefficients for Yield Level III

		Real Activities									
		0	0	74.39	63.24	99.84	28.72	47.33	21.91	14.99	9.30
Yield level	Resource	Buy hay P_{12}	Buy barley P_{13}	Alfalfa P_{14}	Barley P_{15}	Potatoes P_{16}	Oats P_{17}	Corn silage P_{18}	Cattle I P_{19}	Cattle II P_{20}	Cattle III P_{21}
III	Land	0	0	1	1	1	1	1	0	0	0
	Barley minimum	0	-1	-13.0	-80.9	0	0	0	37.50	31.25	0
	Alfalfa minimum	-1	0	-3.8	0	0	0	0	.54	.68	.22
	Potato land	0	0	0	0	1	0	0	0	0	0
	Spring capital	0	0	25.58	41.61	145.86	37.73	62.17	0	0	28.58
	Fall capital	23.16	1.07	0	0	0	0	0	144.52	214.70	28.58
	Range permit a.u.m.	0	0	0	0	0	0	0	0	0	2
	Water	0	0	30.6	25.1	41.9	29.8	15.1	0	0	0
	Labor I	0	0	.91	3.87	4.86	3.82	6.84	0	0	3.09
	Labor II	0	0	3.12	3.31	12.19	6.04	5	0	0	4.52
	Labor III	0	0	4.68	2.91	30.57	2.25	5.83	0	0	4.40
	Z	0	0	0	0	0	0	0	0	0	0
	Z - C	0	0	-74.39	-63.24	-99.84	-28.72	-47.33	-21.91	-14.99	-9.30

In the resource column of each tableau is found the remaining or surplus resources as well as the amount of activities that have entered the program. The final tableau indicates the optimum solution including supplies of resources left unused and the amount of activities which entered the optimum program.

Discussions on procedure for working a simplex problem are discussed in detail by Mitts (7), Heady and Candler (7), Gass (5), and others, and the reader is referred to them for detailed operational procedures.

Presentation of Results for Objective 1

The purpose of this section is to present optimum farm plans under different yield assumptions and resource levels. Various optimum combinations are listed in tables 13 through 19. The reasoning for changes in combinations is given, as is the effect of each change on returns to fixed factors, marginal values, and resource use.

Enterprise combinations

Tables 13 through 19 show the optimum combination of crop and livestock enterprises included in this study. Each table lists the yield level under which is considered three water levels and three levels of capital. This in effect gives alternate combinations that are applicable to many different situations.

Tables of optimum combinations are arranged in order of yield beginning with Yield I. In tables 13 through 16, two levels of capital were considered, $4,000 and $5,000. Tables 18 and 19 indicate optimum plans for an unlimited capital condition for all four yield levels.

Table 13. Optimum enterprise plan for Yield Level I for specified levels of water and operating capital with marginal value of limiting resources and surplus resources

		Capital supply					
		$4,000 level			$5,000 level		
		Water level			Water level		
Item	Units	12 ac.in.	24 ac.in	36 ac.in.	12 ac.in.	24 ac.in.	36 ac.in.
Enterprises							
Cattle I	head	20	20	22	26	26	26
Barley	acres	7	--	--	14	--	--
Alfalfa	acres	53	118	150	48	117	150
Cattle III	a.u.	41	41	30	41	41	41
Return to fixed factors	dollars	2241.17	3679.49	4412.39	2389.23	3830.37	4620.18
		Marginal value of limiting resources					
Land	acres	--	--	20.74	--	--	24.39
Spring capital	dollars	--	--	.17	--	--	--
Fall capital	dollars	.15	.15	.15	.15	.15	.15
Range permit	a.u.m.	2.53	2.48	--	2.53	2.53	2.48
Water	ac.in.	.80	.80	--	.80	.80	--
		Surplus resources					
Land	acres	90	32	--	89	32	--
Spring capital	dollars	1441.06	356.46	--	2291.96	1326.48	676.72
Fall capital	dollars	--	--	--	--	--	--
Labor I	hours	384	363	375	364	359	340
Labor II	hours	708	576	550	701	574	499
Labor III	hours	652	440	374	654	440	324
Range permit	a.u.m.	--	--	23	--	--	--
Water	ac.in.	--	--	810	--	--	810

Table 14. Optimum enterprise plan for Yield Level II for specified levels of water and operating capital with marginal value of limiting resources and surplus resources

		Capital supply					
		$4,000 level			$5,000 level		
		Water level			Water level		
Item	Units	12 ac.in.	24 ac.in.	36 ac.in.	12 ac.in.	24 ac.in.	36 ac.in.
Enterprises							
Cattle I	head	20	28	28	26	35	35
Barley	acres	41	57	--	41	104	--
Alfalfa	acres	25	71	146	25	32	137
Cattle III	a.u.	41	--	--	41	--	--
Potatoes	acres	--	--	4	--	--	13
Return to fixed factors	dollars	4045.83	6973.07	8508.79	4197.44	7318.78	8851.11
		Marginal value of limiting resources					
Land	acres	--	--	47.60	--	--	47.60
Spring capital	dollars	--	.19	.19	--	.19	.19
Fall capital	dollars	.15	.15	.15	.15	.15	.15
Labor III	hours	--	--	--	--	--	--
Range permit	a.u.m.	2.48	--	--	2.48	--	--
Water	ac.in.	1.87	1.55	--	1.87	1.55	--
		Surplus resources					
Land	acres	84	22	--	84	14	--
Spring capital	dollars	558.07	--	--	1558.07	--	--
Fall capital	dollars	--	--	--	--	--	--
Labor I	hours	271	300	434	271	157	403
Labor II	hours	653	660	589	653	517	517
Labor III	hours	638	583	316	639	612	112
Range permit	a.u.m.	--	82	82	--	82	82
Water	ac.in.	--	--	765	--	--	667

Table 15. Optimum enterprise plan for Yield Level III for specified levels of water and operating capital with marginal value of limiting resources and surplus resources

		Capital supply					
		$4,000			$5,000		
		Water level			Water level		
Item	Units	12 ac.in.	24 ac.in.	36 ac.in.	12 ac.in.	24 ac.in.	36 ac.in.
Enterprises							
Cattle I	head	28	28	28	30	34	35
Barley	acres	8	--	--	10	--	--
Alfalfa	acres	29	108	149	25	98	140
Cattle III	a.u.	--	--	--	25	--	--
Corn silage	acres	47	20	--	52	40	--
Potatoes	acres	--	--	1	--	--	10
Return to fixed factors	dollars	5498.90	9570.53	11799.41	1899.48	9935.71	12162.61
Marginal value of limiting resources							
Land	acres	--	--	68.98	--	--	68.98
Spring capital	dollars	.21	.21	.21	.19	.21	.21
Fall capital	dollars	.14	.15	.15	.14	.14	.15
Range permit	a.u.m.	--	--	--	--	--	--
Water	ac.in.	2.27	2.25	--	2.36	2.27	--
Labor I	hours	--	--	--	--	--	--
Labor II	hours	--	--	--	--	--	--
Surplus resources							
Land	acres	66	22	--	63	12	--
Spring capital	dollars	--	--	--	--	--	--
Fall capital	dollars	--	--	--	--	--	--
Labor I	hours	193	337	430	78	208	397
Labor II	hours	688	604	560	557	534	484
Labor III	hours	607	419	303	481	349	88
Range permit	a.u.m.	82	82	82	32	82	82
Water	ac.in.	--	--	795	--	--	701

Table 16. Optimum enterprise plan for Yield Level IV for specified levels of water and operating capital with marginal value of limiting resources and surplus resources

		Capital supply					
		$4,000 level			$5,000 level		
		Water level			Water level		
Item	Units	12 ac.in.	24 ac.in.	36 ac.in.	12 ac.in.	24 ac.in.	36 ac.in.
Enterprises							
Cattle I	head	25	28	28	30	35	35
Barley	acres	--	--	--	--	--	--
Alfalfa	acres	38	111	147	29	101	143
Cattle III	a.u.	--	--	--	--	--	--
Corn silage	acres	43	14	--	61	32	--
Potatoes	acres	--	--	--	--	--	7
Return to fixed factors	dollars	7304.43	11932.25	14191.16	7952.97	12631.28	14915.35
		Marginal value of limiting resources					
Land	acres	--	--	--	--	--	84.49
Spring capital	dollars	.53	.55	3.40	.53	.55	.30
Fall capital	dollars	.12	.15	.15	.12	.15	.15
Range permit	a.u.m.	--	--	--	--	--	--
Water	ac.in.	2.62	2.54	--	2.62	2.54	--
Labor I	hours	--	--	--	--	--	--
Labor III	hours	--	--	--	--	--	--
		Surplus resources					
Land	acres	69	25	3	60	16	--
Spring capital	dollars	--	--	--	--	--	--
Fall capital	dollars	--	--	--	--	--	--
Labor I	hours	198	351	427	66	219	392
Labor II	hours	667	585	544	594	512	460
Labor III	hours	561	382	293	487	307	70
Range permit	a.u.m.	82	82	82	82	82	82
Water	ac.in.	--	--	910	--	--	728

Table 17 gives results of three programs which have one or more of the enterprises at a higher level of production than was considered at Yield Levels I through IV. Although many other combinations could be entered, those presented are indicative of optimum programs possible.

Return to fixed factors and marginal value of limiting resources are indicated for each program. Included also are the resources left unused in the optimum combination. To illustrate this, table 15 was selected as an example and has no special significance. Under $4,000 capital level and water level of 12 acre inches, the optimum combination returns $5,498.90 to fixed factors. The optimum plan included 28 head of Cattle I, 8 acres of barley, 29 acres of alfalfa, and 47 acres of corn silage. The marginal value of spring capital was $.21 per dollar, fall capital was $.14 per dollar, and water was $2.27 per acre inch. Resources unused were 66 acres of land, 193 hours of Labor I, 688 hours of Labor II, 607 hours of Labor III, and 82 range permits. Fall capital was fully utilized in every program.

Enterprise response to limiting resources

Changes in optimum enterprise combinations in response to changes in resource supplies are indicated in tables 13 through 19. Table 20 shows the relative efficiency of resource use by the different enterprises in terms of returns to fixed factors per unit of capital and water at designated yield levels. At all yield levels, alfalfa made the most efficient use of capital. Returns to fixed factors per unit of capital ranged from $1.16 at Yield Level I to $3.40 at Yield

Table 17. Optimum enterprise plan for Yield Levels V, VI, and VII for specified levels of water and operating capital with marginal value of limiting resources and surplus resources

		Yield Level V	Yield Level VI	Yield Level VII
		Capital supply		
		$5,000 level	$5,000 level	Unlimited level
Item	Units	Water level 12 ac.in.	Water level 24 ac.in.	Water level 12 ac.in.
Enterprises				
Cattle I	head	26	26	26
Cattle III	a.u.	41	41	41
Alfalfa	acres	57	117	57
Barley	acres	3	--	3
Return to fixed factors	dollars	5391.02	10,841.19	5391.02
		Marginal value of limiting resources		
Spring capital	dollars	--	--	--
Fall capital	dollars	.15	.15	.15
Range permit	a.u.m.	2.56	2.48	2.56
Water	ac.in.	3.03	3.03	3.03
		Surplus resources		
Land	acres	91	32	91
Spring capital	dollars	2263.34	7.14	9999
Labor I	hours	383	333	383
Labor II	hours	669	472	669
Labor III	hours	586	283	586
Fall capital	dollars	--	--	--
Range permit	a.u.m.	--	--	--
Water	ac.in.	--	--	--

Table 18. Optimum enterprise plan for Yield Levels I and II for specified levels of water and unlimited operating capital with marginal value of limiting resources and surplus resources

		Unlimited capital supply					
		Yield Level I			Yield Level II		
		Water level			Water level		
Item	Unit	12 ac.in.	24 ac.in.	36 ac.in.	12 ac.in.	24 ac.in.	36 ac.in.
Enterprises							
Cattle I	head	26	26	26	26	26	26
Barley	acres	13	1	--	41	113	--
Alfalfa	acres	48	117	150	25	25	140
Cattle III	a.u.	41	41	41	41	41	41
Potatoes	acres	--	--	--	--	--	10
Return to fixed factors	dollars	2389.23	3830.37	4620.18	4197.44	7560.07	8990.67
		Marginal value of limiting resources					
Land	acres	--	--	24.39	--	--	48.18
Spring capital	dollars	--	--	--	--	--	--
Fall capital	dollars	.15	.15	.15	.15	.15	.15
Labor III	hours	--	--	--	--	--	.93
Range permit	a.u.m.	2.53	2.53	2.48	2.48	2.48	.43
Water	ac.in.	.80	.80	--	1.87	1.87	--
		Surplus resources					
Land	acres	89	32	--	84	12	--
Spring capital	dollars	9999.90	9999.90	9999.90	9999.90	9999.90	9999.90
Fall capital	dollars	--	--	--	--	--	--
Labor I	hours	364	359	340	271	2	287
Labor II	hours	701	574	499	653	424	356
Labor III	hours	654	440	324	639	437	--
Range permit	a.u.m.	--	--	--	--	--	--
Water	ac.in.	--	--	--	--	--	700

Table 19. Optimum enterprise plan for Yield Level III and IV for specified levels of water and unlimited operating capital with marginal value of limiting resources and surplus resources

		Unlimited capital supply					
		Yield Level III			Yield Level IV		
		Water level			Water level		
Item	Units	12 ac.in.	24 ac.in.	36 ac.in.	12 ac.in.	24 ac.in.	36 ac.in.
Enterprises							
Cattle I	head	25	30	26	29	35	35
Barley	acres	6	--	--	--	--	--
Alfalfa	acres	25	87	144	25	87	140
Cattle III	a.u.	41	22	41	4	--	--
Corn silage	acres	58	62	--	68	62	--
Potatoes	acres	--	--	6	--	--	10
Return to fixed factors	dollars	5848.09	10278.73	12275.10	8191.61	13539.68	155006.46
		Marginal value to limiting resources					
Land	acres	--	--	69.79	--	--	85.92
Spring capital	dollars	--	--	--	--	--	--
Fall capital	dollars	.12	.15	.15	.12	.15	.15
Range permit	a.u.m.	1.87	--	.32	--	--	--
Water	ac.in.	2.82	2.39	--	4.05	2.89	--
Labor I	hours	.71	1.65	--	1.91	4.15	--
Labor II	hours	--	--	.98	--	--	--
Labor III	hours	--	--	--	--	--	1.31
		Surplus resources					
Land	acres	61	1	--	56	1	--
Spring capital	dollars	9999	9999	9999	9999	9999	9999
Fall capital	dollars	--	--	--	--	--	--
Labor I	hours	--	--	285	--	--	--
Labor II	hours	465	358	331	547	390	435
Labor III	hours	385	173	--	439	183	--
Range permit	a.u.m.	--	37	--	74	82	82
Water	ac.in.	--	--	741	--	--	701

Table 20. Return to fixed factors per unit of water and capital at specific yield levels

Resource	Enterprise	Yield level I	II	III	IV	V	VI
		dollars	dollars	dollars	dollars	dollars	dollars
Capital (dollars)	Alfalfa	1.16	2.21	2.91	3.40	3.40	3.40
	Barley	.50	1.15	1.52	1.76	1.15	1.76
	Potatoes	.19	.53	.68	.85	.53	.53
	Oats	.36	.52	.76	1.14	.52	.52
	Corn silage	.11	.32	.76	1.10	.32	.32
Water (ac.in.)	Alfalfa	.80	1.73	2.43	3.02	3.02	3.02
	Barley	.78	1.86	2.52	2.96	1.86	2.96
	Potatoes	.58	1.77	2.38	3.10	1.77	1.77
	Oats	.45	.65	.96	1.48	.65	.65
	Corn silage	.38	1.17	3.13	5.03	1.17	1.17

Level IV. Corn silage made the least efficient use of capital with a range of $.11 to $1.10 for Yield Levels I to IV respectively.

Alfalfa also made the most efficient use of water at low yield levels. At Yield Level I, it had a return to fixed factors of $.80 per acre inch of water. However, at Yield Level IV corn silage had the highest return to fixed factors with $5.03 per acre inch of water. At low yields corn silage was least efficient returning only $.38 per acre inch of water. At highest levels the oat enterprise was least efficient and returned $1.48 per acre inch of water.

As yield levels increased, returns to fixed factors increased for each unit of capital and water used. While costs increased at the higher levels of production they did not increase as rapidly as returns.

Yield Levels V and VI, table 20, also indicate the return to fixed factors per unit of capital and water. However, Yield Level V incorporated an alfalfa enterprise at Yield Level IV while all other enterprise yields remained at Yield Level II. A similar situation was indicated for Yield Level VI except both alfalfa and barley enterprises were used at the production rate of Yield Level IV. This was done to indicate the possibilities of optimum enterprise combination with higher yields for individual crops.

When changes in limiting resources occur, changes in enterprise combinations should likewise occur. This enterprise combination change should be in the direction of the most efficient use of resources. If, for example, the level of water is raised from 12 to 24 acre inches and capital is held constant at a presently limiting level, the enterprise making most efficient use of capital should increase since now capital is the most limiting resource. If capital level increased from $4,000 to $5,000 and water was held constant at 12 acre inches, optimum enterprise combination should move in the direction of the most efficient user of water which has become the most restricting resource.

As shown in table 16, corn acreage increased from 14 to 32 acres and alfalfa decreased from 111 to 101 acres when capital increased from $4,000 to $5,000. Water was held constant at 24 acre inches. When water was increased from 12 acre inches to 24 acre inches and capital remained constant at $4,000, alfalfa acreage increased from 38 to 111 acres and corn silage acreage decreased from 43 to 14 acres. Similarly, when resources are decreased the enterprise using the restricting resource more efficiently is increased.

These relationships can be illustrated by means of graphs and iso-resource and price-ratio or iso-revenue curves. The iso-resource curve of alfalfa and barley for Yield Level II was used for illustrative purposes. Water levels at 12, 24, and 36 acre inches were used.

When only one resource is considered, that of land, 150 acre of barley can be raised or 150 acres of alfalfa or any combination of the two not surpassing the limit of 150 acres total, figure 2, AC. If another resource is added such as $4,000 capital, the iso-capital line is drawn as shown in figure 2. With both limiting resources considered the production possibility curve is represented by ABD. Any production on or below this curve is feasible with these two limiting resources. If more restricting resources are added, such as Water II, then the production possibility curve becomes EF.

Only one combination of alfalfa and barley meeting these conditions (i.e. within the bounds of the production possibility curve) will maximize profit to the operator. An iso-revenue line must be drawn to show the ratio between the return to fixed costs of alfalfa and that of barley. A single price-ratio line is shown in figure 4. The point of tangency of the price-ratio line and the production possibility curve indicates the optimum combination of these two enterprises. This is shown on figure 2 at point E for the iso-resource curve of capital, land, and water. For clarity, the price-ratio line is not drawn in but is shown in figure 4.

A shift in any or all of the iso-resource lines causes the production possibility curve to change and may cause a shift in the

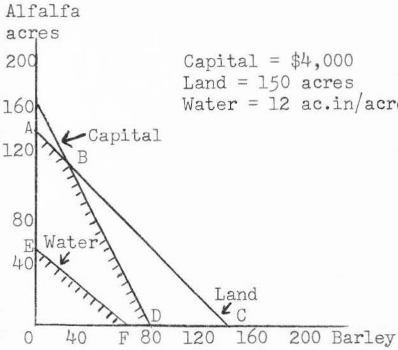

Figure 2.

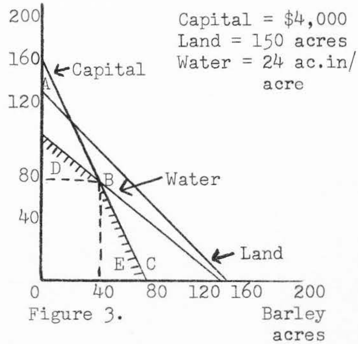

Figure 3.

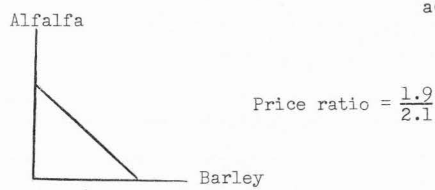

Figure 4.

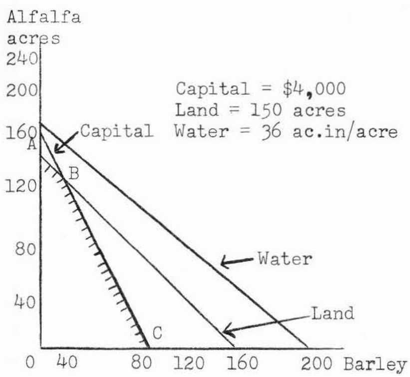

Figure 5.

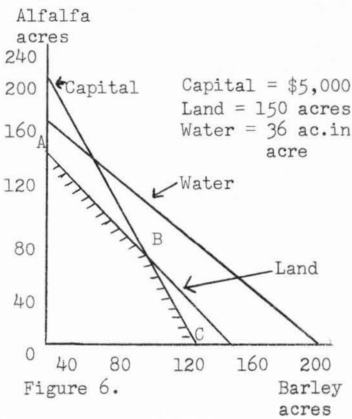

Figure 6.

Figures 2 - 6. Production possibilities and price-ratio curves for Yield Level II optimum combination. When 24 inches of water were considered, the price-ratio line became tangent at point B, figure 3, the optimum point. At 36 inches of water the optimum point is at A, figure 5. This same type of shift or movement may be caused by a change in any other resource level. Figure 6 shows the shift occuring when capital is increased to $5,000. The price-ratio curve remains tangent at point A, indicating that land rather than capital is the most restricting factor.

The foregoing discussion and graphs consider only two enterprises. When more than two enterprises are considered, optimum enterprise combinations cannot be shown in two dimensions. Even though this is the case, the principles remain the same; production possibilities and price ratios are the means by which the size of each enterprise is determined.

Oats never entered an optimum solution. This enterprise was completely dominated by the other crops and could have been left out of the programming of this study. However, it could enter an optimum combination in a program where oat yields were at high levels and other enterprise yields were low. For this reason it was included in the programming procedures. The optimum situation as programmed depended upon the production possibility and price-ratio relationship of alfalfa, barley, potatoes, and corn silage. The acreage of each depended upon the comparative efficiency of use of restricting resources by the particular enterprises.

Capital

Of interest to the operator is the amount of capital necessary for an operation when capital is not limited. Table 21 indicates the amount of capital that was necessary for this condition at the first four yield levels.

At Yield Level I, capital was only limiting at the $4,000 level using 36 acre inches per acre of water. Below this level of water capital was not a restricting factor. Yield Level II indicated that at the 24 and 36 acre inch level, $6,367.79 and $5,864.08 respectively were necessary to obtain the optimum solutions. At Yield Level III, capital was restricting at all water levels. Amounts required to give the optimum solutions were $5,666.80, $6,708.76, and $5,730.46. At Yield Level IV, capital was also restricting at all water levels with $6,645.90 required for the 24 acre inch level of water. In no case was more than $6,709.00 capital necessary for an optimum program.

This information would be helpful to an operator in determining how much capital to borrow in order to utilize other resources most effectively.

Labor

At capital levels of $4,000 and $5,000, labor was not a limiting factor in this study. At unlimited capital supply and low water supply, labor became restricting. At low yield levels all labor that was necessary was available. It was not until yields increased to level III with water supply at level I that labor was limiting. Labor II was never limiting. Capital was the main resource that

Table 21. Amounts of capital necessary at various yield and water levels when spring capital is not a limiting factor

	Yield Level I			Yield Level II		
	Water level			Water level		
	12 ac.in.	24 ac.in.	36 ac.in.	12 ac.in.	24 ac.in.	36 ac.in.
Capital required	2691.42	3669.27	4323.28	3432.35	6367.79	5864.08

	Yield Level III			Yield Level IV		
	Water level			Water level		
	12 ac.in.	24 ac.in.	36 ac.in.	12 ac.in.	24 ac.in.	36 ac.in.
Capital required	666.80	6708.76	5730.46	5483.74	6645.90	5351.10

caused labor to become limiting. All labor limiting activities were found with unlimited capital.

Return to fixed factors

Water levels made an important difference in profit. Considerable differences existed among different water levels when the capital level remained constant. Smaller differences existed between the same water level in different capital levels than between different water levels in the same capital levels. Only at the 36 inch water level was water a non-limiting factor. As water supplies increased, so did returns to fixed factors at all yield levels. In a similar manner although at a lower rate returns increased when capital supply was increased.

Yield level was the most significant determining factor in total return. At the 12 acre inch water levels using $4,000 capital supply, the return for Yield Level I was $2,241.17. The same levels of water and capital returned $4,045.83, $5,498.90, and $7,304.43 respectively for Yield Levels II, III, and IV. The importance of higher yields is indicated by this illustration. Table 17 shows an increase in acreage of alfalfa from 32 acres to 117 acres and an increase in returns from $7,318.78 to $10,841.19 when alfalfa yield was increased from 2.8 tons per acre to 4.6 tons per acre and all other yields remained constant.

Marginal value of limiting resources

Tables 13 through 19 also indicate the marginal value of limiting or scarce resources. The marginal values included are the values of the last additional unit of the resource. These values are important in making decisions as to the purchase of additional supplies of the resource. The operator, for example, uses his water supply to the point where the marginal value of an acre inch of water is $4.05. He would find it feasible to purchase additional water as long as the cost of an additional acre inch of water was less than $4.05.

Surplus resources

Supplies of resources which were left unused in the study are shown in tables 13 through 19. Labor was frequently left unused except at levels of production using high levels of capital and water. Water was left surplus only at the 36 acre inch level. Other factors such as spring capital, Labor I, and Labor III or land became restricting at this level thus preventing water from being fully utilized. Spring capital was often unused at the lower yield and water levels since water generally restricted farm operations before spring capital was fully employed.

In the unlimited spring capital case, the next most limiting resources were Labor I or Labor III.

At lower yield levels range permits were seldom left unused. At higher yields they were nearly always unused. Land went unused most often at lower water supply levels. Where water was available land was always used. Water supplies of 36 acre inches would make possible the use of all land of the operator.

In order to determine optimum resource allocation for the area of this study, it was necessary to ascertain the available supplies of scarce resources. The resources considered were land, water, range cattle grazing permits, and Grade A Base. Also considered were sources of data and assumptions made in the determination of Objective 2.

Area land resources

Total acres of land were determined from data from an unpublished study by the Economic Research Service of the United Stated Department of Agriculture, data from a study by Reuss and Blanch (12), the United States Census of Agriculture (19), Utah Agricultural Statistics (2), and local Soil Conservation Service offices. A total acreage of 8,100 acres of cropland and 7,800 acres of meadow pasture were assumed to be available for crop and pasture production in the area.

Area water resources

Water supplies were estimated using data from the Sevier River Investigation Hydraulic Studies, United States Geological Survey (22), the Utah State Engineer's Office, and from the Sevier River Water Commission. During the average frost free period from May 23 to September 24, a total of 14,110 acre feet of water was estimated to be available for use on cropland in the area. Farmers reported that little, if any, water was used to irrigate meadows during this part of the year.

It will be understood that this estimate is based on available data. There is need for additional research, particularly in this area since water supplies and uses are very complex and data are limited and completely lacking on some of the streams and irrigation companies in the area.

Area range permits

Total range permits used in this study were determined from Economic Research Service data and the work by Reuss and Blanch (12). Bureau of Land Management permits carried an average of 4.8 months per animal unit and Forest Service permits carried an average of 3.9 months per animal unit. Total supply was 13,022 animal unit months.

Area grade A dairy resources

Number of cows available was estimated from a study by Christensen (3), from data of United States Census of Agriculture (19), and by County Agent estimates of dairy potential of the area. It was estimated that a maximum of 450 cows could fill the Grade A market needs of the area. Milk is presently transported to Cedar City, Utah, for processing and then distributed in the Las Vegas, Nevada area. It should be noted that development will be necessary to reach this figure, but this estimate is based on possible cows available for Grade A milk production in the area.

Area farm budget

The farms of the area were classified into six major types representative of farms presently in the area. For each of these representative farms an optimum organization was computed using enterprises that each was assumed to include, table 22.

It was assumed that a maximum of 140 acres of irrigated cropland was available for each type farm. For farms involving range cattle enterprises, an additional 125 acres of meadow pasture land was assumed available. Water and capital supplies were assumed to be two acre feet per acre and $10,000 per farm respectively. Range permits were limited at 202 animal unit months per farm. Neither labor nor owned rangeland was assumed to be a limiting factor. Linear programming techniques were utilized to find the optimum program for each farm type.

Farm A. Farm A consisted of a Grade A dairy operation with a cropping pattern selected from alfalfa, barley, oats and corn silage. The optimum program included 72 acres of alfalfa and 46 acres of barley and a Grade A dairy enterprise of 15 cows. Dairy enterprises were assumed dry lot fed. Returns to fixed factors were $6,856.21.

Farm B. Crop enterprises only were considered for this farm. Possible enterprises were alfalfa, barley, oats, potatoes, and corn silage. Optimum enterprise organization showed a return to fixed factors of $5,911.16 and included 72 acres of alfalfa and 46 acres of barley.

Farm C. This plan was a range beef operation with alfalfa, barley,

Table 22. Optimum combination of resources for six farm types for the Circleville-Kingston-Junction areas, 1961[a]

Enterprise		Farm A	Farm B	Farm C	Farm D	Farm E	Farm F
Alfalfa	acres	72	72	72	72	72	72
Barley	acres	46	46	46	46	46	46
Pasture	acres	--	--	125	125	125	--
Cattle III	a.u.	--	--	45	33	45	--
Cattle IV	a.u.	--	--	60	--	--	--
Cows I	head	15	--	--	10	--	--
Cattle I	head	--	--	--	--	25	--
Return to fixed factors		6856.21	5911.16	8424.05	7567.24	7784.61	5041.91
Marginal value of limiting resources							
Land II		--	4.16	13.95	13.81	13.81	--
Land III		1.01	--	2.21	.67	.91	4.16
Water		1.59	1.70	1.63	1.58	1.58	1.70
Range permits		--	--	.91	--	.14	--
Capital		.15	--	.09	.16	.15	--
Surplus resources							
Land I		22	22	22	22	22	22
Range permits		--	--	--	--	--	--
Capital		--	6426.57	--	--	--	361.02
Alfalfa minimized		138	--	164	152	189	138
Barley minimized		3737	--	3920	3799	2977	3737
Land II minimized		--	--	46	110	105	--

[a] Capital 10,000
Water level 24 acre inches/acre

oats potatoes, and corn silage as possible crops. The optimum plan consisted of 45 animal units of range beef utilizing Forest Service and BLM ranges and 60 animal units of range beef utilizing meadow pasture without Forest Service and BLM range rights. Acreages of alfalfa and barley in the final plan were the same as in the other farms, with 125 acres of meadow pasture included. Return to fixed factors was $8,424.05.

Farm D. A range beef and Grade A dairy combination operation made up this model. The same crops were considered as Farm C and resulted in 72 acres of alfalfa, 46 acres of barley and 113 acres of pasture. Range beef included 33 head using Forest Service and BLM range and 10 Grade A cows. Return to fixed factors was $7,567.24.

Farm E. This farm consisted of a feeder beef and range beef operation. Feeders were dry lot fed and did not utilize pasture. The optimum program included twenty-five 380 pound beef feeder calves and 45 range beef cattle utilizing Forest Service and BLM range. Crop enterprises were the same as Farm D. Return to fixed factors was $7,784.61.

Farm F. A Grade C dairy farm which considered the crop enterprises of barley, oats, and corn silage made up the final representative farm. Alfalfa and barley were the only crops to enter the optimum solution for this model. Cows were dry lot fed and utilized no pasture. The return to fixed factors was $5,041.91.

In all representative farms the water restriction of 24 acre inches per acre limited crop production to 72 acres of alfalfa. The restriction for barley was placed at 46 acres. This was based on the assumption that for soil conservation practices not more than 46 acres would be plowed up during any one year.

It should be noted that capital was the factor limiting the range cattle on meadow pasture. It was assumed for purposes of linear programming that the farmer could not rent his pasture out. In real life, however, this assumption can be relaxed if he cannot obtain the cattle himself.

Presentation of Results for Objective 2

This section presents the results obtained for Objective 2 and outlines a method of area resource allocation. An illustration of the method was prepared for presentation. More detailed examples were considered to be beyond the scope of this study. In the determination of optimum resource allocation on an area basis, certain farm types were specified. Linear programming was used to determine the optimum combination of enterprises that would maximize returns to each farm type. Linear programming was then used a second time to determine the most profitable combination of farm types for the area.

Farm combination

Average enterprise crop budgets as determined by the survey were used to ascertain input-output coefficients for each crop enterprise of the six typical farms. Livestock enterprise input-out coefficients as determined for Objective 1 were used. A meadow pasture budget was prepared from secondary sources and was used to determine meadow pasture input-output coefficients.

Input-output coefficients that were used in table 23 for determining area optimum resource allocation were taken from the optimum plans of the six farms, table 22. For example, the plan of Farm A included 72 acres of alfalfa and 46 acres of barley for a total of 118 acres of cropland Therefore, 118 was entered as the input coefficient for Farm A in table 23. Each of the six farms was used as a real activity as shown in table 23, which indicates the first mastrix for the area programming. Supplies of resources in the P_o column are those determined for the entire area. The C row shows the return to fixed factors for each of the real activities. Table 24 indicates the results of the programming on an area basis. A total of 54 Type C farms were included in the optimum plan. Returns to fixed factors for the 54 farms was $424,509.44. Farm Type C, which is a crop-range cattle farm, is similar to the model farm of Objective 1 except the model farm used did not consider meadow pasture land in the operation.

Realistically, operators will not allow resources to go idle as the method indicates. The acres of cropland remaining would be put to use. For example, water might be reduced on other acreages to give at least partial irrigation to the remaining land, or waste water might be utilized to obtain a crop or partial crop from the surplus acres. Pasture land could be fully utilized without water, either rented or owned, in amounts larger than the 125 acreage figure used

Table 23. Input-output coefficients for area as first linear programming matrix

Resource	Supply P_o	Land I P_1	Land II P_2	Range permits P_3	Water P_4	Cows I P_5	Farm A P_6	Farm B P_7	Farm C P_8	Farm D P_9	Farm E P_{10}	Farm F P_{11}
	C	0	0	0	0	0	6856.16	5911.16	8424.05	7567.24	7784.61	5041.91
Land I acres	8100	1	0	0	0	0	118	118	118	118	118	118
Land II acres	7800	0	1	0	0	0	0	0	125	125	125	0
Range permits a.u.m.	13022	0	0	1	0	0	0	0	202	148	202	0
Water acre feet	14110	0	0	0	1	0	280	280	280	280	280	280
Cows I head	450	0	0	0	0	1	15	0	0	10	0	0
Z		0	0	0	0	0	0	0	0	0	0	0
Z - C		0	0	0	0	0	-6856.16	-5911.16	-8424.05	-7567.24	-7784.61	-5041.91

Table 24. Optimum combination of farms for the Circleville-Kingston-Junction area on an area basis[a]

Items	Type farm	Number of farms	Total returns to area fixed factors
Farm	C	54	$424.509.44

Marginal Value of Limiting Resources

Resource	Unit	Marginal value
water	ac. ft.	$30.00

Unused Resources

Resource	Unit	Amount
Land I	acres	2154
Land II	acres	1500
Range permits	a.u.	2843
Cows I	head	450

[a] Based on area average yield and 24 acre inches per acre water

in the study so that none went idle or surplus. In a similar manner the range permits would be utilized by operators.

Marginal value and surplus resources

The limiting resource was water. Table 24 shows that the marginal value of water was $30 per acre foot, indicating that this amount could be paid for additional water.

Surplus resources included 2,154 acres of cropland and 1,500 acres of pasture land, 2,843 a.u.m. range permits, and 450 dairy cows. If water supplies could be increased to 148 percent of present estimated levels, 66 farms of Type C could be included in the optimum plan. At this point pasture land would be a limiting factor and would cause six Type A farms to come into the program. This would result in 404 idle range permits. Of the 72 farms in the area, 66 would be of the range beef, Type C, and 6 would be Grade A dairy, Type A.

SUMMARY

This study was conducted to provide information to farm operators regarding the optimum enterprise combinations for farms in the Circleville-Kingston-Junction area of Piute County, Utah, and to present a method of determining optimum resource allocation on an area basis.

Farm operators were interviewed to obtain data from which individual crop enterprise budgets were constructed. Budgets were also constructed for various livestock enterprises, but secondary sources were used in addition to interview information. These budgets were later adjusted for the last ten-year weighted average price-cost situation. The crops that were considered were alfalfa, barley, potatoes, oats, and corn silage. Cattle enterprises were two beef fattening operations and a limited beef herd enterprise.

Four yield levels were selected from the range indicated in the survey to represent existing conditions and to provide realistic variations in enterprise combinations that would be useful to farmers in the area. Data were not available to detect differences due to soil types.

Linear programming was used in determining optimum enterprise combinations.

The four different yield levels chosen from the survey were used with 12, 24, and 36 acre inches of water. Spring capital levels were $4,000, $5,000, and unlimited. Fall capital was limited to $4,000 and

$5,000. In order to illustrate the many different combinations of yield levels of enterprises, three other yield levels were chosen. This procedure of using different yield levels may be adapted to most situations to meet individual operators' needs in reaching an optimum organization of enterprises.

Representative size of farm was chosen as 150 acres. It was assumed that a minimum of 25 acres should be planted to alfalfa for soil conservation purposes. For the same reason a maximum of 25 acres was assumed for the potato enterprise.

Three livestock enterprises were considered. However, Cattle I, the feeder enterprise using 380 pound calves for 180 days, was dominant over Cattle II, consisting of 700 pound feeder cattle for 150 days. The latter enterprise never was included in an optimum plan. Cattle I enterprise entered every plan at every yield level.

Cattle III was a range cattle enterprise. This was limited by the number of permits for public grazing available to each operator. This was assumed to be 82 animal unit months. At low levels of production this enterprise regularly entered optimum plans. At higher yield levels where other enterprises were more profitable, it did not occur as frequently. Only at lower water levels which restricted other enterprises from entering did it occur at these higher yield levels. At Yield Level IV, Cattle III was not profitable enough to enter an optimum plan.

Alfalfa entered nearly every optimum program at all yield levels. At lowest yield levels alfalfa entered every program. However, at

Yield Level II, at water level of 12 and 24 acre inches, barley came into optimum use before alfalfa because at this yield level barley made more efficient use of water than did alfalfa. When capital became more of a limiting factor, alfalfa entered more into the program since at these levels alfalfa made more efficient use of capital than did barley.

At the two lowest yield levels, corn silage did not enter an optimum plan because of its relatively low efficiency of water and capital. However, at Yield Levels III and IV, where corn had a relatively high efficiency of water use, it was brought into optimum plans at the two lower water levels. Where water was not a restricting factor alfalfa entered the program since this crop uses capital more efficiently.

Potatoes entered plans at Yield Levels II, III, and IV, when capital and water supplies were available and capital was used relatively efficiently. Potatoes did not enter plans where water and capital were strong restricting resources.

Oats did not enter an optimum program.

Resource allocation for the entire area was determined by selecting six types of farm operations most commonly found in the area. These farms included a Grade A dairy farm, a range beef operation, a farm with only crop enterprises, a range beef-Grade A dairy combination, a range beef and feeder beef type operation, and a Grade C dairy farm. All farms included crops with the main enterprise.

Plans for these farms were prepared from the area enterprise surveys as well as secondary sources and were based on average conditions as they existed. Assumptions were made regarding farm size which was assumed to be 140 acres available for each farm. It was assumed that 125 acres of meadow pasture land was available for each farm except the crop and dairy farms which used no pasture. Enterprises selected were typical of crop and livestock enterprises on the particular farm.

Linear programming was used to determine optimum organization of the six farms. Water was a restricting factor which resulted in 118 acres of cropland in all six farms. The range beef farm operation showed the highest returns to fixed factors of all enterprises considered.

Area resources were from secondary sources. Linear programming was used to determine the optimum resource use in terms of a particular type of farm or farms. This resulted in 54 Type C range beef farms as the final optimum solution as shown in table 24. This allowed 2,154 acres of cropland, 1,500 acres of meadow pasture land, and 450 cows to go unused.

CONCLUSIONS

Farm plan recommendations in this section are based on optimum plans determined by this study. Choices by the operator may be based on factors which are similar to those of the study. Caution should be exercised by the operator to ascertain that prices and costs are similar to those used in the study since programming was not done for changes in prices and costs.

Farm Basis

A beef fattening operation should be included in each farm operation at all yield levels. The most limiting factor in the beef fattening enterprise was fall capital. Seven head of beef can be entered in this enterprise, which is Cattle I, for each $1,000 of operating capital.

At lower levels of yield, range beef cattle may be entered in the program at the rate of 35 head for each $1,000 fall and spring capital available. However, at higher yield levels and limited capital levels, more return to fixed factors can be obtained by investing in crops which are more profitable. When capital is unlimited a maximum of 41 head can be utilized. This is a result of the relatively low return to range cattle, but if enough capital is available range cattle would always be a profitable enterprise. Cattle II was not economically feasible.

Alfalfa hay should be included on every farm regardless of yield level. It would be feasible consistently, and as water levels increased more alfalfa could be grown to a maximum of the full 150 acres, particularly at the lower yield levels. Levels of capital have relatively little effect on number of acres which may be grown. Water levels are the most important factor in determining alfalfa acreages. Where 36 acre inches of water are available, 137 to 150 acres should be planted. This range is due to the relative efficiency of water and capital use of alfalfa at different yield levels. For 24 acre inches of water, a wider range may be planted--from 71 to 118 acres. Twelve acre inches of water would include from 25 to 53 acres.

Barley should be planted at lower water levels at all yield levels, except the very highest, and at all levels of capital. At low yield and water levels acreages should be from 7 to 13 acres of barley. As water supply increases, acreages of barley decrease as alfalfa becomes more profitable. When yield levels are very high barley would not be planted since alfalfa is more profitable. When yield levels are average barley should be planted. Forty-one acres of barley should be planted when 12 acre inches of water are available at all capital levels. As yield levels increase less barley should be planted. At high yield levels no barley should be planted. However, if barley yield could be increased to 90 bushels while alfalfa yields remained at Yield Level I, barley would be profitable and then should be included.

Potatoes should be planted only when 36 acre inches of water are available at all capital levels providing yields are high. At lower yield levels none should be planted. Not more than 13 acres should be planted at any time unless potato yields are at high levels while other crops remain at low levels.

When yields from corn silage reach 15 and 20 tons and 12 and 24 acre inches of water are available, corn silage should be planted. Acres planted should range from approximately 50 acres with 12 acre inches of water and $4,000 or $5,000 capital. When 24 acre inches of water are available, 14 acres of 20 ton yield corn silage should be planted at $4,000 capital level. If $5,000 capital is available 32 acres should be planted, and if unlimited capital is available 62 acres should be planted. If yields are at the 15 ton level acres of corn silage should be decreased. However, if yields of corn silage could be increased while other crop yields remained at low levels, acreages of corn could be increased.

Oats did not enter an optimum plan. If yields of this crop could be raised to 75 bushels and other crop yield levels were at Yield Level I, it could then enter the program as a profitable enterprise.

Area Basis

The particular method used to illustrate optimum resource allocation for the area showed a situation that would maximize returns to the area. Based on average conditions, this method indicated that all farms should plant 72 acres of alfalfa and 46 acres of barley. Range animal units included should be 45 head of range beef utilizing Forest Service and Bureau of Land Management grazing permits and 60 animal units utilizing owned meadow pasture land without range permits on Forest Service or BLM land. Average conditions which were assumed by this method include water levels at 24 acre inches of water per acre and $10,000 operating capital.

However, many farmers may not feel inclined to become range beef operators because of risk, aversion, personal preference, family tradition, and other reasons not covered in this study. The method used indicates one possibility of determining optimum area resource use. In real life farmers may not allow resources to go unused as this optimum plan suggests but would make all possible adjustments and other possible methods to utilize these resources in the most profitable way.

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