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ECONOMIC ANALYSIS OF FUTURISTIC

BEEF CATTLE AND FORAGE

PRODUCTION SYSTEMS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

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* * * * *

The Ohio State University
1973

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TABLE OF CONTENTS

CHAPTER

APPENDIX

LIST OF TABLES

TABLE		Page

LIST OF FIGURES

INTRODUCTION

Setting

American consumers have expressed a preference for beef in their diets. In 1950, annual consumption was 63.4 pounds per person; in 1971, 113.0 pounds.[1] Increased consumption is projected to continue in the future, because of increasing population and rising incomes. The U.S. beef demand is projected to be 30.3 billion pounds in 1980 and 39 billion pounds in 1985.[2] After subtracting projected imports and adding military consumption, the U.S. beef industry will need to produce 29 billion pounds in 1980 and 36 billion pounds in 1985. These projections require a 7 billion pound or 30 percent increase in production from 1971 to 1980 and a 14 billion pound or 64 percent increase by 1985.

In the past, it took 14 years, from 1954 to 1968 to achieve the last increase of 7 billion pounds of beef and veal. But future increases in production cannot be made through the same methods employed in the past. "Since 1950 beef production has increased more than twice as fast as the cattle inventory because of an increasing proportion of slaughter cattle cattle being fed to maturity rather than being slaughtered as calves. This has been largely the result of a substantial growth of cattle feeding, an expanding beef herd, and a shrinking dairy herd. In the future, most of the

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[1] U.S. Department of Agriculture, Economic Research Service, Livestock and Meat Situation, LMS-182, (Washington, D.C.: Government Printing Office, Nov., 1971).

[2] Thomas T. Stout, "Systems Management in the Beef Industry," Occasional Paper ESO-116 (Department of Agricultural Economics and Rural Sociology, The Ohio State University, 1971).

expansion in beef output will have to come from increases in the beef calf crop."[3]

From 1954 to 1969, cattle numbers rose only about 15 percent and the total number of cows increased less than 3 percent per year, but total beef production increased 50 percent. The proportion of total beef finished in commercial feed lots on high energy rations increased from 39 percent in 1954 to probably over 90 percent in 1971. A second source of increased beef supply came from the dairy herds. As dairy animal numbers declined from 36 million head in 1954 to 16.2 million head in 1972, there was a ready market for the surplus cows in the beef market. With 16 million dairy animals needed in 1980 to produce the U.S. milk supply, this reservoir of supply is nearly depleated. The dairy industry also supplied bull calves and heifers not required as dairy replacements. Rather than market veal calves at 80- to 300-pounds weights, increasing numbers have been grown out and finished at 1000-pound weights. Number of calves slaughtered has declined from 10.2 million head in 1950 to 3.9 million head in 1971. dropping 56 percent during the past decade.[4]

The estimated number of potential feeder cattle from reduced dairy calf slaughter and feeding of non-feed steers and heifers was 14.5 million head in 1955-57; 10.4 in 1960-62; 8.9 in 1965-67; 5.3

[3]U.S. Department of Agriculture, Livestock and Meat Situation, LS-178, March, 1971.

[4]U.S. Department of Agriculture, Livestock and Meat Situation, LMS-182.

in 1969, and may be below 3.6 million in 1971.[5] In his report Larsen noted, "On balance, extending the foregoing assumptions and trends, if cattle feeders continue to expand near the pace in recent years, opportunities for expanding numbers from these sources (nonfeds and dairy) will be largely utilized by the mid-1970's . From that point on, increases in fed beef output will largely depend on expansion of the beef calf crop."

Imports as a solution to production deficiencies is often given. A summary of projections made by the Food and Agricultural Crganization of the U.N., the EEC (Common Market) Commission and the Organization for Economic Cooperation and Development with respect to beef and veal production and consumption in 1975 and 1985 does not concur that imports are an easy solution. Despite divergence among the projections, it seems likely that world demand for all types of meat, especially beef and veal, will rise faster than production. Although the industrialized countries of Europe and North America as a whole can be expected to meet the bulk of the increased demand from domestic production, their total deficit will probably grow.[6]

The obvious conclusion exists that to get more beef in the future, the U.S. needs more beef cows and/or increases in the rate of production from the existing herd.

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[5]U.S. Department of Agriculture, Economic Research Service, Livestock and Meat Situation, "Potential Feeder Cattle Supply," by John T. Larsen, LMS-171, (Washington, D.C.: Government Printing Office, 1970).

[6]T.R. Preston and M.B. Willis, Intensive Beef Production, (Oxford, England: Pergamon Press, Headington Hill Hall, 1970).

Technical improvements which do not require basic research include higher calving rates, heavier weaning rates, bigger cattle, better feed conversion, and less carcass fat. An animal scientist has estimated a billion dollar saving to the beef industry by diligent application of neglected skills and available knowledge.[7] He pointed out that calving rates have increased only 4 percent, from 84 to 88 percent in the past quarter century. In 15 years, the average weight of feeder steer calves moving through the Denver market has increased 20 pounds; 15 pounds of that increase was attributed to better management and only 5 pounds to improved cow production.[8] Other improvements in technical efficiency do require basic research. These include such things as multiple births, feeding bulls, and genetic control of sex. "Yet all the technical improvements cannot alone yield the required seven billion pounds of increased production."[9]

Problem Delineation and Justification

Considering the projected increase in beef demand and the limitations upon sources of supply, the central questions become:

1. What production methods can be employed to produce the supply of feeder calves,

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[7]E.J. Warwick, "Beef for Tomorrow," (paper presented before the Agricultural Research Institute, Washington, D.C., October, 1969. At the time of the presentation, Dr. Warwick was Assistant Director, Animal Science Division, Agricultural Research Service, USDA).

[8]Jerry Litton, "Beef Tomorrow" (paper presented before the Ohio Cattleman's Association, Columbus, Ohio, January, 1972).

[9]Stout, "Beef Industry."

2. What farm organization will be most profitable, and

3. Will beef cow-calf production in Ohio be increased through adjustments in production methods?

The answers lay in the relevant costs and returns producers can expect to experience. Does sufficient economic incentive to expand Ohio beef cow production exist? To answer the question of sufficient economic incentive, one must first answer what returns can be expected from an optimum farm organization utilizing up-to-date techniques and technologies in beef cow-calf production. The second question to be answered is whether returns from the added investment are sufficient to encourage capital expenditures to improve pastures and purchase more brood stock.

Area of Study

The unglaciated region of southeastern Ohio provides one logical area for investigation (Figure 1). The terrain is rolling to steep and generally suited to grass rather than crop production under present economic conditions. The climate is moderate, snowfall light, rainfall adequate and reasonably well distributed. Frost free dates extend roughly from May 10 to October 10. Normal rainfall for the growing season (May through September) is 18 to 20 inches.[10] Southeastern Ohio is similar to the Appalachain regions extending from Pennsylvania to Georgia and from Virginia into Kentucky and southern Indiana and Illinois.

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[10]Ohio Extension Agronomy Staff, 1970-71 Agronomy Guide, Bulletin 472 (Columbus, Ohio: Cooperative Extension Service, the Ohio State Universidy, n.d.)

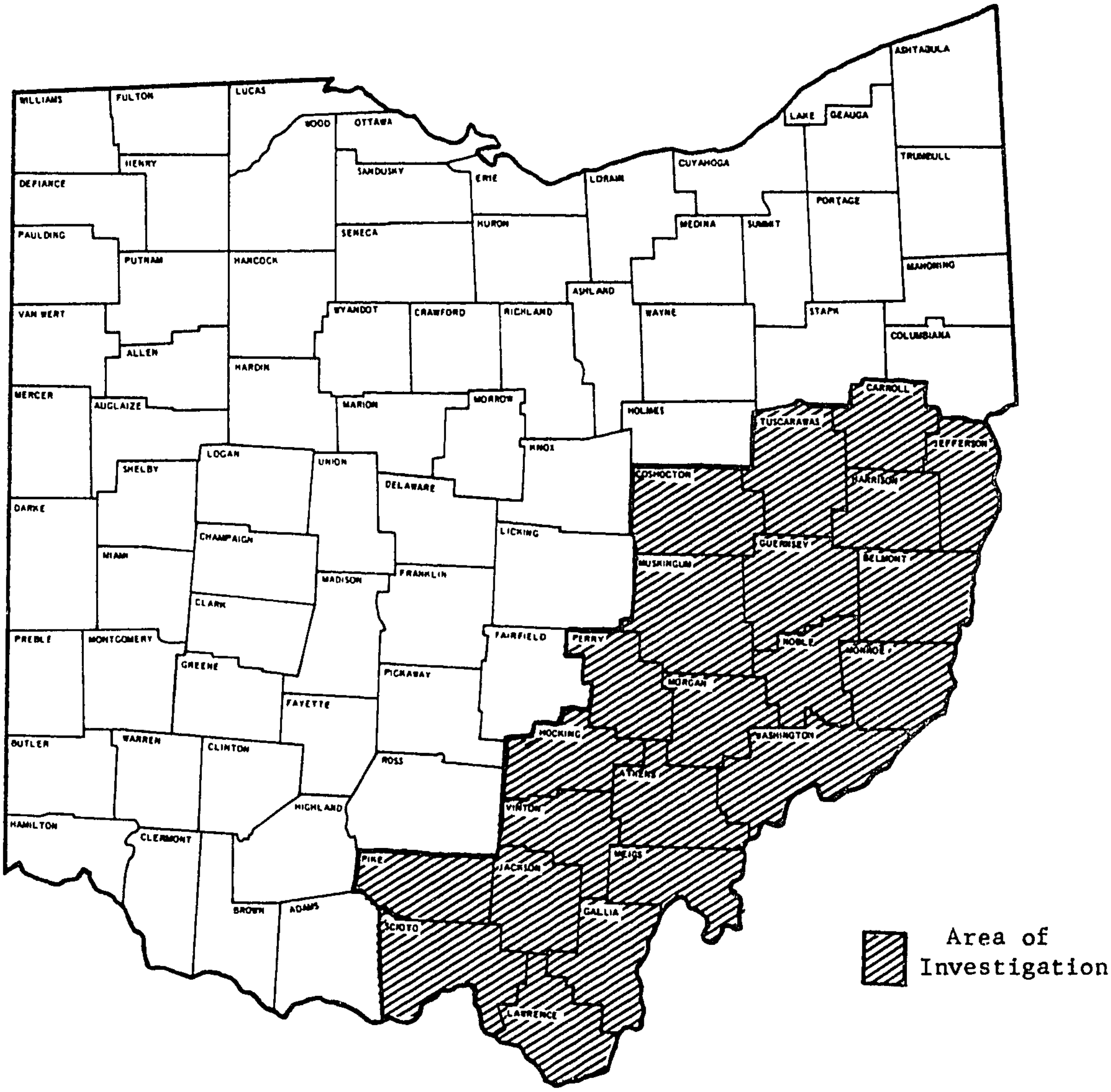

Figure 1: Ohio Map and Resource Area to be Investigated

The soils of the region developed from sandstone and shale formations. Glaciation had little influence in the area, with the exception of the alluvial or terrace soils resulting from stream movement of glacial-derived material.

Population in the unglaciated area is low compared to other areas of Ohio. Open space is an asset. It may be possible to develop large farm units if economic incentives exist. Correspondingly, farm income levels are below other areas of the state.[11] Optimum farm organization may increase income.

According to the 1969 Census of Agriculture, 78 percent of the farms in the unglaciated region of Ohio with sales over $2500 annually had cow herds.[12] Four thousand, two hundred sixty-two farms had from 1 to 19 beef cows; 1818 farms, 20 to 49 cows; 303 farms, 50 to 99 cows; and 62 farms had 100 and over beef cows. The average size herd on the 6445 farms with beef cows was slightly over 18 cows. In the 22 county area, there are 2,124,800 acres of pasture land.

If the carrying capacity of the pasture land were developed to 4 acres per cow unit, the area could carry over 482,900 cows, their replacements, and bulls. If the carrying capacity were improved to 2 acres per animal unit, the potential capacity would be over 966,000 cows. The 1969 Census reports 267,134 total beef and dairy cows in the area.

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[11]David H. Boyne, Francis B. McCormick, George Hill, Dan Tucker and Eldon Houghton, 1971 Ohio Farm Income, Department Series E.S.M. 483, (Wooster: Ohio Agricultural Research and Development Center, November, 1972).

[12]U.S. Department of Commerce, Bureau of the Cenus, United States Census of Agriculture: 1969, Vol. 1, Counties, Part 10, Ohio.

In a study of eastern Ohio feeder calf producers, Sherer found that one-third of them planned to enlarge their herds in the next 5 years.[13]

Optimum organization of the existing herds and answers to the questions of whether they should set goals of expansion and by what means are justification for a study of beef production practices. Producers need to know what adjustments can be profitable.

The results would likewise benefit farmers in similar resource situations in the entire Appalachian region.

Objective

"Our ability to produce enough cattle for the feedlots is not clear. We need to increase our beef cattle herd by one-third to one-half between now and 1985. That is a tall order. We in ERS have examined this subject during the past year and we feel that the physical capacity exists to produce enough forage for beef needs in 1985. The issue is whether the economic conditions will be such to convert the potential capacity into actual output. We estimate that farm prices above 35 cents per pound for feeder cattle, over an extended period of time, will lead farmers to make the investment to provide the needed forage and the feeder cattle."[14]

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[13]George W. Sherer, "Producers Educational Needs in Marketing Feeder Calves in Selected Eastern Ohio Counties," (unpublished M.S. Thesis, The Ohio State University, 1972).

[14]John E. Lee, Jr., "Input Requirements of the Food Industry," talk at 1973 National Agricultural Outlook Conference (Washington, D.C.: USDA, ERS, February, 1973).

Increasing beef calf production in Southeastern Ohio requires increasing output per cow and/or the number of cows. Output per cow can be increased by weaning more pounds of calf per cow herd through higher percent calf crop weaned and heavier average weaning weights. Adding more cows requires production of more feed nutrients to support them. An individual operator can add additional acres by rental or purhcase; but in total, all operators can increase production only by improving existing pasture or by establishing more productive forages. The profitability of any forage improvement practice depends upon the increase in forage produced and the livestock system through which forage is utilized.

The specific objectives of this study are:

1. To estimate input-output relationships for alternative beef cow production programs.

2. To estimate input-output relationships for alternative feed production systems.

3. To define the optimum beef cow-calf program and feed system, comparing existing patterns with new technology.

4. To determine potential rates of return on added investment required for intensification.

CHAPTER I

REVIEW OF LITERATURE

Beef Cow-Calf Cost Studies

Cost of studies in the past have demonstrated that commercial beef cow herds usually yield low returns. Size, efficiency, and resource input combinations are frequently cited as important factors affecting profits.

Shaudys and Sitterley[1] found that about 15 percent of the southeastern Ohio beef farmers studied had a profit above all costs. Practically all operators had a return above cash costs of operation. The average return over cash cost was $519 per farm. Harvested feeds and cash expenses accounted for about 70 percent of total production costs. Grain, hay, and silage comprised 45 to 65 percent of total costs depending upon the system of production used. Pasture, labor, and buildings represented 25 to 30 percent of total costs. The ability to utilize effectively the resources available was more important than the system of handling the enterprise. Farm operators achieving a high production of beef per cow, a high percent calf crop while holding feed, labor, and overhead cost down earned a profit.

[1]Edgar T. Shaudys and J.H. Sitterley, Costs, Returns, and Profitability of the Beef Cow-Calf Enterprise in Southeastern Ohio by Systems of Management, Research Bulletin 937 (Wooster: Ohio Agricultural Experiment Station, April, 1963).

Feeder calf producers could earn greater profit by using more farm produced or purchased feed to permit additional cows to be carried during the winter and to make more complete use of available pasture and labor.

Stauffer[2] found that most cow-calf herds in Western Ohio cover variable costs and provide some return to fixed inputs. Ninety percent of the producers covered variable costs and 46 percent covered all costs of production. Feed costs comprised 69 percent of total costs; labor, 14 percent; overhead, 10 percent; and other costs 7 percent. Farmers earning the greatest net income per cow held these costs down while breeding for and marketing heavier weaning weights and consequently higher returns per cow.

An income and expense summary on 87 eastern Kansas cowherd farms by size and efficiency groups reports operator return for management and labor for the period 1960 to 1964.[3] The return was $1532 for all farms; small farms averaged $1363 and large farms, $2127. By efficiency groups, the inefficient beef farms had $106 operator labor returns; the efficient farms, $3173.

During 1965-66, a survey of Georgia operators utilizing practices designed to produce high daily gains in nursing calves was made.[4]

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[2]Bruce B. Stauffer, "A Cost-Return Analysis of One Hundred Beef Cow-Calf Herds on Ohio Corn Belt Farms," (unpublished M.S. Thesis, The Ohio State University, Columbus, 1964).

[3]Dale A. Knight, Efficiency and Size Considerations on Beef Farms in Eastern Kansas, 1960 to 1964. Technical Bulletin 160. (Manhattan: Kansas Agricultural Experiment Station, Kansas State University, January, 1969).

[4]John R. Allison, Profitability of Cow-Calf Operations in Georgia, Research Report 83, (Athens: College of Agriculture Experiment Stations, University of Georgia, July, 1970).

Realized costs and returns found on the survey painted a relatively dismal picture of the profitableness of Georgia cow-calf herds. Even with the deletion of data from several operations because the magnitude of their costs suggested either unrealistic reporting of actual or highly unusual costs, the average returns to the operator's management and to his investment in land and cattle were negative for both north and south Georgia. Returns were unfavorable regardless of whether creep feeding, annual winter grazing, or concentrates were utilized.

Western beef cow-calf ranches have also experienced low rates of return (Table 1). Capital and management returns calculated on Wyoming and New Mexico ranches reflected 1965 conditions.[5] Prices received per hundredweight of calves averaged $21.40.

Table 1: Rate of Return on Western Ranches, by Size, 1965

Size	No. of Cattle	Percent Return*
Wyoming		
Medium	362	2.41
Large	674	2.46
Very Large	1494	2.96
New Mexico		
Small	98	-0.39
Medium	283	1.30

*Percent return on fixed capital and management.

[5]Delwin M. Stevens, Mountain Valley Cattle Ranching: An Economic Analysis, Bulletin 485, (Laramie; Agricultural Experiment Station, University of Wyoming, April, 1968), and James R. Gray, Production Practices, Costs, and Returns of Cattle Ranches in the Central Mountains of New Mexico, Agricultural Experiment Station Research Report 166, (Las Cruces: New Mexico State University, April, 1970).

In numerous linear programming studies of typical resource situations, beef cow-calf herds seldom appear as the optimal use of the resources. Beef herds have not usually offered competitive returns for use of available resources when compared to dairy, beef feeding, steer grazing, or swine production.

For the optimum organization of southeastern Ohio farms, Shaudys[6] reports that Grade A dairy and feeder pigs maximized returns to resources found on the farms studied. The next best alternative was a beef cow-steer finishing enterprise in combination with feeder pigs. An intensive beef finishing enterprise failed to permit the available labor to be employed and often resulted in part of the land base being utilized less intensively than necessary for a good return. It was found that a beef cow herd required a large extensive land base and that returns would be low. Generally, economic studies made for land of the type found in Southeastern Ohio have indicated that off-farm employment was a more profitable use of labor than farm work.

A Virginia study based upon resources present in the mountainous area of the state with limestone valleys and sandstone-shale uplands showed that beef cow-calf farms could increase their incomes through improved organization.[7] In no instance, however, would additional beef cows have increased income; an additional cow would have reduced income from $59 to $128 depending upon the resource situation. The addition

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[6]Edgar T. Shaudys, Optimum Organization of Southeastern Ohio Farms, Research Bulletin 1023, (Wooster: Ohio Agricultural Research and Development Center, June, 1969).

[7]James D. Oliver and Ralph G. Kline, Optimum Enterprise Combinations for Beef Cow and Calf Farms in Southwest Virginia, Technical Bulletin 180, (Blacksburg; Virginia Agricultural Experiment Station, June, 1965).

of market hog, steer wintering, and/or laying flocks were required to raise the income levels.

On the other hand, opportunities for improved profitability apparently do exist, Cogan[8] concluded that a beef cow herd can be a profitable livestock enterprise on southeastern Ohio farms with a high level of management. Selling finished fat cattle rather than yearlings or feeder calves yielded the highest family income for typical resource situations. The most profitable system of handling the cattle was a delayed finishing program.

Woods and Buddemeir[9] concluded that beef cow herds in the unglaciated area of southern Illinois offfered a reasonable potential for improving income on many farms. Economical use of resources, especially labor, was difficult with small herds; hence, small herds seriously limited the financial success of beef cattle farms. Farms of good size with land resources suited to the production of large quantities of roughage provided a combination that had excellent advantages for beef cow herds.

Janssen[10] reported that a beef herd will show a profit with average weaning weights, calving percentages, and costs of production in southern Indiana. Profits were likely to be greater if high calving percentages

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[8]Robert E. Cogan, "Optimum Organization of Southeastern Ohio Farms with the Beef Cow Herd Enterprise," (unpublished M.S. Thesis, The Ohio State University, Columbus, October, 1960).

[9]H.S. Woods and W.D. Buddmeir, Increasing Production and Earnings on Farms with Beef Cow Herds in the Unglaciated Area of Southern Illinois, School of Agriculture, Publication No. 6 (Carbondale: Southern Illinois University, 1959).

[10]M.R. Janssen, Beef Cow Herd Costs and Returns in Southern Indiana, Research Bulletin No. 725, (Lafayette: Indiana Agricultural Experiment Station, August, 1961).

and weaning weights were achieved. Winter feed costs were minimized by maximizing pasture use and feeding 20 pounds of forage per day. It was concluded that three types of farms were adaptable to beef cow herds. One type was the large rolling - to - hilly farm that produced an abundance of pasture and harvested forages. Another type was the small farm whose operator had full-time employment off the farm, particularily in the rough land areas. A third type was the grain farm. The beef cow herd provided a market for stalk, stubble, pasture, and roughage that would not be used otherwise.

Similar situations and methods of adjustment are possible in other states. In a Michigan study,[11] a budgetary analysis was made for three types of situations reflecting 1965 conditions: (1) part-time herd of 25 cows, (2) 50 cow herd added as a supplemental enterprise or substituted for a small dairy enterprise, and (3) full-time 200 cow beef herd.[12]

The part-time enterprise of 25 cows added from $300 to $1,300 returns to land and labor. As a supplemental enterprise, when enough semipermanent grass was available for grazing and a charge was made only for taxes on the grazing land, the 50-cow herd added from $1,100 to $2,300 to net income. Replacing a 22 dairy enterprise with a 50-cow beef herd reduced labor requirements by 2,000 hours and net income by $96 to $1,314. Labor income for the full-time, 200-cow beef herd in the Upper Peninsula ranged from $2,700 to $7,887, depending on crop yields, percentage calf crop and calf weights.

[11] L.J. Maish, and C.R. Hoglund, The Economics of Beef Cow Herds in Michigan, Research Report 58 (East Lansing: Michigan State University Agricultural Experiment Station, n.d.).

[12] Average calf price used in the budgets was $26.00 per hundredweight.

Howell[13] studied the optimal enterprise combination on large farms in a transitional soil area of east central Ohio. Using average production coefficients and typical systems of management[14] the beef cow herd was not usually the most profitable use of the resources. However, where beef cow facilities existed, they were filled by high level managers in all optimal organizations. At feeder calf prices below $26.56 per hundred weight, the beef cow-calf enterprise did not enter optimal solutions at all. Nor did the size of cow herd expand beyond limitations of existing facilities when calf prices rose to $50 per hundredweight. In situations where labor availability was varied, the beef cow herd and feeder pig enterprises appeared as the optimum at the lowest levels of labor availability. As labor increased, the number of beef cows decreased and the number of sows increased. Additional labor resulted in both the beef cows and sows decreasing to zero as the dairy enterprise expanded. Finishing cattle facilities were used to capacity in nearly all resource situations.

In summary, these studies indicate, first, that returns from a beef cow herd producing weaner calves are characteristically low, but that there are opportunities for increasing expected returns. Secondly, they indicate that other enterprises offer opportunity for great returns.

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[13]James D. Howell, "Large Farm Organization in East Central Ohio," (unpublished Ph.D. Dissertation, The Ohio State University, 1972).

[14]The production rate used was 450 pound calf, a 95 percent weaning percentage, and an 11 percent replacement rate. Prices assumed were $28.55 per hundredweight which reflected the average for 1967-1971.

Shifts in Production

A review of Census data shows that for a 22 county area (the sandstone and shale region) in southeastern Ohio, number of beef cows increased from 32,510 in 1950 to 113,702 in 1969. During the same period dairy cow numbers declined from 177,200 to 62,250; total cow numbers, from 209,710 to 179,000. West Virginia had 82,600 beef cows in 1950 and 117,000 in 1969. The cow herd in Virginia increased from 178,000 in 1950 to 400,000 in 1969.[15] The question arises as to why so many producers are joining a bad thing?

One answer lies in the adjustment that has been occurring in farming during the last 20 years. A summary of these adjustments is presented in Table 2. It reports changes that have occurred in the 22 county region of southeastern Ohio with respect to land use and cattle production. Number of farms declined 57 percent; cropland harvested declined 43 percent; pasture land in total declined 24 percent, but cropland pastured increased; dairy cow numbers declined 63 percent; and beef cows increased 71 percent.

As intertilled crop enterprises ceased to be economic, as markets for dairy products were lost, as age of operator increased, and as labor received higher wages in other employment, usually off the farm, the farming pattern changed. From 1950 to 1970 the number of beef cow herds in southeastern Ohio increased from 2,073 to 6,971. Size of herd averaged 15.7 cows in 1950 and 16.3 cows in 1970. Beef herds

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[15]U.S. Department of Commerce, Bureau of the Census, County Data: 1940, 1954, 1959, and 1969, Ohio, West Virginia and Virginia.

Table 2: Adjustments in Farmland Use and Dairy and Beef Cow Numbers, Selected Years 1950-1969 for 22 Southeastern Ohio Counties[a]

		12 Northern Counties			10 Southern Counties			Change in 22 Counties 1950-69	
	Unit	1950	1960	1969	1950	1960	1969	Total	Percent
Farms	No	23,910	16,280	10,900	19,050	11,760	7,390	-24,670	-57
Crops Total	a.	688,830	565,570	410,020	405,230	310,460	197,950	-462,090	-43
Hay	a.	318,670	272,040	235,080	166,320	129,040	105,520	-144,390	-28
Tilled	a.	606,680	152,420	110,940	325,940	127,990	74,630	-747,050	-80
Sm. Grain	a.	173,500	107,300	59,440	67,710	29,850	15,920	-165,850	-69
Pasture Total	a.	1,701,490	1,310,800	1,297,790	1,107,040	785,460	827,010	-683,730	-24
Cropland	a.	288,000	183,430	312,610	159,610	99,500	189,230	+54,230	+24
Pasture Land	a.	1,413,490	1,127,370	985,180	947,430	685,960	637,780[b]	-737,960	-31
Idle & Failure	a.	189,490	143,110	145,050	125,990	85,560	95,940	-74,490	-24
Dairy Cows	hd.	115,060	80,055	46,271	62,140	41,291	18,979	-111,950	-63
Beef Cows	hd.	20,100	51,348	69,426	12,410	28,117	44,276	+81,192	+71

[a]Source: Census data from unpublished material compiled by John Sitterley in connection with a farm adjustment study now in progress.

[b]1965 data, 1969 unavailable, statistics on pastureland for the entire state changed very little from 1965 to 1969; therefore it is assumed the 1965 data fairly accurately represent 1969 data.

did not increase in size but new herds were substituted for dairy herds to use the resources. Low labor requirements and reduced management load with beef herds allowed the part-time operator or semi-retired farmer to maintain some level of returns, generally in excess of variable costs.

In his study of eastern Ohio feeder calf producers, Sherer[16] found that most had small herds and were employed off the farm. The average size herd was 28 cows; only 6% of the producers had herds of 100 cows or more and 54% had less than 20 cows. Sixty-one percent of the producers worked off the farm 100 days or more; 47 percent, 200 days or more. Only 36% did not have an off-farm job.

There are non-economic reasons why operators raise beef cattle. A West Virginia[17] study examined both economic and non-economic forces affecting beef cattle production. Beef production has continued to grow in the state despite economic studies which indicate the enterprise was less profitable than other alternatives. The primary economic factor was land resource; when full utilization of all hilly pasture land was required, beef cattle entered into the optimal linear programming solution. Farmers cited land adaptability, labor requirements, and lower risk as affecting the selection of beef herds as their major farm enterprise. Perhaps more important factors were the preferences of the farmers; most preferred to handle beef cattle and would continue to do so although other enterprises might be more profitable.

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[16]Sherer, "Feeder Calves."

[17]Stephen K. Hedrick and Dale K. Colyer, <u>Socio-Economic Factors Affecting Beef Production in West Virginia</u>, Bulletin 610 (Morgantown, West Virginia University Agricultural Experiment Station, October, 1972).

Smith and Martin[18] concluded that purchases of Arizona cattle ranches were not made for the purpose of maximizing returns on investment (a combination of current income and land appreciation). On the supply side of the equation, ranches were selling at such high prices that an extremely low return on the opportunity cost of investment was implied on all retained ranches. The authors extended the argument that cattle ranching and ranchers can better be understood by viewing the ranch resource as generating both production and consumption outputs. It was found that non-monetary outputs of ranch ownership were the most significant factors in explaining high sale prices of Arizona ranches. Land fundamentalism, rural fundamentalism, and conspicuous consumption/speculative attitudes were the most important of these consumption outputs. With knowledge of these three basically consumption factors alone, it was possible to predict with approximately 80 percent accuracy which ranchers would consider selling their ranches and which ranchers would not consider selling at current market prices.

Economic Conditions

Back to the economic side of the coin, incentives now exist for expansion of beef cow numbers due to a significant increase in prices received for feeder calves since 1965 when most of the previously cited

[18]Arthur H. Smith and William E. Martin, "Socioeconomic Behavior of Cattle Ranchers, with Implications of Rural Community Development in the West," American Journal of Agricultural Economics 54:217-225 (May, 1972).

data were collected. Prices of feeder steers and finished steers since 1964 are given in Table 3. Feeder calf prices in Ohio have increased 80 to 90 percent from 1964 levels. An example of the results of the uptrend in prices can be gleaned from an Ohio report[19] on 10 beef breeding enterprise records from farmers mailing in their 1971 records for analysis. Their profit above all costs averaged \$388; family labor and management income averaged \$1,657 on the average size herd of 40 cows.

Table 3: Average Price Per Hundredweight of Feeder Steers and Fat Steers, Selected Markets, 1965-1972

Year	Choice Feeder Steers Kansas City[a]	Ohio Feeder Calf Sales[b] Steers	Heifers	Choice Fat Steers, Omaha or Chicago[a]
	$/cwt	$/cwt	$/cwt	$/cwt
1965	25.30	25.91	20.79	26.19
1966	30.31	29.11	24.99	26.29
1967	30.10	28.71	24.37	26.04
1968	31.26	29.49	24.87	27.74
1969	35.45	33.86	28.78	29.66
1970	38.76	34.60	29.57	29.34
1971	39.25	37.79	31.17	43.42
1972	46.80	47.34	39.89	42.93
Increase 1972 over 1965	85%	83%	92%	64%

[a]Source: U.S. Department of Agriculture, Economic Research Service, Livestock and Meat Situation, LMS-188, LMS-179, LMS-170, LMS-158, LMS-152 (Washington, D.C., Nov., 1972, Nov., 1969, Nov., 1968, Nov., 1967, Nov., 1966).

[b]Source: R.O. Smith, 1972 Summary Ohio Demonstrational Feeder Calf Sales, A.S.B.C. 722 C (Columbus: College of Agriculture, The Ohio State University, n.d.).

[19]John W. Bastian, Reed D. Taylor, Richard D. Duvick, and John E. Moore, "1971 Farm Business Analysis Report, Beef Summary," Extension MM No. 327, Columbus: Cooperative Extension Service, The Ohio State University, n.d. (Mimeographed).

Relatively high prices for choice fed beef are predicted to continue in the years ahead (Table 4).[20] The projected price of feeder calves, calculated relative to the projected price of fed steers, is also presented in Table 4.

The magnitude of price changes in recent years and the projected continuation of high price levels will create a production response. Given a resource base and market demands for production increases, how can Ohio producers react profitably?

Beef Cow Production and Nutrition

Beef cattle are relatively inefficient converters of feed nutrients into beef. Work at the Ohio Station has shown that only 13 percent of the metabolizable energy fed to the cow and calf was recovered as net energy in the calf at slaughter.[21] Thus, 87 percent was required for maintenance and other non-productive functions.

Long[22] calculated cow efficiency of production (dividing TDN consumption of the cow and calf into the 205-day calf weight) to be approximately 8 percent.

To make beef cow-calf production profitable, nutrient costs must be held at minimum levels consistent with maximum output. Modern techniques of cow production and feed nutrient production need to be

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[20] U.S. Department of Agriculture, Economic Research Service, Effects of Alternative Beef Import Policies on the Beef and Pork Sectors, Agricultural Economic Report No. 233, by Andrew Duymovic, Richard Crom, and James Sullivan (Washington, D.C., October, 1972).

[21] Earle W. Klosterman, V.R. Cahill, and C.F. Parker, A Comparison of the Hereford and Charolais Breeds and Their Crosses Under Two Systems of Management, Research Bulletin 1011 (Wooster: Ohio Agricultural Research and Development Center, May, 1968).

[22] J.R. Long, "Milk Production and Productive Efficiency of Different Sized Beef Cows" (Unpublished M.S. Thesis, The Ohio State University, 1969)

Table 4: Predicted Choice Steer Price, Beef Consumption, Cow Inventory and Feeder Steer Price, 1973-1980

Year	Qtr.	Choice Steer Price[a]	Per Capita Beef Consumption[a]	January 1 Beef Cow Inventory[a]	Calculated Price Choice Feeder Steer, 500 lbs.[b]
		$/cwt.	lbs.	million head	$/cwt.
1973	1	31.85	31.4	40,897	
	2	34.83	30.5		
	3	32.88	32.3		
	4	31.00	32.5		44.25
1974	1	29.75	33.5	41,984	
	2	32.11	32.9		
	3	34.16	32.6		
	4	31.69	33.0		43.35
1975	1	32.93	32.8	42,800	
	2	35.02	32.5		
	3	34.18	33.7		
	4	30.20	35.0		43.00
1976	1	31.69	34.7	43,203	
	2	35.52	33.4		
	3	34.43	34.7		
	4	34.43	34.0		51.50
1977	1	34.56	34.2	43,669	
	2	39.26	32.5		
	3	38.76	33.8		
	4	36.20	34.4		53.50
1978	1	36.47	34.5	44,187	
	2	40.43	33.1		
	3	40.13	34.3		
	4	39.89	33.8		62.10
1979	1	38.25	34.9	45,745	
	2	42.72	33.3		
	3	44.55	33.4		
	4	43.57	33.3		58.90
1980	1	41.95	34.4	48,265	
	2	44.09	34.2		
	3	43.54	35.6		
	4	41.73	36.0		

[a]Source: U.S. Department of Agriculture, by Duymovic, Effect Of Import Policies, using variant I.

[b]Choice feeder steer price was calculated by assuming 600 pounds of gain costing $25 per hundredweight total feeding costs inflated 3%annually subtracting this cost from the value of an 1100 pound choice steer in the subsequent third quarter, and dividing the remainder by 500.

reviewed and economically evaluated to select the most profitable production alternatives.

Production in the future will be guided to supplying what consumers want through price differences they will pay for differing characteristics. At the present time, market value of beef carcasses is primarily determined by two factors: (1) quality of the meat (palatability) and (2) the quantity of lean meat available. USDA quality grades -- prime, choice, good, standard, commercial, utility, cutter and canner-- have been used since 1927 to identify differences in palatability of beef. Marbling, the amount and distribution of small flecks of fat within a muscle tissue, is the most important single factor in determining quality grades. Since 1965 USDA yield grades (also referred to as cutability grades) have provided an additional marketing tool in identifying the amount of lean meat present in a carcass. They are based on the amount of trimmed retail cuts that can be obtained from a beef carcass.[23]

Recent research has shown that marbling is of less value in determining palatability than was true in the past. Iowa researchers[24] explained that in taste panel tests of beef from young finished animals, the degree of marbling had essentially no effect on flavor, tenderness,

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[23]Donald G. Chafin, "Dual Grading of Meat Products," Virginia Farm Economics No. 187 (Blacksburg: Virginia Agricultural Extension Service, Sept. 1964).

[24]F.C. Parish, Jr., D.G. Olson, R.E. Miner, and R.E. Rust, "Beef Palatability Studies Report," (presented at Iowa State University Meat Science Day, reported in Better Beef Business, Vol. 14, No. 2, December, 1972).

juiciness, or overall acceptability. Nor did marbling affect shear values. Internal temperature or doneness was the only criteria associated with acceptability. The results lead to the conclusion that young, grain finished beef is acceptable irrespective of marbling requirements in present grading standards. If such research leads to changes in grading standards (changes are already being discussed[25]), the beef animal in the future will be young and lean. How to economically produce such an animal is at question. Whether producers can and will adjust to different production methods is a second question.

Importation of purebred Charolais cattle into the U.S. in 1966 can be designated as the start of a new era of adopted beef cattle production methods.[26] Prior to that time, selection emphasis was upon short, compact, early maturing animals. This emphasis led breeders to produce dwarf animals which were economic disaster and feedlot animals which produced more fat than consumers wanted. On the other hand, the Charolais breed can be termed a surrogate for rapid growth, heavy

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[25] (no author) "Beef Breeds Council Opposes Any Changes in Grading Standards", Better Beef Business, Vol. 14, No. 3 (Kansas: Shawnee Mission, Jan., 1973).

[26] Rapid expansion of fed beef production, beginning in 1950, was the impetus for change in type of animal produced. Several years were required for the market to reflect consumers wishes to the producer and for the producer to change his production emphasis. Charolais were first introduced into the U.S. from Mexico in 1936. There was no attempt to keep them purebreds, rather they were crossed on other cattle. In 1966, purebreds came to the U.S. from France through Canada, overcoming import bans. A history and description of the breed is given by: Hilton M. Briggs, Modern Breeds of Livestock, Third edition (London: The Macmillan Company, Collier - Macmillian Limited).

muscling, and high ratio of lean to fat production. Many other breeds of similar characteristics have been introduced in subsequent years and this type of animal has been selected within existing breeds.

Revenue to the beef cow-calf enterprise is pounds of calf produced multiplied by market price. Crossbreeding, increased milk production by mother cows, and fast gaining cattle provide means for increasing size of calf.

Crossbreeding of beef cattle, to boost output yields, is not a new practice, but its widespread acceptance ties to the Charolais importation. Crossbreeding was described as early as 1906 and was reported numerous times.[27] Much of the earlier work was concerned with carcass yield and quality rather than with production problems, including feedlot performance.

A project was started at the Ohio Station in 1939 to determine the advantages and disadvantages of crossing Aberdeen Angus and Hereford breeds of cattle.[28] In general the advantages of crossbreeding were found to be heavier weaning weights, more rapid daily gain in feedlot,

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[27]C.S. Plumb, Types and Breeds of Farm Animals (Boston: Ginn and Company, (1906), and Jay L. Lush, "Practices and Problems Involved in Crossbreeding Cattle in Coastal Plain of Texas," American Society of Animal Production (1927) pp. 58-61, and J.G. Fuller, "Crossbreeding Types for Baby Beef Production," American Society of Animal Production, (1927) pp. 53-57, and W.H. Black, "Developing New Types of Beef Cattle for Semi-Tropical Conditions," American Society of Animal Production, (1934) pp. 71-73.

[28]Paul Gerlaugh, L.E. Kunkle, and D.C. Rife, Crossbreeding Beef Cattle, Research Bulletin 703 (Wooster: Ohio Agricultural Experiment Station, Reprint Sept. 1, 1951).

higher dressing percentage, and higher proportion of choice carcasses. Disadvantages listed were longer gestation period and heavier calves at birth. Parenthetically, their work lead them to ask: "Although size was not considered in the experimental design, some of the results obtained in this test raise the question as to whether there is more opportunity for making progress in beef cattle production by paying attention to size and milk production within a breed, rather than by crossing beef breeds of the same size."

Many articles in recent years have confirmed crossbreeding to yield superior results over straight breeding.[29] Increased production results from both larger weaner calves and increased weaning percentages. Production per cow exposed for breeding can be increased 20 to 25 percent by systematic crossing of British breeds. Crossbreeding with fast growing cattle yield even superior pre - and post-weaning growth rates. Charolais crosses produce carcasses grading 1/3 to 2/3 of a grade lower but contain a higher proportion of lean and less fat than cattle of British breeds.

A management system has to be tailored to the production process in order to gain the benefits of rapid growth. A significant breed by method of management interaction was detected in the Ohio data for edible portion (of meat) per day of age.[30] Cattle which were creep fed and finished out immediately following weaning, produced more pounds

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[29] Earle W. Klosterman, Comparison of Breeds, and E.J. Warwick, "Crossbreeding and Linecrossing Beef Cattle Experimental Results," World Review of Animal Production, Vol. IV, No. 37 (1968) pp. 19-20, and L.V. Cundiff, "Experimental Results of Crossbreeding Cattle For Beef Production," Journal Animal Science, 30:694 (1970).

[30] Klosterman, Comparison of Breeds.

of edible portion per day of age than those on the deferred system. However, the advantage of Charolais and Charolais-Hereford crosses over Herefords was greater when creep fed and finished immediately after weaning than in the deferred system, indicating that the rapid growth rate of the large breeds can be utilized best by liberal feeding at a young age. Economic evaluation of respective cost input items and resulting output can lead to defining optimum production systems. The fact that nutrient costs vary by time of year may make deferred systems more profitable than achieving maximum efficiency.

Work at Wisconsin[31] has shown that breed differences and rate of gain differences should accrue to the feeder calf producer, rather than the feedlot operator. Within breed, faster gaining cattle did not produce more efficient weight gains. When feeding cattle of various sizes and post weaning growth potentials to a constant grade or fat content, no advantage in feed conversion could be extracted from the data. The added maintenance requirements of larger cattle fed to a constant grade explains in part these results. The effect of size of animal and rate of growth on returns the cow producer can expect are shown in Table 5. Larger, faster gaining cattle yield greater returns to the cow after costs of feeding the cattle are subtracted from carcass value.

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[31]Val H. Brungardt, "Wisconsin Size Conferences Explained," Better Beef Business, Vol. 12, No. 10 (Kansas: Shawnee Mission, August, 1971).

Table 5: Gross Returns to the Cow by Breed and Size Variation, Wisconsin, 1971

Size	Weight Per Day of Age			Gross Return Per Cow
	Angus	Hereford	Charolais Crossbred	
1 (very small)	1.97	1.97	-	$188.32
3 (medium)	2.30	2.35	2.40	$214.97
5 (large)	2.50	2.47	2.60	$245.17
7 (very large)	-	-	2.75	$244.51
Gross Return Per Cow	$223.48	$218.77	$233.67	

Source: Brungardt, "Size Conference."

But heavier calves require larger mothers according to Klosterman et al.[32] Highly significant positive relationships were found between weight of cow and birth weight, weaning weight, final weight, and weight of edible portion produced by her calf. The analysis was among cows within breeds.

Heavier milking dams consistently produce heavier calves at weaning. Rutledge, et al.[33] stated that on a within herd-year-sex basis, the single most important determinant of weaning weight was the lactation performance of the dam. It explained 60 percent of the variation in 205-day weaning weight. Of the total variance in eight month calf weight, 66% was due to differences in milk consumption according to

[32]Klosterman, Comparison of Breeds.

[33]J.J. Rutledge, O.W. Robison, W.T. Ahlschwede, and J.E. Legates, "Milk Yield and Its Influence on 205-day Weight of Beef Calves," Journal Animal Science 33:563, (1971).

Neville.[34] Pope _et al._[35] stated the correlations between milk production and calf gain were in excess of 0.80 at three months of age, and 0.50 from birth to weaning. However, Melton, _et al._[36] stated that average daily gain in calf and average daily milk production were significantly correlated only in the initial period of lactation. Milk yields from dairy type cows exceed beef type cows.[37]

The Oklahoma work reported 2.9 Kg (6.4 lb), 5.4 Kg (11.9 lb) and 7.0 Kg (15.4 lb) average milk production from Hereford, Hereford X Holstein, and Holstein cows respectively. In Hereford,

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[34] W.E. Neville, Jr., "Influence of Dam's Milk Production and Other Factors on 120- and 140-Day Weight of Hereford Calves," _Journal Animal Science_ 21:315, (1962).

[35] L.S. Pope, L. Smithson, D.F. Stevens, D.O. Pinney and Valasco, _Factors Affecting Milk Production of Range Beef Cows_, Misc. Publ. MP-70, (Stillwater: Oklahoma Agricultural Experiment Station).

[36] A.A. Melton, J.K. Riggs, L.A. Nelson, and T.C. Cartwright, "Milk Production, Composition, and Calf Gains of Angus, Charolais, and Hereford Cows," _Journal Animal Science_ 26:804, (1967).

[37] L.J. Cole and Ivan Johansson, "Inheritance in Crosses of Jersey and Holstein-Fresian With Aberdeen Angus Cattle: III," _American Naturalist_, 82:265-80 (1948) and W.M. Dawson, A.C. Cook, and Bradford Knapp, Jr., "Milk Production of Beef Shorthorn Cows," _Journal Animal Science_ 19:502 (1960) and Warren Gifford, _Milk Production of Dams and Growth of Calves_, Bulletin 531, (Fayetteville: Arkansas Agricultural Experiment Station, 1953) and R.D. Totusek, D.F. Stevens, J.R. Kropp, J.W. Holloway, L. Knori, and J.V. Whiteman, _Milk Production of Range Cows_, Miscellaneous Publication 85 (Stillwater: Oklahoma Agricultural Experiment Station, 1971).

Angus, and Shorthorn cows, Gifford found more variation within breeds than between breeds. Cole concluded Angus vs Jersey produced 2,030 pounds and 4,528 pounds, and Angus vs Holstein, 2,606 pounds and 4,499 pounds respectively in 180 days.

The weight gains in calves per unit of milk decreases as milk production in the dam increases.[38] Melton calculated a 5.2:1 conversion ratio (milk yield to calf gain) at 1,500 pounds of milk production; Drewry 9.9:1, at 2,300 pounds; and Wilson 11.2:1, at 3,600 pounds. This information indicates that response of weight gain in calves is curvilinear. Calves utilize additional milk less efficiently. However, since calves must rely on other accesible feeds when milk is not available, they may eat more grass, for example, than a calf on a heavy milk flow. This difference points to the question of whether it is more profitable to feed the cow to feed the calf, or to feed the calf directly. Klosterman[39] kept calves and dams confined, individually fed them and weighed their consumption. Calves that received more milk ate less other feed. Creep feeding trials have shown that in years of luxurious grass, calves do not consume

[38]L.L. Wilson, J.E. Gillooly, M.C. Rugh, C.E. Thompson, and H.R. Purdy, "Effects of Energy Intake, Cow Body Size, Calf Sex on Composition and Yield of Milk by Angus-Holstein Cows and Pre-weaning Growth Rate of Progeny," Journal of Animal Science 28:789 (1969), and K.J. Drewry, C.J. Brown, and R.S. Honea, "Relationships Among Factors Associated with Mothering Ability in Cattle," Journal of Animal Science 18:938 (1959), and Melton, "Milk Production."

[39]Klosterman, Comparison of Breeds.

as much creep feed as they do when pasture growth is restricted by drought.

To reap the benefits of increased calf growth from increased milk yields, several dairy breeds are receiving increased attention as prospects for crossbreeding in commercial beef production. Brown Swiss cows have been handled under range conditions along with other breeds at Miles City, Montana.[40] Crossbred calves out of Brown Swiss dams sired by Charolais, Angus, and Hereford bulls have been heavier at weaning than crossbred calves out of Charolais, Angus, and Hereford cows sired by the same bulls. The crossbreds with Brown Swiss breeding were comparable to the beef crossbreds in post weaning gain and were only 1/6 of a grade lower in carcass grade. A project involving Brown Swiss, Holsteins, Angus, and Hereford cattle in semi-confinement fall calving management program at Iowa[41] indicate major material differences. Holsteins ranked over Brown Swiss, Angus, and Herefords in that order.

There is a popular notion that milk yields in excess of the calf's capacity is detremental. Neville[42] observed that seven calves were able to consume 18 to 22 pounds of milk early in lactation without any noticable udder damage, nor was there a sharp reduction of milk production in subsequent months. Christian[43] also found calves could

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[40]O.F. Pahnish, J.S. Brinks, J.J. Urick, B.W. Knapp, and T.M. Riley, "Results of Crossbreeding Beef X Beef and Beef X Dairy Breeds: Calf Performance to Weaning," Journal Animal Science 28:291 (1969).

[41]R.L. Willhams, Iowa Station Report to NC-1, Ames, Iowa, July, 1971 (Mimeographed).

[42]W.E. Neville Jr., "Influence of Dam's Milk Prodution."

[43]L.L. Christian, E.R. Hauser, and A.B. Chapman, "Association of Preweaning and Post Weaning Traits with Weaning Weights in Cattle," Journal Animal Science 24:652 (1965).

consume 20 pounds per day. Pahnish[44] reported the volume of milk supplied by Brown Swiss dams under range conditions was not in excess of the amount that the calves could consume. In studying 44 Angus-Holstein F_1 cows, Wilson et al.[45] found only three quarter infections throughout the entire lactation and two of these were present at the beginning of the study. The main conclusion of the bacteriologic studies was that the incidence of intramammary infections with pathogenic organisms was extremely low.

In a discussion on the secretion of milk, Espe[46] notes that as milk pressure increases in the mammary gland, the rate of secretion decreases until a pressure of about 25 to 35 mm. Hg. is reached. Then, secretion usually stops. He states that considerable milk can be left in the udder of the recently fresh cow without causing any appreciable decline in milk production.

In Nebraska[47] Holstein cows were maintained under beef cattle management conditions for six years. Cows had potential production

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[44]Pahnish, "Results of Crossbreeding."

[45]L.L. Wilson, R.J. Eberhart, M.J. Simpson, H. Valera-Alvarez, M.C. Pugh, and L.G. Bair, "Incidence of Intramammary Infections and Effects of Number of Lactations, Lactation Stage, Quarter, and Calf Sex on Somatic Cell Content of Milk From Angus-Holstein F_1 Cows" Journal Animal Science 33:433 (1971).

[46]Dwight Espe, Secretion of Milk, Third Edition, (Ames: Iowa State College Press, 1946).

[47]Mogens Plum and Lionel Harris, "Holstein Cows and Calves Udder Beef Cattle Management," Journal Dairy Science 54:1086 (1971)

of 14 kg. (31 lbs) milk daily for four months, but it was not until the calves were four months old that they consumed all the milk. Although the cows were high milk producers (14,680 lbs. per year in the dairy herd) no serious complications arose. Mastitis occurred in some cows but did not consitute a major problem. Several cows were assigned to the experiment because they had injured or diseased udders, but still had potential for high milk production. There was no evidence of active mastitis when the calves were weaned. Many of the cows returned to the dairy herd after the beef experiment, with no adverse effects. Only during one summer was there serious trouble with scours in the calves. Since it occurred only in one of six years, it could not be attributed to the high intake of milk by the calves.

Arguments against dairy beef state that it is of inferior quality to traditional beef cattle and that dairy yields less meat. If tenderness is the yardstick of quality comparison, there is little support for the argument. Husaini _et al._[48] found the meat of common grade Holsteins and choice Herefords of the same age to be equally tender. No differences in tenderness between beef and dairy-type steers were observed by Cole _et al._[49] The only evidence in favor

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[48]S.A. Husaini, F.E. Deatherage, L.E. Kunkle, and H.N. Droudt, "Studies on Meat, 1: The Biochemistry of Meat as Related to Tenderness" _Food Technology_ 4:366, (1950).

[49]J.W. Cole, C.M. Kincaid, and C.S. Hobbs, "Some Effects of Type and Breeds of Cattle on Basic Carcass Characteristics" _Journal Animal Science_ 17:1153 Abstract (1958).

of beef versus dairy animals is that of Heck et al.[50] However, the data related to bulls and the dairy animals were heavier. Cole also reported that at the same live weight, steers from the dairy breeds (Holsteins, Jersey, and Guernsey) had a higher percentage of rib, loin, and round than beef breeds (Angus, Hereford, and Brahman). Breidenstein[51] and his associates found no difference in edible meat distribution between Holstein and Angus. In Switzerland, Schneeberger[52] observed no differences in edible meat distribution between Brown Swiss or Simmental cattle.

On the production side, heavier milking cows require more feed nutrients.[53] Ewing, et al.[54] studied energy requirements of mature beef

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[50] M.C. Heck, P.K. Lewis, Jr., C.J. Brown, and O.T. Stallcup, "Effect of Type and Storage on Beef" Journal Animal Science 27:1140 Abstract (1968).

[51] B.C. Breidenstein, B.B. Breidenstein, W.J. Gray, D.S. Garrigus, and H.W. Norton, "Comparison of Carcass Characteristics of Steers and Heifers," Journal Animal Science 22:1113 Abstract, (1963).

[52] H. Schneeberger, "Problems of Carcass Evaluation in Cattle," Proceedings 9th International Congress Animal Production, Edinburgh, (1966).

[53] National Research Council, Nutrient Requirements of Dairy Cattle, Third Revised Edition, Publication 1349 (Washington: National Academy of Science, 1966).

[54] S.A. Ewing, Larry Smithson, Craig Ludwig, and Dwight Stephens, Energy Requirements of Mature Beef Cows as Influenced by Weight and Level of Milk Production, Miscellaneous Publication 80 (Stillwater: Oklahoma Agricultural Experiment Station, 1968).

cows as influenced by weight and level of milk production. He concluded that total energy requirements can vary importantly in similar weight cows with different levels of milk production.

More feed for larger cows or heavier milking cows raises feed cost. As previously cited feed costs constitute 70 percent of total production costs.[55,56]

Wilson et al.[57] fed Angus-Holstein cows suckling Hereford sired calves at levels of 85 and 115 percent of NRC requirements. The cows on 115 percent energy level maintained their weight while the 85 percent level cows lost an average of 54.4 Kg. (120 lbs.). The weight changes suggested that the Angus-Holstein cows would not maintain their post-parturition weight on 100 percent NRC requirements for beef cows because of high milk producing ability of Angus-Holstein cows.

The answer to what size cow, producing how much milk, and yielding what size calf depends upon price relationships: Is the value of calf produced greater than the costs associated with feeding a larger, heavier milking cow?

Nutrient levels must be high enough to supply energy requirements, but excessive amounts reduce profitability.

Minimum nutrient levels at critical times in the reproductive

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[55]Shaudys and Sitterley, Beef Cow-Calf Enterprise.

[56]Stauffer, "Cost-Returns Analysis."

[57]Wilson, "Effects of Energy Intake."

cycle are necessary to insure that cows rebreed. Wiltbank *et al.*[58] studied the effect of energy level on reproductive performance of mature Hereford cows. The feed levels and preganancy rates he discovered are reported in Table 6.

Table 6: Feed Levels and Pregnancy Rates of Hereford Cows

Feed Level	Cows Showing Estrus After Calving, Days 50	60	70	80	90	Percent Pregnant
High-High[a]	65	80	90	90	95	95
High-Low[b]	76	81	81	86	86	77
Low-High	25	45	70	80	85	95
Low-Low	6	17	22	22	22	20

Source: Wiltbank, "Energy Levels"

	TDN Before Calving	TDN After Calving
a. High Level	9 lb./day	16 lb./day
b. Low Level	4.5 lb./day	8 lb./day

In Florida, five breed groups of cows including Brahman, Shorthorn, 3/4 B 1/4 S, 1/2 B 1/2 S, and 1/4 B 3/4 S were grazed continuously on pasture management programs designed to provide low, medium, and high nutritional regimes.[59] The pastures were native range, a combination of native and improved pasture, and all improved pasture including irrigated clover-grass area. The trial ran for 10 years. Each breed of cow was mated to both Brahman and Shorthorn sires. Pregnancy and weaning rates were significantly influenced, in order of the magnitude of effects, by pasture program, breed of cow, breed of sire, and the

[58] J.N. Wiltbank, W.W. Roden, J.E. Ingalls, K.E. Gregory, and R.M. Roch, "Effects of Energy Levels on Reproductive Phenomena of Mature Hereford Cows" Journal Animal Science 21:219 (May, 1962).

[59] F.M. Peacock, M. Kroger, W.G. Kirk, E.M. Hodges, and A.C. Warnick, "Reproduction in Brahman, Shorthorn, and Crossbred Cows on Different Pasture Programs" Journal Animal Science 33:458 (1971).

interaction of breed of cow with pasture program. The significant breed of cow by pasture program interaction was accounted for mostly by crossbred cows responding more to improved pastures than did purebred cows. Economic analysis of the data is planned to see whether the improved performance is economically justifiable.

In an earlier Florida study[60] with Brahman-Shorthorn crosses pasture programs were designed to supply low, medium, and high nutrition planes. On high planes, cows became too fat and were irregular breeders and there were more calf losses from birth to weaning than with other herds on lower nutrition planes.

An Arkansas study[61] reports the feed costs and returns associated with two beef herds of 60 cows each at the Batesville Station, from the Spring of 1959 until the Spring of 1963. One herd was pastured on oats, sudangrass, and Johnson grass and wintered on grain sorghum silage, grass hay, and a protein supplement; this was designated as a high quality forage regime. The other herd was pastured on bermudagrass overseeded with Lespedeza and wintered on grass hay and a protein supplement; this was designated as a low quality forage regime.

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[60] W.G. Kirk, E.M. Hodges, F.M. Peacock, M. Kroger, "Nutrition and Weaning Performance of Brahman-Shorthorn Crosses," Crossbreeding Beef Cattle (Gainesville: University of Florida Press, 1963) pp. 142-147.

[61] W.A. Halbrook, M.L. Ray, and A.E. Spooner, Feed Costs and Returns from Beef Calves Produced Under Two Different Forage Regimes, Bulletin 735 (Fayetteville: Agricultural Experiment Station, University of Arkansas, November, 1968).

Annual feed costs averaged $116.62 for cows on the high quality forage regime and $77.09 on the low quality regime. Average returns per calf were $120.45 for calves on the high quality regime and $104.12 for calves from the low quality regime. The average price per hundredweight was about the same for calves from both herds, but calves from cows on the high quality forage averaged 59 pounds heavier.

Even though high quality forages increased returns per calf, the increased returns were not enough to offset the additional costs. Price levels during the study period made the extra weight worth $14.40; it was worth $25.80 at 1972 price levels, however.

Forage Production

Gerlow and Wolf[62] used budgeting and linear programming techniques to evaluate selected combinations of forage programs and production systems to determine what changes will achieve maximum income from beef cattle on Louisiana farms. They found that improved pasture systems increased returns over native grass system. Cattle prices, calving rates, and weaning weights affected the ratio of improved acres to native grass acres. As each of these factors increased there was a larger proportion of improved pasture, and returns per acre showed a larger proportionate increase for the improvements. In general,

[62]Arthur R. Gerlow and Willard F. Woolf, Economic Effects of Changes in Production Practices in Beef Cattle Production in the Southwest Louisiana Rice Area, D.A.E. Research Report No. 433 (Baton Rouge: Louisiana State University Agricultural Experiment Station, January, 1971).

profitable utilization of forage from improved pastures required high calving rates (above 80 percent) heavy weaning weights (above 300 pounds), and strong prices (above $24 per hundredweight).

Barr and Plaxico[63] defined optimum cattle systems and range improvement practices for Oklahoma conditions. Reseeding abandoned cropland to native grass would yield returns of 24 percent on short-term and 21 percent on long-term capital. Aerial brush spraying and bermuda grass establishment would yield 9-6 percent respectively on short-term and long-term capital. In general, a price decline reduced the profitability of all pasture improvement alternatives, and increased the profitability of cows relative to steers. Higher livestock prices increased the rate of return to range improvement practices, thus making them profitable at higher capital cost levels.

Providing summer pastures for beef herds requires facing several problems and economically evaluating the alternatives. Growth patterns of forages often do not fit nutritional schedules of livestock. Adjustments must be made to achieve maximum production and utilization. Various species, each with its characteristic growth pattern, can be rotationally grazed to harvest the crop at its optimum productivity and to level out the supply available. Stocking rates can be fitted to the lowest production month of a species if no rotation is practiced. Forage growth can be stored on the stump or harvested for hay for use in low production periods.

[63] Barr, Optimum Cattle Systems.

Increased fertilization levels increased yields of forage crops while reducing acreage required to carry an animal unit. The manager has to decide whether the added plant food costs exceed savings in land changes. Some species are not native but must be established; grasses last several years, but summer annuals must be planted every year. Establishment requires a capital expenditure which must be amortized over the life of the stand and added to annual maintenance costs to determine total annual cost.

A report by Van Keuren[64] characterizes the major pasture grass alternatives for Ohio. Bluegrass is most productive in early spring and in the fall. Orchard grass and tall fescue are productive during these periods, but are also more productive during summer than bluegrass. Alfalfa-grass mixtures have a high yield potential throughout the growing season, but they present some management problems and dangers of bloat. Summer annuals are sometimes used for summer feed sources.

Several alternative forage production alternatives with their respective yields and production distribution patterns for Ohio have been derived by Myers.[65] He reports on bluegrass with varying nutrient treatments, tall grass (orchardgrass and fescue), alfalfa- and clover-grass mixtures, and other forages such as sudangrass, small grain, and corn stalks. A copy of the Pasture Guide is included in Appendix A.

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[64]Robert W. Van Keuren, "Summer Pastures for Beef Cows," Ohio Report, 55 (3): 43-45 (Wooster: Ohio Agricultural Research and Development Center, May-June, 1970).

[65]Don Myers, "Pasture Production Guide," Department of Agronomy, The Ohio State University, 1971, (Mimeographed).

A winter feeding plan has to complement the summer feeding regime. An added dimension of a summer pasture system is that deferred grazing can be practiced and part of the winter requirements come from summer growth stored on the stump. The conventional system of winter feeding is baled hay fed from barn storage. A recent development for winter feeding in Ohio has been a pasture system with stockpiled round bales.[66]

Six years of research results showed that beef cow herds can be successfully managed on an all-season forage system without housing in Southeastern Ohio. The winter feed was supplied by round-baled first crop left in the pasture and the fall-saved regrowth. Tall fescue successfully withstood close grazing, and trampling by livestock during the winter feeding period, roughly November 15 to April 15, and has proven superior to other grasses studied. The nutritional level of the feed was adequate for mature pregnant beef cows without supplemental feed. Combinations of nitrogen-fertilized orchardgrass, Kentucky bluegrass, and tall fescue, each grown in pure stands, provided satisfactory summer pasture. Satisfactory October weaning weights and grades were obtained with February-March calves born on winter-pasture and raised on such programs.

White[67] synthesized budgets comparing the costs and resource requirements of an all season grazing system (field stored round bales)

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[66]Robert W. Van Keuren and E.W. Klosterman, "Winter Pasture System for Ohio Beef Cows," Ohio Report 52 (5): 67-69 (Wooster: Ohio Agricultural Research and Development Center, Sept.-Oct. 1967).

[67]Bennie Lee White, "An Economic Comparison of Beef Cow-calf Feeding Systems in Southern Ohio," (Unpublished M.S. Thesis, The Ohio State University, 1969).

compared to the conventional system used by farmers in a 3 county area of Southern Ohio. He found that the all season system offered lower total cost per cow for all farm sizes and resources bases than did the conventional system. Expansion of herd size was more economical by converting to an all season plan rather than through the conventional system. The land requirement for the all season system was 40 percent less than conventional. All season system required fewer laborers during the harvest season and their employment was less critical. The all season system, however, involved renovating pastures which required more intensive management than was true of untreated bluegrass pastures in the conventional system. Additional capital was required by the all season system.

Stock[68] evaluated the economic performance of the all season grazing system in operation at the Eastern Ohio Research and Development Center at Caldwell, Ohio. He calculated total costs of production to be $113.07 per cow with $100 per acre land value and $121.60 per cow with $150 land values With feeder calves averaging $191.25 in 1972 Ohio sales, opportunities for profit exist in the all season system.

Neither of the previous two authors attempted to vary the cow production system or evaluate intensity of forage production with species or fertility levels. Depending upon the type of cow defined, alternative feed sources may provide higher valued nutrients at

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[68]Charles E. Stock, "Analysis and Projections for a Beef Cow-Calf All-Season Grazing Program," (Unpublished M.S. Thesis, The Ohio State University, 1972).

certain periods. Nor did they vary calving dates to note the effects on feed costs and returns from spring vs fall calves.

Summary

In summary, the literature indicates that beef cow-calf enterprises have been only modestly profitable in the past. Improved organization would have helped increase income; but supplemental enterprises would likely have yielded higher returns. Contrary to what might have been expected, the number of farms maintaining beef herds, and consequently total beef cows, have increased significantly in the Appalachian region. Explainations for this apparent uneconomic situation include shifts in the farming pattern from small crop and dairy farms and the non-economic benefits cattlemen receive from cattle herds. Rather than allow their resources to remain idle many operators shifted to beef herds and took off-farm jobs to supplement their income.

Over the last five years, the economic situation has changed drastically. Calf prices are at record high levels and they are projected to remain high. There is economic incentive to increase beef calf production.

A review of research can guide a producer to alternative production methods. The meat trade wants tender, lean beef finished at a young age. Several types of cows and breeding plans can produce this desirable animal.

With feed costs constituting 60-to-70 percent of total costs, all agronomically feasible forage alternatives and their respective handling systems should be defined.

Given these cow and forage alternatives, with their respective inputs and outputs, an economic evaluation can determine the most profitable combination.

CHAPTER II

THEORETICAL FRAMEWORK

Economic principles form the decision making framework by which resources are combined in a production mix to maximize farm income or to minimize cost. There are three basic economic principles which govern economic decisions.

Added Costs - Added Returns or Conversely Reduced Costs - Reduced Returns: Diminishing Returns

This relationship guides all decisions in determining how much of one resource to add to the production mix. As long as an increase in cost produces more receipts than cost, the added cost can profitably be incurred. Conversely, a cost cutting measure which does not reduce receipts by a greater amount than the reduced costs is like-wise a profitable decision. An example of this relationship is nitrogen fertilization of grasses. The management question is whether an added $1.00 of nitrogen cost per acre will yield more than $1.00 worth of nutrients produced.

The diminishing return relationship is known as Resource-Product, Factor-Product, or an Input-Output relationship.

Least-Cost Combinations for Obtaining a Given Output: Substitutes

The production process requires a mix of resources to attain a given level of output. Within physical limitations, money can be saved by using more of a lower cost resource or input and less of a higher prices input.

For example, dairy cows will produce 15,000 lbs. of milk with many combinations of hay and grain. As grain becomes relatively more expensive the manager feeds more hay and less grain; conversely, with grain prices decline relative to hay, he increases grain feeding and decreases hay.

Economically, this relationship is called Resource Substitution, Factor Substitution or Input-Input Substitution.

Highest Return Products: Alternatives

This principle involves selection of the enterprise which pays the highest return to land, labor or capital when two or more uses compete for use of the same resources.

For example, oats and wheat crops compete for the use of the same land, labor, and capital. When one is grown, the same land and related resources cannot be used to grow the other. Management is to choose which enterprise yields the highest return.

Economically, this relationship is known as Product Substitution, Output-Output relationships or Product-Product relationship.

Yet given this economic framework, evaluation of cost or value of forage crops is difficult and complex. The value could be market value of the number of pounds of beef gain on calves; the value of the crop harvested as hay; the rental rate someone would pay; the direct costs of producing the forage; the opportunity cost of utilizing meadow land for corn production; or the cost of providing the nutrients from purchased feeds.

ECONOMIC PRINCIPLES APPLIED IN FORAGE PRODUCTION AND UTILIZATION

Forage As An Individual Input or Product[1]

A decision-making frame of references is presented graphically in Figure 2. This figure applies to a given farm as organized at a given time whether the farm is well or poorly set up. It often combines in each value concept the worth of two products of the forage investment--feed and fertility. Similarly, it sometimes lets the use of other inputs--such as grain--influence the value or earning power of forage. Figure 2 contains three lines that represent concepts of basic importance in evaluating forage and forage-producing stands.

The most important of these three lines is the marginal value product (MVP) line. This line represents successive additions to the gross income of the farm business that result from using successive additional quantities of the asset being evaluated. In general, beyond some limit within a given farm organization, additional quantities of an asset trend to be used less efficiently in a given use and/or devoted to less efficient uses; hence, a portion of the MVP line slopes to the right.

Two other important lines appear in Figure 2. One of these is labeled "acquisition cost," the other "salvage or disposal value." Acquisition cost is the cost of adding one more unit of the asset to the

[1]The ideas for this discussion were adapted from: Glenn L. Johnson and Lowell S. Hardin, Economics of Forage Evaluation, North Central Regional Publication No. 48, Station Bulletin 623 (Lafayette, Indiana: Purdue University Agricultural Experiment Station, April, 1955).

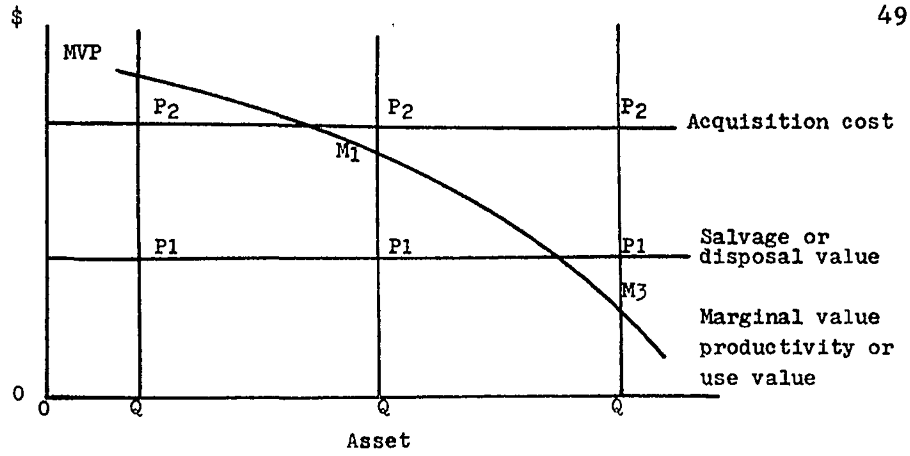

Figure 2: Marginal Value Product Curve

business. Salvage or disposal value is what could be realized from one unit of the asset now on hand, if it were to be disposed of either within or outside the business. Although the acquisition cost and salvage value lines are drawn straight and parallel in Figure 2, they may vary as to level and in relation to each other. Acquisition cost is the marginal factor cost (MFC-cost of an additional unit) if the asset is purchased. Or it is the marginal cost (MC) of producing more of the asset if the asset is produced on the farm. In some instances both MFC and MC are relevant as the asset may be both purchased and farm-produced.

If, as in Figure 2, a farm has a quantity, Q_1, of an asset on hand, that quantity has an MVP of Q_1M_1 which is greater than Q_1P_1 (the revenue realized by salvaging another unit of the asset), and less than Q_1P_2 (the cost of acquiring another unit of the asset). In this case there would be no reason to acquire more of the asset or to dispose of it. The asset is fixed. Its value, under these conditions, is its use value (MVP). In this case the MVP is greater than salvage value and less than acquisition cost. In this situation, the asset is worth more to the farm concerned than if placed on the market, though less than the cost of buying it from the market and getting it to the farm.

If, on the other hand a quantity, Q_2, were on hand, an MVP of Q_2M_2 would result which is greater than Q_2P_2 the acquisition cost. In this case it would be advantageous to acquire more of it. Under these conditions the asset must be regarded as variable. It is unreasonable, however, to value the asset at its MVP, as this value exceeds the price at which the market stands ready to supply additional quantities. One cannot say or assume that the asset is worth more than the price at which one can have it delivered to the business.

To explore the framework still further, what are the consequences of having a quantity Q_3 on hand? Such a quantity would have an MVP of Q_3M_3 which is less than Q_2P_1, its salvage value. In this case, it would be advantageous to dispose of at least a portion of the asset as the market would pay more for it than the business can get out of it. Disposal of part of it would increase its MVP to a level equal to its salvage value. It would be unreasonable to value the asset at its MVP if such is less than its salvage value. The market stands ready to take the asset at a value higher than its MVP and it is worth at least what the market will pay for it.

From a decision-making viewpoint, two of the three cases just analyzed call for reorganization of the business by changing the quantity of the asset used. In the other case, the asset remains fixed even through other changes in the business are called for, such as in the introduction of a technology. Such changes could easily shift the MVP line to the right or left, thus increasing or decreasing Q_1M_1 in Figure 2.

Forage As One of Two Inputs or Two Products

That portion of the frame of reference discussed thus far has dealt with forage as an individual input. When the cost of producing it was discussed, it was considered as a single product It is recognized that the MC of producing forage depends upon the amounts of other products produced and that the MVP of forage depends on the amounts of other inputs. These considerations, however, were not made a specific part of the geometric frame of reference. To do this two additional tools of analysis need to be incorporated.

The first of these new analytical tools is an iso-cost (opportunities) map for two products and/or purchased inputs, one of which is a forage asset. The second is an iso-value product map for two inputs, one of which is a forage asset. The method of analysis used is that currently used in the theory of rotations, plus sufficient extensions to cover (1) the existence of two prices (acquisition and salvage), and (2) the possibility that the asset can be purchased and/or farm produced. The case in which assets can be purchased only is not treated separately.

The first step in presenting this frame of reference is that of developing the iso-cost map. Figure 3 shows all combinations of a forage asset, X_1, and another asset such as corn or a group of assets as grains designated by X_2 obtainable at a series of different costs. As such, it reflects whatever degree of complementarity or competitiveness may exist in the production of the two assets. For instance, the line AB in Figure 3 shows all combinations of X_1 and X_2 obtainable for a given cost from their least-cost source, whether that be the market, farm production or some combination of the two.

The line CD shows all combinations of X_1 and X_2 obtainable at a given cost. Cost in this case is by purchase, as the quantities of X_1 and X_2 are not large enough to be farm-produced at a MC less than their market prices. On the other hand, the combinations of X_1 and

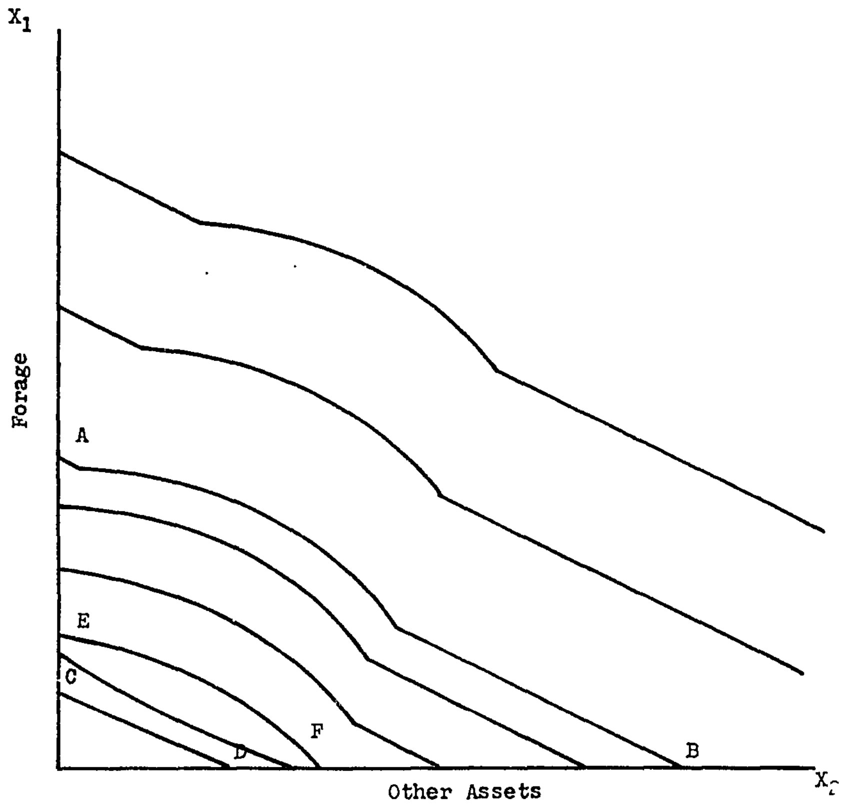

Figure 3: Iso-Cost Map

X_2 obtainable for the cost represented by the line EF are more economically farm-produced than purchased. The line AB is the first of the iso-cost lines in the diagram to represent both farm production and purchases; that is, part of either asset can be farm-produced, but the law of diminishing returns makes it impossible to produce the last units of either as cheaply[2] as they can be purchased. This situation is probably quite common on farms.

The second step in presenting the frame of reference for forage assets as one of two products or inputs is that of developing the iso-value product map. Figure 4 is such a map. All points on each curved line (not converging on H) represent combinations of X_1 and X_2 capable of producing a given gross income or value product. As such, it reflects the degrees of substitutability and/or complementary existing between forage as an input and other inputs.

On each of the iso-value product lines in Figure 4 can be located a "least cost combination" of X_1 and X_2 for a given set of prices for X_1 and X_2. On the iso-value product line, AB, such a point C is defined when the acquisition prices of X_1 and X_2 are used. If the least-cost points for each iso-value product line are connected, an "expansion line," representing the least cost combination for producing any gross income (value product) can be traced out as being the line GKCH. On this line all points satisfy the expansion line condition that:

[2]In terms of direct as well as opportunity cost.

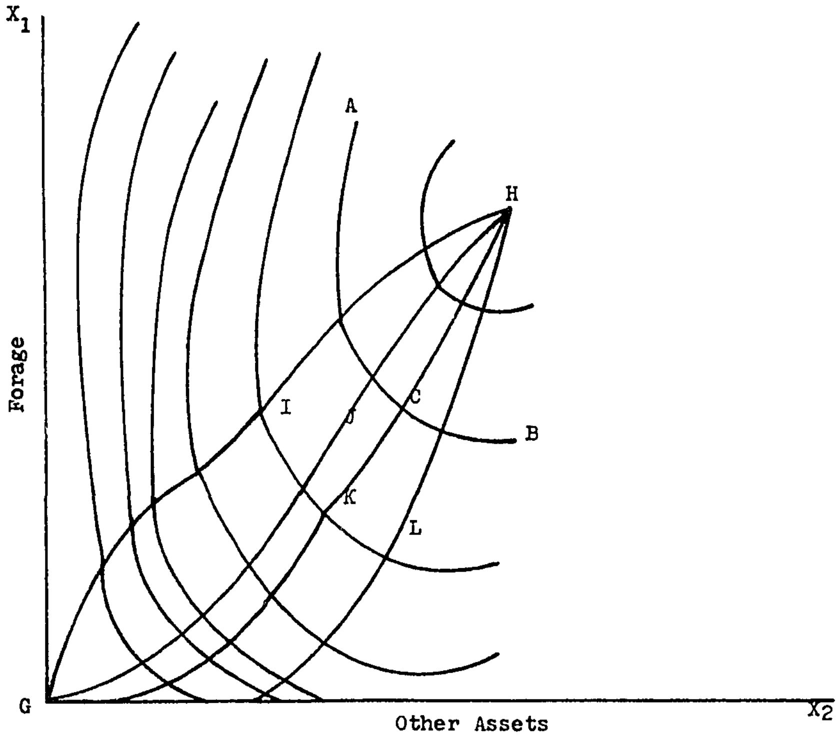

Figure 4: Iso-Value Product Map

$$\frac{\text{MVP } X_1}{\text{acquisition cost for another unit of } X_1} = \frac{\text{MVP } X_2}{\text{acquisition cost for another unit of } X_2}$$

One point on this line is the high profit point--at this point the following condition holds:

$$\frac{\text{MVP } X_1}{\text{acquisition cost for another unit of } X_1} = \frac{\text{MVP } X_2}{\text{acquisition cost for another unit of } X_2} = 1$$

This point is arbitrarily designated to be K and the X_1 and X_2 coordinates defining the point K are the most profitable quantities to acquire.

Three other "expansion lines" of interest can be located in Figure 4. One of these is the line GLH which represents the least cost combination of X_1 and X_2 when X_1 (forage) is valued at acquisition cost and X_2 is valued at salvage value. Another, GJH, represents the least cost combinations of X_1 and X_2 when both are valued at salvage prices. This line is drawn above the line GKH on the assumption that:

$$\frac{\text{salvage price } X_1}{\text{salvage price } X_2} < \frac{\text{acquisition cost } X_1}{\text{acquisition cost } X_2}$$

which is implied by the assertion that transportation and transfer costs are relatively greater for forage than for other assets. The fourth "expansion line" of interst is GIH, which represents the least cost combinations of X_1 and X_2 when forage X_1 is valued at its salvage value and X_2 is valued at its acquisition cost. The points I, J, and L, as well as K, are defined to be the high profit points on their respective expansion lines for their respective sets of prices for X_1 and X_2.

In addition to the four expansion lines in the value product map for two inputs, four other lines reflecting utilization of the forage products are important. These lines are first traced out in Figure 5, an X_1X_2 plane. These four lines equate the marginal value products of X_1 and X_2 with their respective acquisition costs and salvage values.

Thus:

the line OB is the locus of points at which MVP_{X1} = salvage value of X_1 for the different levels of X_2

the line AC is the locus of points at which MVP_{X_1} = acquisition cost of X_1 for the different levels of X_2

the line PF is the locus of points at which MVP_{X_2} = salvage value of X_2 for the different levels of X_1

the line DE is the locus of points at which MVP_{X_2} = acquisition cost of X_2 for the different levels of X_1

At point "I" the MVP_{X_1} = salvage of X_1 and the MVP_{X_2} = the acquisition value of X_2. Hence.

$$\frac{MVP_{X_1}}{\text{Salvage Price } X_1} = \frac{MVP_{X_2}}{\text{Acquisition Cost of } X_2} = 1$$

Therefore, point I lies on the expansion line GIH in Figure 4 and is identical with the high profit point I, previously located on that line in Figure 4. Similar reasoning establishes the correspondence between the J, K, and L points on diagrams 4 and 5. It should be remembered that diagram 4 handles the purchase or farm production of X_1 and X_2

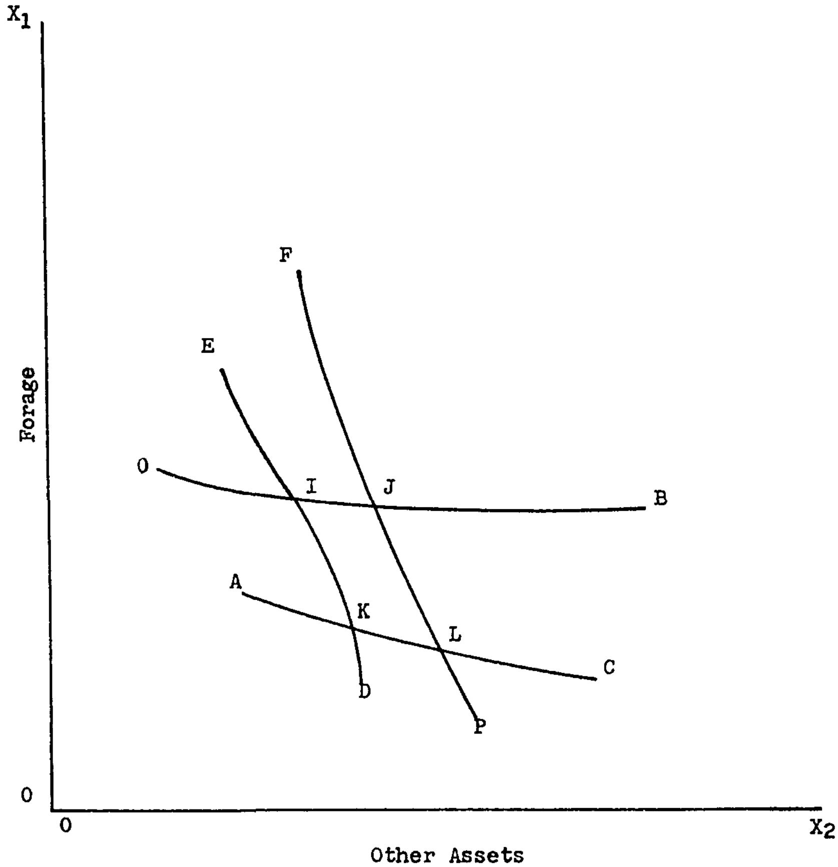

Figure 5: Iso-Value Product Map and Marginal Product Curves

whereas diagram 5 handles their utilization. Establishment of correspondence between points I, J, K, and L on the two diagrams makes it possible accurately to combine them as in Figure 6. Area IJKL constitutes the economic decision region. When regarding a forage asset--X_1--as an individual input and/or product, three alternative responses are found to exist. These are: (1) it is advantageous to expand its use, because $MVP_{X_1} >$ acquisition cost of X_1, (2) it is advantageous to contract its use because $MVP_{X_1} <$ salvage value of X_1, and (3) it is advantageous to leave X_1 fixed as the acquisition cost of $X_1 > MVP_{X_1} >$ salvage value of X_1. In placing a value on the forage it can be seen in the first case that acquisition cost is the appropriate value. In the second, salvage or disposal value is appropriate, while in the third the MVP of forage is the appropriate value.

Use of Frame of Reference in Long Run Forage Evaluation and Decision Making

In long runs permitting the asset to be produced on the farm, managers maximize profits by equating the marginal cost of producing it with the discounted value of its earning power or marginal value productivity. If in the long run the asset must be purchased, managers maximize profits by equating its marginal factor cost with its marginal value producitivity. Cost of production, purchase price, marginal value productivities, and the quantity of these assets produced depend on many partly controllable variables such as variations in price, weather, plant diseases, insect infestations, animal diseases and other biological events. The result is that farm managers often fail correctly to equate the discounted marginal value productivity of durable assets with their marginal factor cost or marginal cost of production.

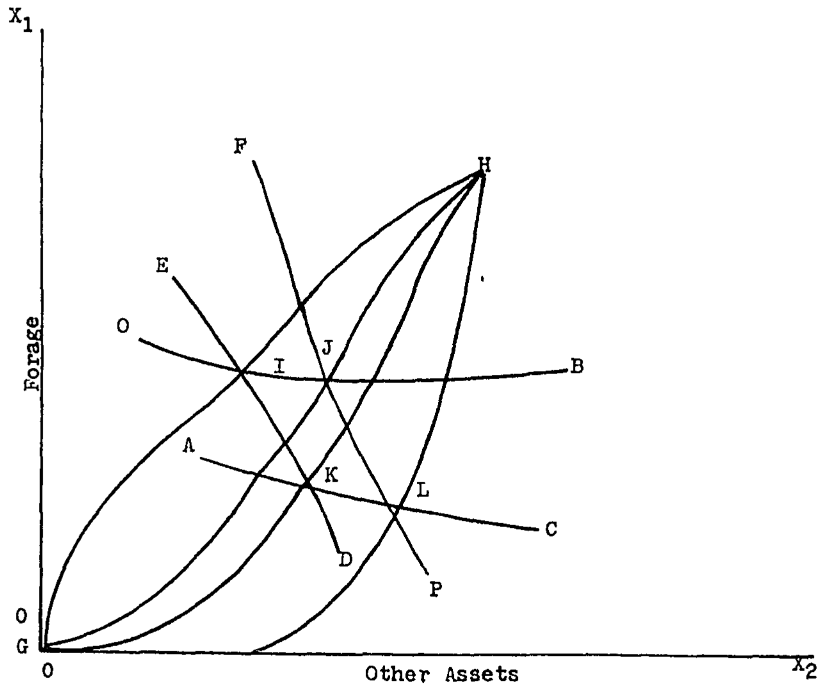

Figure 6: Marginal Value Product Curves and Expansion Paths

Figure 7 applies to a farm with Q_1 acres of permanent bluegrass sod. This hypothetical farm has a quantity (Q_1) of untillable bluegrass sod on hand capable of yielding a series of annual MVP's (primarily feed) per acre which, when discounted, have a present value of Q_1M_1. This value (Q_1M_1) is less that Q_1P_2 (the price of buying more acres of bluegrass sod after allowing for the value of land acquired). Q_1P_2, it is noted, is less than Q_1C_1, the marginal cost of establishing (producing more sod). Thus, it is not advantageous to expand the acres of bluegrass sod by either purchase or production. The salvage value of the sod, SV, is what can be realized on a net basis by disposing of it either by plowing it up or by sale after allowance for the value of land also sold. Thus, residual fertilizer nutrients, soil structure, brokerage fees on land sales, etc., are all taken into consideration in arriving at salvage value. For the farm and land involved, the SV line is drawn low. In reality, this could result from poor quality land which has little use other than in permanent pasture. At any rate Q_1M_1, as drawn, is greater than Q_1P_1 and there is no advantage to be gained in disposing of the bluegrass sod. Hence, it remains a fixed asset--permanent bluegrass sod. The hypothetical situation diagrammed in Figure 7 is believed to be rather typical for farms on which permanent bluegrass sods have persisted over the years. The sod has a value Q_1M_1, which is the logical value to put on it. To value it at less is to underestimate its earning power.

Figure 8 diagrams the situation on a perfectly adjusted farm where a decision has just been reached to establish a stand of Q_1 acres of alfalfa-orchardgrass.

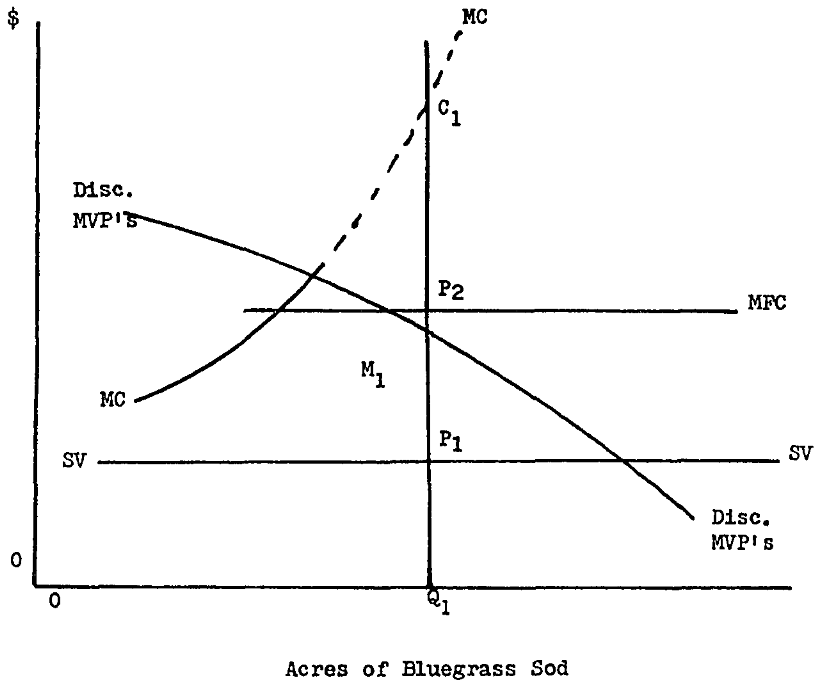

Figure 7: Marginal Value Product Curve for Fixed Bluegrass Sod

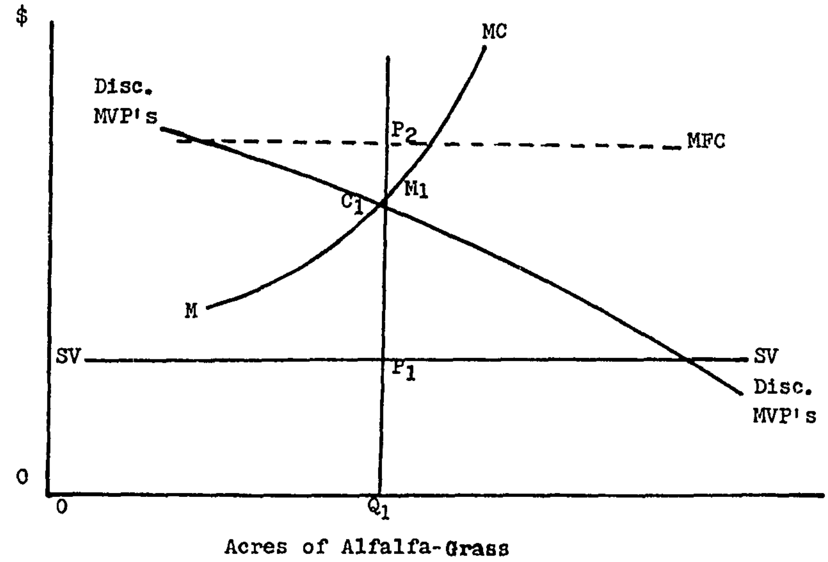

Figure 8: Marginal Value Product Curve for Alfalfa-Orchardgrass Sward

Q_1 acres of alfalfa-orchardgrass are being established. The present value (Q_1M_1) of the future annual MVP's which this stand will produce (both feed and fertility) is equal to Q_1C_1, the marginal cost of producing the last acre of alfalfa-orchardgrass. It would not pay to produce more acres. Nor, (as Q_1P_2 is greater than Q_1C_1) would it pay to buy more acres. Neither would it pay to dispose of any part of the stand, once it is on hand, as its salvage value (SV) is less than Q_1M_1. In this case, an acre of alfalfa-grass is valued at $Q_1M_1 = Q_1C_1 = MC$.

Four years later, however, the picture may be entirely different with respect to what is left of this stand of alfalfa-orchardgrass (Figure 9).

The use value (present value of the remaining MVP's of the stand) has dropped below what it was when the stand was new. Q_1M_1 is now less than SV which has increased as a result of nitrogen fixation, the development of improved soil structure and humus accumulation. As diagrammed, Q_1P_1--the salvage value--exceeds Q_1M_1, the value in use. Hence, it is advantageous to dispose of at least a part of the stand--probably by plowing it down for production of a crop (such as corn) which will effectively utilize the nitrogen, improved soil structure and humus. Here Q_1P_1, which is a salvage value, is the appropriate value to use as it is greater than the MVP of Q_1M_1.

The situation that may be developing on level rich corn belt farms with commercial nitrogen available can be diagrammed as in Figure 10.

In this instance the salvage value of any set of resources tied up in forage stands may be greater than the discounted value of the stream of MVP's which would be produced. In such instances forage stands would be omitted from the rotations.

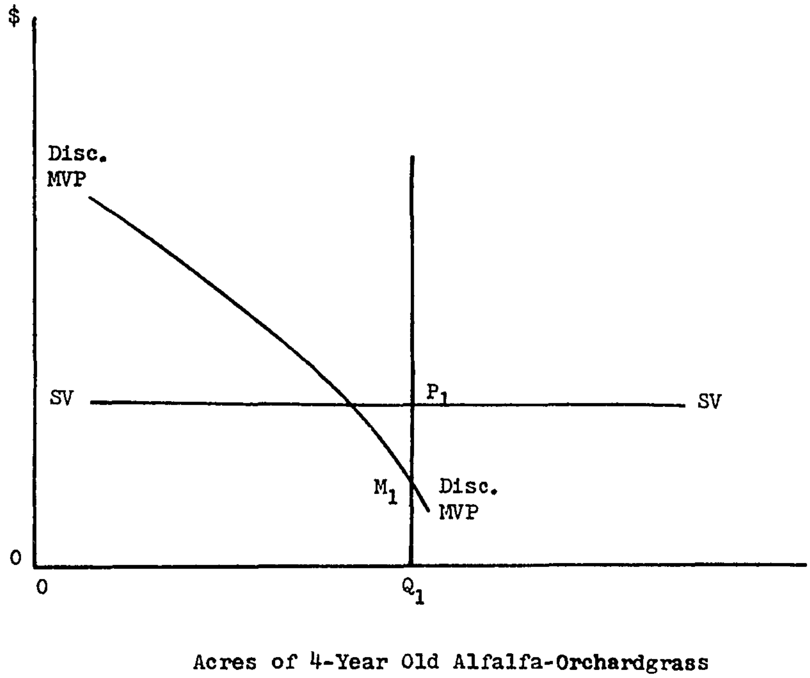

Figure 9: Marginal Value Product Curve for 4-Year Old Alfalfa-Orchardgrass Sward

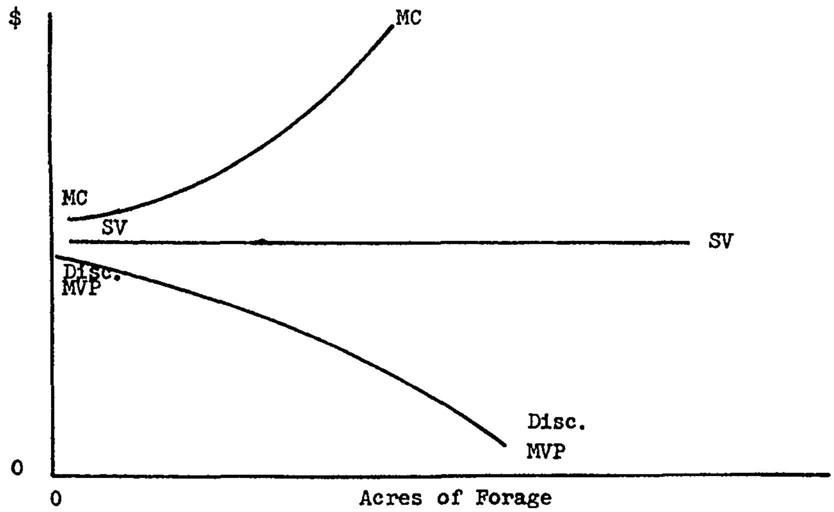

Figure 10: Forage Marginal Value Product Curve with Nitrogen Available

<u>Estimating Dollar Values in Long-Run Situation</u>

In the long-run situation the farmer needs estimates to help him decide whether to expand, contract, or leave his forage acreage unchanged. On a farm of given acreage, three values are pertinent in deciding to expand, not to expand, or to contract. First, the cost of additional acres of forage stand (MC) is needed. This is the direct plus the opportunity cost with the opportunity cost frequently becoming the most important consideration.

Second, estimates of disposal or salvage value are needed. This may be established as a net sale value of the stand or the opportunity cost of using the forage-producing resources for an alternative crop--whichever is higher. Use of accumulated fertility is reflected in the potential yields of alternative crops, hence it is included in the salvage value. Third, estimates are required of the discounted MVP's of the forage stand. This is an estimate of the current worth of the series of MVP's the stand will produce during its life. Both feed and fertility contributions are included.

In the short-run situation, feed inputs and crop outputs (products of stand) were valued after a given acreage is on hand. Opportunity costs are not considered because, in effect, no alternative cropping opportunity existed. Use of land is already committed and it is too late that year to change.

Looking ahead to forage values in coming years, opportunity cost often enters into both the acquisition and disposal values. If the discounted MVP of a forage stand is only $30 while the salvage value is $60 (the probable net return from using the resources for corn), the farmer will probably contract his forage and increase his corn acreage. Conversely, if the discounted MVP of an acre of new forage stand were \$90 and the acquisition cost (including opportunity cost) \$70, the farmer probably would expand his forage acreage.

Summary

Investments in forage stands yield joint products: (1) feed, and (2) fertility factors. A forage stand, unlike an annual crop, is a semi-durable asset. This stand is capable of yielding its joint products annually over a period of years.

While acquired at substantial cost, the stand may have almost a zero sale value. Earnings through use may be substantial. And because of high handling and transportation costs plus imperfections in the market, considerable spread exists between the individual farmer's purchase and sale prices for pasture or hay.

The framework for economic evaluation as developed suggests that the value of forage be:

1. Not less than the highest net value realizable by disposal -- salvage value.

2. Not more than the cost of acquiring by the most economical means available additional forage units or their equivalent -- acquisition.

3. The value through use -- marginal value product -- if this value falls between the limits of 1 and 2 above.

Situations in which each of the above values are appropriate were described.

Dollar values resulting from the computations suggested in Table 7 meet the requirements for pricing one-use assets -- forage as a feed input

Table 7: Suggested Methods of Estimating Three Different Values of Forage and of Forage Stands

Kind of value		One-use assets-Forage acreage fixed		Durable assets-Forage acreage variable
		Treated as feed input	Treated as crop output	
Salvage or disposal values	Off-farm	Cash pasture rental less value of N, P, K carried away by grazed animals. Cash receipts for sale of standing hay less value of N, P, K removed.	Feed value plus credit for above- and below-ground fertility contributions.	Net sale price of land seeded to forage stands less value of bare land and non-forage improvements.
	On-farm			Opportunity cost of using forage resources for alternative crop.
Acquisition values	Off-farm	Cash paid for pasture rental plus charge for inconvenience (location). Purchase price of equivalent in hay or substitute feed less credit for N, P, K acquired	Feed value plus purchase price of crop's net fertility contribution.	Gross purchase price of land seeded to forage stands less value of bare land and non-forage improvements.
	On-farm	Direct cost of cultural practices to produce additional feed units from existing stands. Direct plus opportunity cost of producing additional feed units from emergency crops. Direct plus opportunity costs of converting existing nonforage crops to forage uses.		Direct plus opportunity cost (MC) of establishing additional acres of forage stands on the farm.
Marginal value products		MVP of forage as used by livestock.	MVP of forage as used by livestock plus discounted MVP of forage's fertility contributes to succeeding crops.	Discounted MVP of forage stand considering feed, above- and below-ground fertility contributions.

or crop output in a single year, quantity of stand fixed. Dollar values suggested by the third column are useful in deciding whether to expand, contract, or leave the forage acreage on the farm unchanged. These latter values must be estimated in advance of the crop planting season, not after the crop is produced or fed. Potential returns from using resources for crops other than forage enter the values in the third column as opportunity costs in both on-farm disposal and acquisition possibilities.

Going a step further, rotation theory with forage as one of two inputs or two outputs is extended to cover (1) the existence of two prices (acquisition and salvage), and (2) the possibility that the asset could be purchased and/or farm produced.

From a decision-making point of view, the income effect of changes in acreage and utilization of forage may be determined by budgeting. While the budgeting process seldom yields definable values for forage as such, properly applied it should lead the farmer to much the same answer as the previously discussed decision-making process. Practical farm managers have long recognized this fact in successfully using budgeting to solve problems of this type. As the management profession develops, productive and promising methods of estimating MVP's for inputs are being applied. As the products of further studies materialize, more and more precise use values for forage will be available to agriculturists.

Much remains to be done empirically, and this rests on the development of more comprehensive sets of production relationships.

CHAPTER III

METHODOLOGY

Procedure

The beef cow-calf production process is an inefficient conversion of nutrients into salable meat.[1] For the conversion process to be profitable, nutrients must be produced efficiently and at low cost, relative to the value of the salable product.

Production specialists in forage and animal production by definition focus their attention on specific problems. New practices and procedures in feed nutrient production are constantly being evaluated by agronomists. They define cultural methods for satisfactory production; and they determine amounts and timing nutrients can be produced by different species with varying input levels.

Animal scientists measure the conversion of nutrients into meat. They are concerned with quality, quantity, and schedule that nutrients are required for efficient conversion into beef. They develop husbandry practices to complement feeding practices.

The economist can combine the input-output responses derived by agronomists with livestock conversion requirements defined by animal scientists into an economic input-output response which minimizes input cost consistent with a maximum profit level of output.

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[1]Earl W. Klosterman, et al, "Total Feed Efficiency of Beef Production by Cattle of Different Sizes and Breeds," Better Beef Business, Vol. 14, No. 3, Shawnee Mission, Kansas, January, 1973.

Specifically, several alternative forage production programs representing varying degrees of intensity will be combined with several alternative beef cow-calf production systems. An optimum combination, defined as the one yielding maximum profit, will be identified and evaluated.

Alternative summer forage programs considered are: (1) improving existing bluegrass sod with fertilizer application, (2) seeding fescue, alfalfa, or orchard grass swards for overall and/or rotational grazing, (3) purchase additional land.

A winter feeding program will supplement each summer regime. Conventional baled hay stored in a barn and hauled out for feeding will be compared with winter grazing of fescue swards where the early growth is round-baled and stored in the field. Purchased corn or hay can supplement energy needs at any time. The respective combinations are listed in Table 8.

The resource inputs and product outputs associated with each forage production enterprise will be estimated. Inputs for each improvement practice will be classified into both an establishment category, requiring capital investment, and a maintenance category, expensed annually. Yields will be estimated in terms of monthly total digestible nutrient (TDN) production. Thus forage alternatives will use land, capital, and labor while producing a supply of nutrients for livestock.

Cows and their calves are nutrient users. Monthly TDN requirements will be defined consistent with cow size, milk production, calf growth rate, and date of calving. The assumption is made that use

Table 8: Alternative Summer Pasture Programs,
Southeastern Ohio, Sandstone Area, 1973

1. Native bluegrass
2. Improved bluegrass
3. Tall fescue
4. Orchardgrass
5. Alfalfa-grass mixture rotationally grazed all season
6. Buy land

<u>Alternative Winter Program</u>

1. Conventional baled hay
2. Tall fescue round baled

<u>Optional Use Procedures</u>

1. Graze current growth
2. Field store excess growth on stump
3. Barn store excess growth in square bales for deferred feeding

value of forages exceed market value; no attempt is made to put a direct monetary price on value of grazing. Livestock nutrient requirements will draw directly from forage outputs. Cost of feeding livestock will be determined by what it costs to produce forage. Relative profitability of each forage alternative will be calculated.

Any forage improvement practice that increases carrying capacity and allows herd expansion must also provide the additional animals to consume the additional forage. Actually, the situation works in the opposite direction. When the value of increased livestock production is sufficient to cover improvement costs, the improvements are made. The marginal value product from additional forage production sold through the calves is compared to forage production costs. If marginal value product is greater than cost, improvements are instigated.

The cow production alternatives will be: (1) straight British breeding, (2) crossbred British cows mated to fast gaining sires, and (3) heavy milking dairy or dairy crossbred cows mated to fast gaining sires. Calving dates will include both fall and spring alternatives. The pertinent aspects of the system are summarized in Table 9.

The forage-livestock combination chosen will not necessarily be the lowest cost nor most efficient. It will be the most profitable combination, however.

Table 9: Cow Production Systems

Process	Cow Breeding	Cow Weight (lb.)	Calving Season	Marketing Date	Weaning Percentage	Average Weaning Weight Per Calf (lb.)
P_1	British X British	1000	March 15[a]	Nov. 15	88	450[b]
P_2	British X British	1000	Nov. 15[a]	Sept. 15	88[e]	550[b]
P_3	Charolais X British Crosses	1100	March 15	Nov. 15	92[e]	520[c]
P_4	Charolais X British Crosses	1100	Nov. 15	Sept. 15	92	630[c]
P_5	Charolais X Dairy Crosses	1200	March 15	Nov. 15	92	590[d]
P_6	Charolais X Dairy Crosses	1200	Nov. 15	Sept. 15	92	715[d]

[a]No difference in gain rate between seasons. (E.G. Morrison, Dates of Calving in a Beef Cattle Management Study, Bulletin 623, (State College: Mississippi State University Agricultural Experiemtn Station, June, 1961)

[b]1.60, [c]1.85, [d]2.10, Average daily gain birth to weaning , in pounds per day.

[e]Heterosis effects upon weaning percent. (L.V. Cundiff, "Experimental Results of Crossbreeding Cattle for Beef Production," Journal of Animal Science 30:694 (1970).

Technique

Linear programming is an appropriate and useful technique for selecting an optimum production system. It is a formalized budgeting process which assures selection of the most profitable production organization, given the assumptions of the model (Appendix B). Linear programming is a mathematical method of simultaneously solving a set of equations which allocate scarce resources among alternative production activities. It maximizes output advantageously with all other productive units until the supply of some needed resource or its substitute becomes limiting. The activity or combination of activities yielding the greatest marginal output per unit of the most limiting resource is selected.

Linear programming requires statement of an objective function and two types of resource information: (1) resource requirements of each alternative activity or process (the a_{ij} values) specified, and (2) initial quantity of resources which may become limiting (the b_i values).

The programming model can be modified in four ways: (1) altering resource restrictions (b values), (2) increasing or decreasing number of admissable production activities or processes (X's), (3) changing the costs or returns per unit (c_j's), and (4) varying requirement or production coefficients (a's). In order to determine the effect of a given change in any a, b, c or x value upon the optimum enterprise combination, profits, or production, all other data must remain unchanged.

Capital Rationing

The method of matrix construction can cause the solution to answer specific questions. For example, given that a set of resources and a production exists, an operator may desire to know what rate of return he can expect from a capital expenditure which increases production.[2] A capital rationing model is an appropriate tool for investigation of this question.[3] Since beef cow herds are capital intensive, the availability of investment capital has a profound effect on the optimum organization. A systematic scheme for determining alternative capital levels allows the optimal system to change as capital levels change.

For purposes of this analysis, capital rationing exists when the amount of capital available to the competetive firm is less than the amount which would equate marginal value product (MVP) of capital with its price. Capital available to the firm for investment in productive enterprises may be limited by (1) forces external to the firm (external rationing by lenders), and/or (2) factors internal to the firm (internal rationing by the operator).

In this study, alternative absolute levels of capital availability are to be determined by requiring alternative prices for capital.

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[2]This assumes added production requires added cost or investment.

[3]Alfred L. Barr and James S. Plaxico, Optimum Cattle Systems and Range Improvement Practices for Northeastern Oklahoma: Static and Dynamic Analysis, Miscellaneous Publication 62 (Stillwater: Oklahoma State University Experiment Station, July, 1961) p. 4.

This is accomplished by assuming that the enterpreneur is willing to invest capital, and lenders are willing to lend so long as returns exceed the selected rate. Assuming that the law of diminishing returns holds, the quantity of capital that can be profitably used increases as the preselected rate is lowered (Figure 11). The marginal value product for capital utilized with a fixed set of other resources is represented by the curve, AB. If the rate of return selected is OR_1, the amount of capital which will yield a return equal to or exceeding this rate is OC_1; at a lower rate OR_2, a larger amount, OC_2, of capital will be used. If OR_3 represents the external or market rate of interest, then OC_3 is the maximum amount of capital which could be utilized by the operator as none would be available at a lower rate. Thus, at different rates, the marginal value product shows the amounts of capital which the enterpreneur will use per production period.

With capital restricted in the manner mentioned, only those activities returning a rate equal to or greater than the predetermined rate are included in the programmed optimum. A given improvement practice appears as an activity in the optimum program only if its return, as measured in terms of value of beef produced with an optimum system, is equal to or higher than the selected rate. The optimum beef system and the profitability of various forage improvement practices can thus be simultaneously determined for each selected rate of return or level of capital restraint.

With a high predetermined rate of return, capital is restricted to the extent that returns exceed this rate. As the predetermined

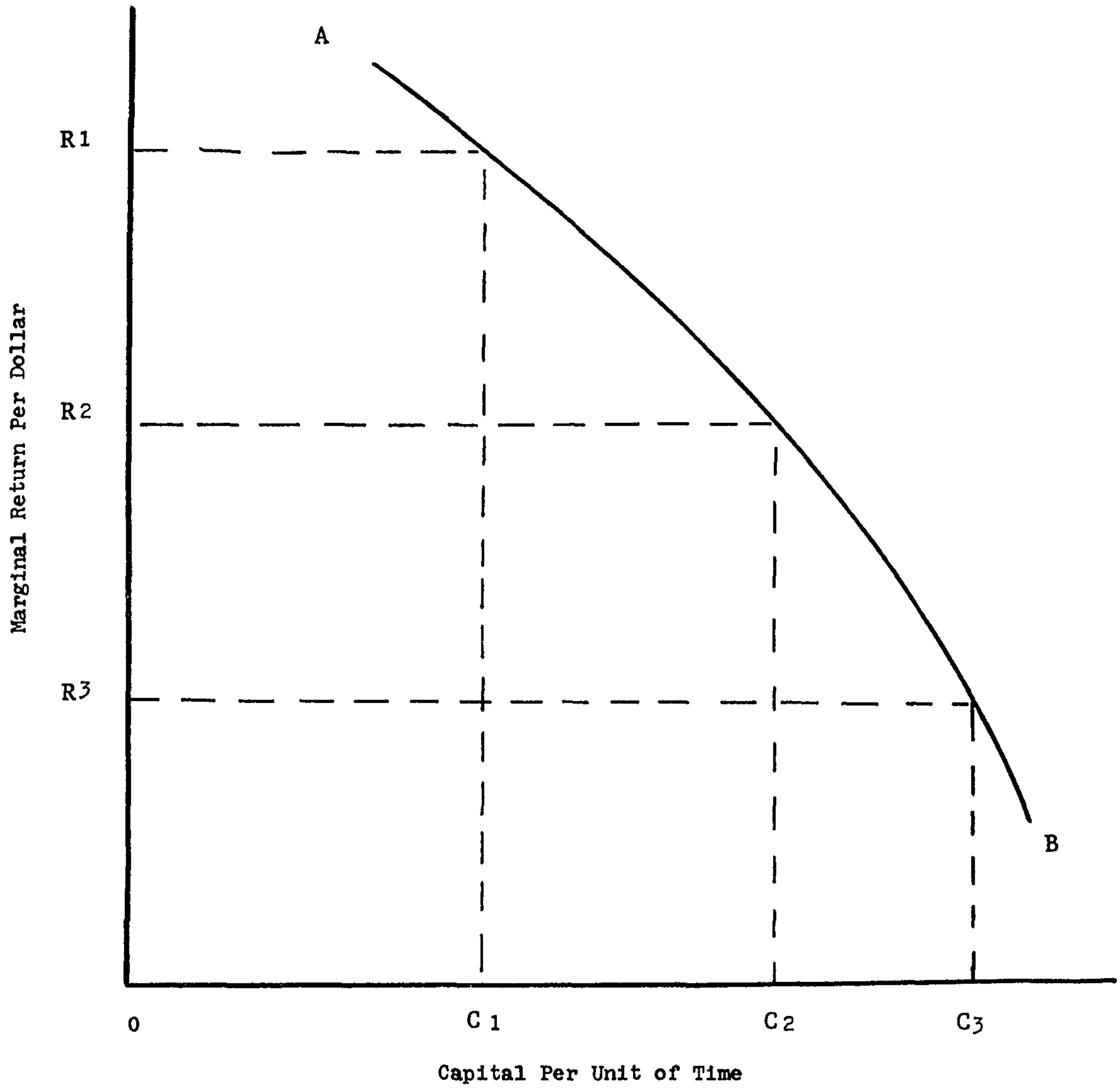

Figure 11: Marginal Value Product Curve For Capital

rate is lowered, use of more capital is profitable and land yielding lower returns is brought into production. This continues until all land is brought into production, first, in the production of enterprises yielding a high return to capital and a low return to land, and then as the required return is lowered further, it becomes profitable to shift to alternatives yielding a low return to capital and a higher return to land which becomes the scarce resource.

In this study it is assumed that the total amount of capital used during the year establishes the capital restraint. Thus the programming model is formulated so as to require the predetermined MVP rate on all capital used regardless of the length of period that the capital is actually employed. This assumption appears to reflect existing institutional lending practice.

Since capital can be borrowed for long-term projects at a lower rate of interest than can capital for short-term uses, a differential of three percent is assumed between the two rates. Thus, if a rate of five percent is assumed for long-term loans, then the rate for short-term loans is assumed to be eight percent. These two rates, five percent and eight percent, are used as external rates.

Period Transfer

Forage production patterns do not fit nutrient requirement patterns of livestock over time. The LP matrix must be so constructed to allow requirements be met but excess feed be minimized.

In practice, either stocking rates must be limited to the minimum forage production period or supplemental feed be provided. Forage growth can be field stored on the stump, harvested as hay in a conventional manner, or harvested as hay for field storage. As livestock requirements exceed current production, these storage sources can be called upon to provide nutrients.

It is often the practice in LP work to define a rotation as a single activity. In a forage production study, this "rotation" concept could be an acreage, productivity, and/or grass species combination which meet livestock requirements in the least productive period.

Rather than rely on a defined "rotation," this study investigates the input combination within the linear program model. This procedure requires development of a Period Transfer Activity. Given various alternatives by which forage growth can be transferred from one period to another, Period Transfer requires an activity which allows excess production in one period to flow into the second, or subsequent period, for consumption. Both first and second period production can flow into a third period and so on for as many periods as desired or is economically feasible.

Transfer from one period to another does not occur with zero cost. Forages stored on the stump have only a small direct time cost of deferral (interest), but they do have losses in quality and yield potential. Grasses become mature, nutrients leach out, and total production is less if grasses are allowed to mature. Rather than transfer from period to period on a 1:1 basis, yield values in subsequent periods must be discounted.

Another alternative for period transfer is harvesting the growth as hay to be fed later. This method preserves quality and quantity factors, but entails significant direct costs of harvest. Hay production is generally considered the method for providing winter feed and is not practiced as a method of summer deferral. This model will allow the latter process if it is economically feasible.

Purchase hay or purchase grain activities creates an alternative source of nutrients. Should either of these activities be more economical than production of home-grown forage sources, they can provide nutrients required.

The model in general form is presented in Figure 12. Specific coefficients for discounting the deferral or the direct costs of harvest may be gleaned from the matrix on page 115.

Sources of Data[4]

In any analysis, accurate data are all important. There are three possible sources of data: surveys, production experiments and synthesis. Each of these methods has particular advantages and limitations and therefore, depending on the problem one, two, or all three sources may be used.

Production experiments enable the control of non-random variables. Valid comparisons of such factors as feed conversion and rate of gain

[4] This discussion was adapted from: John E. Kadlec, "Production Management Research for Farm Decision Making," Journal of Farm Economics, Vol. 46, No. 5 (December, 1964) pp. 1172-78.

Figure 12. Schematic Presentation of Period Transfer Portion of Model

Period	Nutrient Users		Grass Production Alternatives		Period Transfer			Hay Production Alternative		Buy Hay	Buy Corn	Nutrient Transfer			
	a_1	a_2	b_1	b_2	1	2	3	c_1	c_2	d	e	1	2	3	4
1	a_{11}	a_{12}	b_{11}	b_{12}	1							-1			
2	a_{21}	a_{22}	b_{21}	b_{22}	1	1							-1		
3	a_{31}	a_{32}	b_{31}	b_{32}		-.9	1							-1	
4	a_{41}	a_{42}	b_{41}	b_{42}			-.8								-1
Nutrient Pool								$-c_1$	$-c_2$	$-d_1$	$-e_1$	1	1	1	1

from farm observations would be difficult or impossible because a number of uncontrolled variables (breeding, ration, season, practices, etc.) are confounded with housing system, and the variation due to these factors makes it difficult to isolate the effect of housing, for example.

On the other hand, while control is an advantage, it may also be a disadvantage since the interaction of controlled variables is not determined. To measure the interaction of controlled variables might require a production experiment so complex that it would be impractical. Hence, farm surveys may be used to give insight into the effect of variation in factors held constant in the production experiment. Farm surveys may also provide more accurate estimates of variables such as labor used, rate of building depreciation, and prices because a greater number of observations can be secured for each practice or system being compared.

This production management study is concerned with economic evaluation and organization of new technologies. Farmers need information about the effect of these technologies before they are common on farms.

Production management or experiment or synthesis are the only ways that many of these technologies can be evaluated at a relevant time as there are few, if any farms to survey. For certain types of problems or aspects of a particular problem, data has to be constructed by researchers from related experiments or surveys, specifications by manufacturers of an input, or scientific knowledge.

The chief advantage of this method is a saving of time and money. Certain problems may be solved with synthesized data as the only source of data. Synthesized data may be very effective in some cases but can lead to errors in others. Certain events may occur in practice while they may not be expected from theory. An interdisciplinary contribution of ideas to data evaluation will greatly increase the odds of these systems being physically and economically feasible.

Limitations

Income maximization is assumed to indicate the most desirable farm organization. It is recognized that goals of leisure, recreation, participation in social activities and non-monetary satisfactions are part of the "income" enjoyed; but they are not included in this study model.

The management level assumed is high, reflecting performance of the upper quartile of producers. Successful operators must be able to manage large capital investments and to handle complex production operations. Calculated returns can be discounted to adjust for other levels of management.

The land resource base is representative of much of the Appalachian region of the U.S.A. A specific land base will be defined. Seldom does a single farm conform to such a definition. Answers generated from the study should provide a frame of reference for evaluating a specific situation, however.

A beef cow-calf herd is the only livestock enterprise considered. Other livestock enterprises may compete for use of existing resources;

but emphasis here is upon organizational optimization for beef calf production.

Forages are the only crop enterprises considered. Alternative species and harvest systems are deemed feasible for the region. Price relationships between value of product produced and production input costs determine when adoption occurs, rather than agronomic feasibility.

Optimum organizations defined will be as valid as the technical input-output coefficients. Most coefficients will be developed from Experiment Station research on individual situations, not total production systems. It is recognized that such coefficients are assumed to be compatible. Experience from farm situations and consultation with agronomists and animal scientists are necessary to insure validity of this assumption.

Partial budgeting will be used to define input-output points on production possibilities curves. It is recognized that "average" coefficients have a probability distribution of variability about them. Hopefully, the coefficients selected are mean values and the dispersion is narrow. It is further assumed that the coefficients are valid over the span of the linearity assumption of linear programming. Variations in performance are thus recognized but were not evaluated in this analysis. Nor are the effects of risk and uncertainty evaluated, though they are known to exist.

CHAPTER IV

RESOURCE SITUATION, BUDGETS, AND COEFFICIENTS

General

The initial resources designated as fixed were operator and family labor, land, and a machinery complement. Capital limitations and requirements were determined within the solution. Net return was computed to owned factors: machinery, labor and management, and land. Individual returns to these factors or profit could be calculated by subtracting the opportunity value for the other specified resources from the net return figure.

Labor

Labor restrictions were based on the assumption that the permanent labor force was limited to operator and family labor. Each quarter, 600 hours were assumed available. This supply was drawn upon for performing husbandry jobs for the beef herd and producing forages. In the spring, it was used to fertilize forages, repair fences, and manage cows; in the summer, to mow, rake, and bale hay, clip pastures and inspect cattle; in the fall for constructing temporary fences and managing cows. Winter jobs used operator labor to feed and manage calving.

Labor had to be hired to haul and store hay for conventional hay making activities. It was assumed that 600 hours would be available for use during hay making periods. The wage rate initially selected was $2.00 per hour. The productivity rate was one man hour per ton.

Land

All land in the initial resource situation was assumed owned. A definition of the land base was derived from a survey of beef producers completed by Dr. John Sitterley in 1972 as part of this project. The object of the survey was to interview producers in southeastern counties with herds of 100 cows. All farm operators that could be identified with about 100 cows, or larger herds, were interviewed. Selected data are presented in Table 10. The farms averaged almost 800 acres; however, only 4 percent of the land was devoted to intertilled crops or small grain. An additional 22 percent was in forest, leaving 74 percent of the farm, or 600 acres, in meadow or pasture production mainly for the cow herd. With an average herd of 75 cows, the stocking rate was approximately 8 acres per cow.[1]

The existing land uses and assumed potential uses for the study are listed in Table 11. It was assumed that cropland, meadow, rotation, and open pasture land could be devoted to the forage production alternatives considered. Brushland and woodland could be used likewise after it had been cleared. Forest and other land uses could not be changed, however. No intertilled crop production was considered. Small acreages made cropping uneconomic in view of machinery requirements. Historically crop production outside the river bottoms has almost disappeared.

Alfalfa production could have been carried out on cropland plus one-half the meadow land (Class A quality, 80 acres). Twenty percent

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[1]An exact calculation is difficult because some farms had a ewe flock (usually insignificant numerically) and some operators grazed steers (either their own or purchased) during the summer.

Table 10: Characteristics of Large Beef Cow-Calf Farms, Southeastern Ohio, 1972

Item	Noble County acres		Guernsey County acres		Jackson County acres		Aggregate		
								acres	%
Number of farms		18		9		7		34	
Total Farm		850		995		506		791	100
Owned	514		594		491				
Rented	335		401		15				
Cropped land, total		21		65		23		33	4
Corn	18		44		21				
Soybeans	1		11		0				
Small grain	2		10		9				
Meadow, total		125		102		84		110	13
Cut 1 time	94		89		37		81		
Cut 2 times	21		13		42		23		
Cut 3 times	10		0		5		6		
Pasture, total		526		611		261		494	61
Rotational	29		32		34		31		(42)
Open	310		380		203		307		
Brush	135		139		1		108		(13)
Woodland	52		60		23		48		(6)
Forest		176		215		131		177	22
Other		2		2		7		2	
Number of cows		61		94		88		75	
Total pasture per cow	8.63			6.50		2.96		6.57	
Rotation and open	5.56		4.38		2.69				
Brush & woodland	3.07		2.12		.27				
Acres hay per cow		2.06		1.08		.95		1.57	

Source: Primary data collected by Dr. John Sitterley in Autumn, 1972.

of the pasture had to remain in bluegrass because of topographic limitations (Class C quality, 100 acres). Cropland, meadow, and 80 percent of the pastureland could be devoted to orchardgrass or fescue production (Class B quality, 300 acres). Both brushland and woodland could be utilized as Class B or C after clearing

Table 11: Current Land Use and Assumed Potential Uses

Current Land Use	Acres	Potential Uses[a]	Acres
Cropland	33	Class A	80
Meadow	110	Class B	300
Pasture	338	Class C	100
Brushland	108	Class B or C	100
Woodland	48	Class B or C	50
Forest	177		170
Total	814		800

Source: Primary Data collected by John Sitterley, Autumn, 1972.

[a]Class A may be used to produce alfalfa-meadow, orchardgrass, fescue, or bluegrass; Class B cannot be used for alfalfa-meadow, but all others are possible; Class C can be used for bluegrass only.

Land Development

Land development practices of brush removal and land clearing were investigated in this study. Two degrees of infestation were assumed: brush land had scattered bushes up to 3 inches in diameter, woody brush had dense, non-timber trees up to 12 inches in diameter.

A crawler tractor and bush hog could remove the smaller growth; a larger bulldozer was required to clear the heavy infestation.

Two sources of data provided a basis for developing land clearing budgets. In 1969 cooperatives were formed in several southeastern Ohio regions for purchase of equipment for custom clearing and seeding. Charges assessed and rates of performance were gleaned from Agricultural Stabilization Program records in two counties where farmers using the services had applied for cost sharing assistance.[2] The second source was EORDC experience.[3]

Magnitude of costs were highly variable depending upon degree of ground cover and upon the system of clearing utilized. The attitude toward level of corrective fertilization differed also. ASCS reported 3 to 5 tons of lime, 150 pounds of P_2O_5, and 40 pounds of K_2O needed to be applied. EORDC land tested nearly the same levels of pH (5.4 to 6.0), P_2O_5 (5 to 25 pounds) and K_2O (120 to 400 pounds), but corrective applications were 2 tons of lime, 46 to 92 pounds of P_2O_5 and generally no K_2O. Soil tests from EORDC six years later showed the soil to be generally in the range of 6.5 pH, 25 to 50 pounds P_2O_5 and 300 to 400 pounds of K_2O.[4] EORDC results indicate that lower levels of application provide satisfactory results. The EORDC data was used to

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[2]Unreported data collected by John Sitterley.

[3]T.F. Wonderling, C.B. Boyles, and D.R. Miskell, "Rehabilitation of Land in Southeastern Ohio," Ohio Report, 52(4) (Wooster: Ohio Agricultural Research and Development Center) July-August, 1967, pages 62-63, and field sheets of practices secured from R. W. Van Keuren.

[4]Primary data from field sheets provided by Dr. R.W. Van Keuren.

provide fertility coefficients for this study. EORDC costs were updated to 1973 cost levels where prices have changed. Results of the survey and field work are reported in Table 12.

Buy Land Option

To investigate whether there was sufficient incentive for expansion of a farm operation by consolidating units, the option to purchase land was included in the linear program matrix.

Data collected by Dr. Sitterley[5] from aerial maps of areas in southeastern Ohio identified three prevailing quality groupings. The criteria for identification were Land Capability Classes, according to Soil Conservation Service definitions, and land use categories of cropland, permanent pasture, forest, and other. From this data a breakdown by land quality is defined in Table 13.

It was assumed that a farmer in the area could purchase land represented by one or all three qualities defined. Inclusion of these options in the LP matrix allowed determination of rates of return, at various purchase prices, that could be expected from investment in land for expansion of a beef cow herd.

Machinery

Economic scale of operation of machinery for a unit of 200 to 800 acres in size was assumed. The farm had a machinery complement as defined in Table 14.

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[5]Sitterley, unreported primary data.

Table 12: Land Clearing and Fertilization Costs Per Acre
Southeastern Ohio, 1973

Operation	Unit	Belmont Co.[a]	Muskingum Co.		EORDC[b]	
		Survey and Field Results				
Lime	tons-5	$31.50	3.2	$25.00	2	$14.00
Fertilizer	lb.	12.00		14.00		5.60
N	30		30		0	
P	150		150		60	
K	40		40		0	
Bulldozer	a.	98.00		57.00		30.75
Brush Hog (tractor & operator)	a.	n.a.		13.00		98.50
Land Preparation	a.	8.00		n.a.		n.a.
Seed	a.	5.00		5.00		6.00
Seeding	a.	n.a.		n.a.		12.75
Fencing	a.	n.a.		n.a.		6.40/rd

Budget Costs Used in LP Model, per acre

Operation	Openland	Brushland	Woodland
Bulldozer & prep. land	--	--	$100
Bush hog		$10	--
Lime	$15	15	15
Fertilizer	6	6	6
Seed	6	6	6
Seeding	13	13	13
Fencing	--	(repair) 30	(build) 60
Total investment	$40	$80	$200
Annual charge, prorated 10 years.	$ 4	$ 8	$ 20
Annual charge, omitting fertility, 10 years	$ 0	$ 4	$ 16

Source: a. Survey data collected by John Sitterley in Autumn, 1972.
b. Wonderling, "Rehabilitation."

Table 13: Land Quality and Use for Programming "Buy Land Option"

Use Designation	Quality		
	High	Medium	Low
	acres	acres	acres
Class A	30	10	5
Class B	14	20	11
Class C	11	21	19
Brush	10	7	4
Woodland	4	5	5
Forest	31	37	56
Total	100	100	100

Source: Primary data developed by Dr. John Sitterley in an attempt to stratify land groupings by Quality Classes as part of farm adjustment study.

Variable costs of operating owned machinery were included in each budget to reflect use; fixed charges were costed as an aggregate charge against Net Returns. Preliminary budgets showed low usage of a disc and drill caused fixed cost of these items to be excessively high. Thus, it was assumed that either the operator would do custom work to lower their unit cost of operation or as size of farm increased the machines would become economical. Whereever use of them was required they were charged in at custom rates.

Capital

Investment capital had to be acquired for purchase of livestock and forage improvement practices; operating capital, for annual expenses. It was assumed that capital would be available up to the amount at

Table 14: Machinery Investment and Operating Costs

Machine Owned	New[a] Cost	Operating cost[b] per hour
3 plow tractor	$6,200	$1.50
Baler	3,500	1.00
Rake	800	1.00
Mower	800	.90
Spinner spreader	800	1.00
Wagon	350	.05
Sprayer	300	.80
TOTAL INVESTMENT	$12,750	
	.157 annual fixed rate[c]	
	$ 2,000 annual charge	
Custom operator		
Disc	1,000	.20
Drill	1,500	1.10

[a]Source: Farm Management Faculty, Ohio Farm Management Handbook (Columbus: Ohio State University, Department of Agricultural Economics, December, 1971).

[b]Calculated for fuel, oil, and repairs from data in: Wendell Bowers, Modern Concepts of Farm Machinery Management (Champaign, Illinois: Stipes Publishing Company).

[c]Depreciation 10%, interest 8% on mid-value, and other 1.7 %.

which its marginal value productivity equaled the *a priori* selected interest rate. Thus MVP of capital and level of the predetermined rate simultaneously determined the capital restraint and the amount of capital borrowed.

Since capital can be borrowed for long-term projects at a lower rate of interest than can capital for short-term uses, a differential of three percent was assumed between the two rates. Thus if a rate of five percent was assumed for long-term loans, then the rate for short-term loans was eight percent.[6] These two rates, five percent and eight percent were used as external rates. The manager would not invest unless returns exceeded these rates.

The model required the predetermined MVP rate on capital to be charged for an annual period regardless of the time the capital was actually used. This assumption reflects institutional lending practice and the fact that calf sales were made only once each year.

Beef Cow Budgets

The cow budget reflected the average cow in a 75 cow herd as far as age, productivity and input requirements were concerned. The age composition of the herd, size of weaner calf as function of age of dam, and replacement rate are legitimate managerial considerations;

[6] A 5 percent rate was selected on the basis that an owner with 50 percent equity would accept 2.5 percent on his equity (plus land appreciation) and the market rate would be 7.5 percent on investment capital.

they are discussed elsewhere but are fixed in this study.[7]

The goal for keeping a brood cow was the returns generated from calf sales. Emphasis in the study was upon pounds and value of weaned calf produced and feed costs associated with that level of production. Variables on production were size of cow, mating scheme, calf growth rates and milk production in the dam. Calf prices were a function of size but not grade since it was established that each breeding plan would produce acceptable quality feeders. Average price for a choice 500 pound feeder steer was projected to be $50.00 per hundred weight (page 23) for the period 1973 to 1980. Heifer price differentials were taken from market studies,[8] and lower the average gross receipts per cow. Further price differentials arise from weight differentials of feeder animals. The method for calculating these differences followed that used by Bcwen.[9] Value of the finished animal was determined by price times weight; feeding costs were subtracted and the residual was divided by weight of feeder animal. Assumed feeding

[7]LeRoy F. Rogers, Replacement Decisions for Commercial Beef Herds, Bulletin 736 (Pullman: Washington Agricultural Experiemtn Station, June, 1971). and L.A. Swiger, "Genetic and Environmental Influence on Gain of Beef Cattle During Various Periods of Life," Journal of Animal Science, Vol. 20, No. 187, 1961.

[8]Elmer L. Menzie and C. Curtis Cable, Jr. Major Determinants of Feeder Cattle Prices at Arizona Livestock Auctions, Technical Bulletin 197 (Tucson: University of Arizona Agricultural Experiment Station, September, 1972).

[9]C.C. Bowen and J.E. Moore, What To Pay For Feeder Steers, L-135 (Columbus: Ohio State University, Cooperative Extension Service, October, 1972).

costs were $25 per hundredweight of gain for a 500 animal and gradually increased as efficiency of conversion decreased in larger animals. Prices, price differentials and values are given in Table 15.

Alternative sources of data exist for calculation of the energy requirements for a cow and her calf.[10] These include National Research Council requirements, the Brodie equation, and Feeds and Feeding.[11] They devote little space specifically to nutritional requirements of the beef cow and calf. Maddox[12] developed a schematic system for calculating requirements based upon maintenance of cow weight, travel, reproduction, milk production, and calf growth. His system formed the basis for calculation requirements on this study.[13] No variability in nutrient intake was calculated for cow weight changes on the basis that the cow would regain what she lost. Work sheets for calculating energy requirements for the various cow-calf combinations are

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[10]It was assumed that energy was the limiting feed factor. Protein, minerals, and vitamins were recognized as essential. However, these nutrients were assumed to be sufficient, if energy requirements were met.

[11]National Research Council, Nutrient Requirements; S. Brody, Bioenergetics and Growth (New York: Reinhold Publishing Corporation, 1945). F.B. Morrison, Feeds and Feeding (Ithaca, New York: The Morrison Publishing Company, 1968).

[12]L.A. Maddox, Jr., Nutrient Requirements of the Cow and Calf; B-1044 (College Station: Texas Agricultural Extension Service, 1965).

[13]A problem in his calculation that causes difficulty for an economist is the fact that he uses straight line coefficients for conversion of nutrients into milk by the cow and for conversion of milk yield into growth rates by the calf. These constant coefficients conflict with the idea of decreasing marginal returns and are not consistent with previously cited results (page 31).

Table 15: Projected Prices and Gross Market Values, Feeder Steers and Heifers, 1963-1980

Breed Type	Calf Weight	Price[a]	Value each	Value Per Calf	Weaning Rate	Returns Per Cow
	lbs.	$/cwt	$	$	%	$
British Straightbred						
P_1 average	450			232	88	204
steers	475	53.50	254			
heifers	425	49.30	210			
P_2 average	550			244	88	215
steers	585	46.00	269			
heifers	515	42.50	219			
Charolais X British Cross						
P_3 average	520			241	92	222
steers	550	42.74	263			
heifers	490	44.50	218			
P_4 average	630			268	92	247
steers	670	43.00	288			
heifers	600	41.25	221			
Charolais X Dairy Cross						
P_5 average	590			246	92	226
steers	630	43.20	272			
heifers	550	40.20	221			
P_6 average	715			271	92	249
steers	770	39.50	304			
heifers	660	37.30	246			

[a]Based upon projections page 23: $36.65 choice 1100 lb. steer price and $50 choice 500 lb. feeder steer price.

presented in Appendix C. This system for calculating requirements showed crossbred cows mated to fast gaining sires required about 12 percent more total digestible nutrients (TDN) than straightbred British cattle. Similarly, dairy crosses mated to fast gaining sires required about 27 percent more TDN than British breeds. Pennsylvania[14] results showed that Angus-Holstein crosses would maintain their weight with 15 percent additional nutrients above NRC requirements for the beef cow. Cows in their study were smaller and produced less milk, however, than dairy crosses defined here. Consequently, it was assumed the 12 percent and 27 percent additional nutrients will meet needs of the larger and higher producing cows defined.

A generalized cow budget is presented in Table 16. Specific cost or return items assumed constant across all alternatives are shown as stated amounts; those items determined endogenous to the system are denoted by XXX. New returns are calculated to fixed items at the bottom of the budget. Supplies, health items, breeding, marketing, and cow ownership costs were constant for all cows. Purchase price was $400 per cow; cull value $250; thus average investment was $325. Since it was assumed that no price differences among cow types existed, the manager can easily evaluate cow price differences specific to him from a partial budget. It will allow him to determine whether added costs associated with higher priced cows are greater than added returns.

[14] Wilson, "Effects of Energy Intake."

Table 16: Generalized Beef Cow-Calf Enterprise Budget

Receipts			
Gross Value: Weight x Price			
Gross per cow: Gross value x weaning percent			xxx[a]
Gross Receipts Per Cow			xxx
Expenses			
Vet and medicine			2.50
Salt and mineral			3.00
Cash pasture costs			xxx
Cash winter feed costs			xxx
Breeding charge			7.00
Marketing			3.00
Cow ownership costs			28.50
Depreciation: $400 to $250 in 8 years		$18.75	
Death loss : 3% average value		$ 9.75	
Interest :		xxx	
Labor (hours only)	xxx		
Total expenses			$44.00
Returns to fixed resources			xxx
Fixed costs			
Fixed land			
Fixed machinery			
Operator labor			

[a]The xxx items are determined within the optimum organization.

Heifers for replacement and breeding bulls were not considered part of the cow unit. Changes were made for these items in the cow budget as replacements and bulls were treated as separate enterprises. The bull cost was charged directly at the rate of $7.00 per cow. Replacement costs were covered by cull cow sales plus accumulated cow depreciation and death loss charges.

Cow labor requirements and the seasonal distribution pattern, in Table 17, were taken from EORDC experience. Labor was used very efficiently with less than 6 hours per cow required.

Forage Production Budgets

A generalized forage production budget is presented in Table 18. It follows a format similar to the cow budget. Expense items are costed in; fixed inputs are denoted by xxx. Input prices are listed in Table 19. Fertility inputs accounted for most costs. Fertilizer treatment and yield responses, peculiar to each production alternative, were derived from Myer's work,[15] and verified as attainable from experience at Eastern Ohio Research and Development Center.[16]

Optimality of budgeted fertility input levels were estimated from Kentucky work, reported in Table 20.[17] Inputs for phosphorus and potash were reduced to levels assumed removed by grazing livestock

[15] Myer, "Pasture Planning Guide," and personal interview.

[16] Stock, "All Season Grazing Program," and personal conversations with R.W. Van Keuren, OARDC Agronomist in charge of forages at EORDC.

[17] W.C. Templeton, Jr., T.H. Taylor and J.R. Todd, Comparative Ecological and Agronomic Behavior of Orchardgrass and Tall Fescue, Bulletin 699 (Lexington: University of Kentucky Agricultural Experiment Station, June, 1965).

Table 17: Hours of Labor Used by Month and Activity
E.O.R.D.C. Beef Cow-Calf Enterprise
50 Cows, Typical Year[a]

	Activities							
			Hay Baling		Elec.	Clip	Fence	
Month	Cows	Fert.	Rnd.	Sq.	Fence	Pasture	Repair	Total
Jan.	10				2			12
Feb.	12							12
March	15	8			.8			23.8
April	5	18.6						23.6
May		.6					1.6	2.2
June		3	8	24				35
July	4	1.3	36	32			.8	74.1
Aug.	5	8				27		40
Sept.	5				2.4		.8	8.2
Oct.	5				30.8		1.4	37.2
Nov.	8				2.8			10.8
Dec.	5				1.0			6.0
Total	74	39.5	44	56	39.8	27.0	4.6	284.9
							per cow	5.7

[a]Source: Stock, "All Season Grazing."

Table 18: Generalized Forage Production Budget

Estimated annual cost per acre for establishing and maintaining (type forage)
Southeastern Ohio, Sandstone Area, 1973

			Cost	
Establishing costs	Unit	Amount	Unit	Total
Seed	lb.			
Spray	gal.			
Tractor & Mach.	hr.			
Labor	hr.			
Special Fencing				
Total				
Annual charge, prorated years				
Annual maintenance costs				
Fertility: N	lb.			
P	lb.			
K	lb.			
L	lb.			
Annual establishment cost				
Tractor & Mach. (by jobs)	hr.			
Fence Repair	ac.			
Land Tax	ac.			
Total				
Operator Labor Hours				
Nov. - Jan.	hr.	xxx		
Feb. - Apr.	hr.	xxx		
May - Jul.	hr.	xxx		
Aug. - Oct.	hr.	xxx		
Land	ac.	xxx		
Fixed Machinery	ac.	xxx		

Production: Pounds of TDN Utilized

Total	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.

Table 19: Assumed Seed and Material Costs Southeastern Ohio, 1973

Fertility	$/ton	$/lb. Nutrient
Urea (45%)	81	.09
Triple superphosphate (46%)	79	.086
Muriate of Potash (60%)	61	.051
Lime (spread)	6	6.00/ton
Seed	**$/cwt**	
Orchardgrass	47.50	
Fescue	30.50	
Alfalfa	64.00	
Bluegrass	63.00	
Spray		
2-4D	4.00/gal.	

rather than removed by hauling hay from the fields.

A charge for real estate taxes reflected an average amount per acre for the area.[18]

Establishment charges were segregated from annual costs, but were prorated on an annual basis for the time period noted. In calculating establishment charges, labor costs were included since they represented one time charges not reflected elsewhere on the budget and the manager might rely on hired labor or custom operators to perform the establishment jobs. Operating costs of owned machinery and total costs of a disc and drill were also included in establishment charges. The method of establishment was plowing, discing,

[18] Farm Management Staff, Farm Management Handbook.

Table 20: Fertility Treatments and Hay Yield Responses by Orchardgrass and Tall Fescue, Kentucky, 1965

Fertility Treatments[a]			Added	Dry Matter Production					
				Orchardgrass			Fescue		
N	P	K	Cost[b]	Yield	Change Yield[c]	Value[d]	Yield	Change Yield[c]	Value[d]
	lbs.		$	lbs.	lbs.	$	lbs.	lbs.	$
0	0	0		3900			3800		
0	87	125	13.86	5700	1800	18.00	6600	2800	28.00
30	8.7	25	4.73	4800	1100	11.00	5200	1400	14.00
120	0	0	10.80	4800	1100	11.00	4500	700	7.00
120	8.7	332	28.48	5800	2100	21.00	5800	2000	20.00
120	87	332	35.21	6600	2700	27.00	7100	3300	33.00

Source: Templeton, Agronomic Behavior.

[a]All areas included ladino clover in the grass mix, hence N responses is low.

[b]N @ $ .09; P @ $ .086; K @ $ .051

[c]From the 0-0-0 application.

[d]Value of hay $20/ton or 1¢/lb.

and drilling the seed. A spraying with 2-4D controlled broadleaf weeds. Only areas not endangered by erosion can be established with this procedure. The 100 acres limited to bluegrass production could not be re-established with this procedure because the areas were assumed too steep. No-tillage methods of establishment, utilizing paraquat to kill vegetation and discing to prepare a seedbed, could be safely employed, however. No-tillage methods require more capital and incur additional expense.

Hay production budgets included several cost items in addition to those in pasture budgets. The first one involved fertility requirements. Grazing animals carry only small amounts of nutrients off the land; most are returned in manure. However, significantly more nutrients are removed in hay not fed where it is harvested. Increased fertilizer applications accounted for hay nutrients removed. However, a manure credit was allowed to hay production, representing a nutrient transfer on the farm. Winter grazing of round bales was not charged with higher fertility rates nor credited with manure since it was utilized where produced. The second area of difference arose with labor and machinery. Additional hours added costs for harvesting, and feeding where conventional hay production methods were practiced. All hauling and storing labor was hired at $2.00 per hour with a productivity rate of one man hour per ton. Only operator time was required for feeding. The third area of additional costs for conventional hay was twine and storage. Winter grazing did not require hauling or storage, but it was charged with investment costs posts and wire and labor for managing electric fence.

A summary of production costs and yields on forages in presented in Table 21. Complete budgets for all forage alternatives are included in Appendix D.

Fitting Cow Herd Requirements to Forage Production

The practice of budgeting costs of production for economic analyses of crop production has wide acceptance. However, the livestock producer has to consider two enterprises, the forage crop and the animal, both of which should be expected to make a profit and not be subsidized one by the other. Logically, animal enterprises should be expected to purchase feed from the land, or commercial sources, and add to its value. The question from the standpoint of a profitable livestock program is not what it costs to produce forage, but what is the maximum that could be paid for a given feed to be used in the ration when evaluated in terms of value of product produced or cost of alternative feeds.

Two serious management problems arise in fitting cattle requirements to forage production. One involves nutrient production and requirement patterns; the other, effective utilization of the production (stocking rate, or acres per cow).

Growth curves for improved bluegrass and fescue and a cow requirement curve are presented in Figure 13. Cow and calf requirements increase significantly at birth of calf, increase gradually until weaning when cow requirements drop drastically. Forage grows rapidly in the spring, drops during summer, and picks up in the fall. Forage management involves fitting the two curves together.

Table 21: Summary of Forage Production Costs and Yields

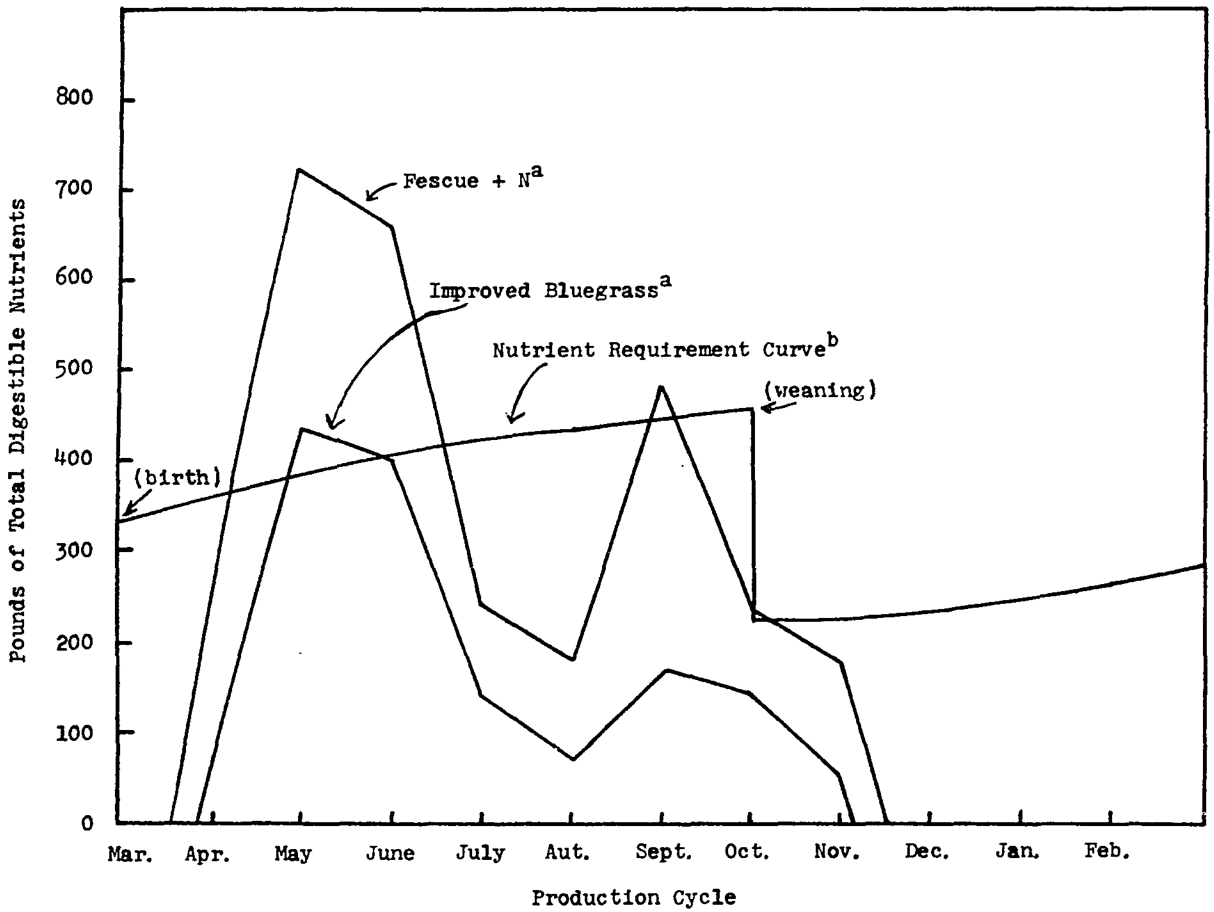
Forage	Use	Variable cost[a]	Utilization rate[b]	Utilized TDN yield	Cost[a] Per cwt. TDN utilized	Total cost[d] per acre	Acres per cow	Total cost per cow
		$/a	%	lbs.	$	$/A	a	$
Native bluegrass	pasture	3.69	60	600	0.62	15.30	4.8	73.44
Improved bluegrass	pasture	11.67	60	1,468	0.80	24.47	2.0	48.94
Orchard-grass	pasture	20.13	60	2,520	0.80	35.03	1.2	42.04
	hay							
	cut 1	42.05	60 - 80[c]	2,744	2.02	70.00	.50	35.00
	cut 2	55.52	80	3,200	1.31	85.12	.40	34.05
Fescue	pasture	20.46	60	3,000	0.68	35.36	1.0	35.36
	hay							
	cut 1	42.38	60 - 80[c]	3,110	1.36	70.00	.42	29.40
	cut 2	55.85	80	3,200	1.75	75.45	.40	30.18
	winter pasture	22.95	40	1,600	1.43	44.15	.81	35.76
Alfalfa-meadow	pasture	15.37	60	2,375	0.65	30.69	1.2	36.83
	hay							
	cut 1	37.99	60 - 80[c]	2,811	1.35	68.00	.46	31.28
	cut 2	51.27	80	3,200	1.60	80.87	.40	32.35

[a] Total cost except fixed machinery, operator labor, and land charges.

[b] Percent of total production harvested by the cow and calf.

[c] Pasture-hay, respectively.

[d] Including machinery, $3.20/a; operator labor, $4.20/hr.; and charges, $150/a @ 7% on land.



a. Acre yields with 60% utilization of total production.

b. Requirements of 1000 pound British bred cow and calf, spring calving.

Figure 13: Nutrient Production Curves of Fescue and Bluegrass Swards and Nutrient Requirement Curves of a Beef Cow and Calf.

A Period Transfer Activity was noted earlier as a method in linear programming for allowing variability in forage production to be fitted to changing nutrient requirements of livestock. Coefficients for discounting quality and quantity of forages transferred are presented below. No published data were available to form a basis for the coefficients. Some indications of reduced yields were derived from the Pasture Calendar.[19] It showed 60 percent recovery of potential

Transfer Coefficients and Yield Discounts Assumed By Period Transfer Activity

Production Period		Transfer Coefficients							
		Periods Transferred							
		0	1	2	3	4	5	6	7
Apr. 15-May 1	1		1						
May 1-Mar. 15	2			.9					
May 15	3				.8				
June 15	4					.7			
July 15	5						.6		
Aug. 15	6							.5	
Sept. 15	7								.5
Production as % of potential yield		100	100	97.8	89.8	78.1	66.3	53.4	50.9

[19]Myers, "Pasture Calendar."

production if grazing were delayed until July. The assumed coefficients of the model product a 66.3 percent recovery rate. At the Ohio Station[20] forages were harvested as hay one, two and three times annually. Bluegrass harvested once produced 73 percent as much as three harvests; orchardgrass, 48 percent, and fescue 61 percent. Grazing may not produce the same recovery rates, however. All forage species were assumed to transfer at the same discount rate. Winter grazing data[21] have shown fescue to retain its nutritive value better than other forages for winter periods, but no data was found reporting quality influences during summer deferral.

Standing or stump deferral was evaluated relative to baling surplus growth by conventional methods and relative to purchase of hay or grain from outside sources. Hay production or purchase, and corn purchase provided nutrients into a nutrient pool on an as feed basis. Nutrients flowed out of the pool into any feeding period when they provided the least cost sources of nutrients. The option to buy feed was included in order to compare economy of production with purchase options.

Effective utilization of production is the second problem area in forage consuming livestock operations. The difficulties of using milk yields (in dairy herds) or beef grains as a yard stick in

[20]R.W. Van Keuren, "All-Season Forage Systems for Beef Cow Herds," (Wooster: Department of Agronomy, OARDC),(mimeograph).

[21]Van Keuren, "Winter Pasture System."

measuring grassland output are serious. These difficulties include variations in stocking rate, potential productive capacity of the animals, variations in herbage due to growth and changing weather conditions, and variations in losses due to trampling and contamination. Consequently the amount of total digestible nutrients (TDN) from forage production harvested as hay often greatly exceeds calculated requirements for products gained from grazing livestock. In an Ohio experiment with dairy cattle the utilization rate varied between 25 percent and 75 percent when harvested forage yields were compared with production levels in the cows.[22]

Whether there is 25 percent or 75 percent utilization greatly affects the production cost structure. Myers'[23] calculations in the pasture calendar averaged 60 percent utilization of TDN green forages. The 60 percent rate was assumed to reflect what good managers can achieve. Likewise, the utilization rate for field stored hay was estimated to be 40 percent, and conventional hay fed from barn storage, 80 percent. It was assumed 100 percent of the nutrients in purchased corn would be consumed by the cattle.

The Matrix

The matrix is presented in Figure 14. Several characteristics about it require review or explanation. In the objective function,

[22]R.W. Van Keuren, A.D. Pratt, H.R. Conrad, and R.R. Davis, Utilization of Alfalfa-Bromegrass as Soilage, Strip-grazing and Rotational Grazing for Dairy Cattle, Research Bulletin 489 (Wooster: Ohio Agricultural Experiment Station, October, 1966).

[23]Myers, "Pasture Calendar."

Figure 14: Linear Programming Matrix[a]

		01BBSP	02BBF	03CBSP	04CBF	05CDSP	06CDF	07NATBC	08IMPBG	09GZOG	100GH1	110GH2	12GZFES	13FESH1	14FESH2	15FESWP	16GZALM	17ALM1	18ALMH2	19HIREL	20G1TR	21G2TR	22G3TR	23G4TR	24G5TR	25G6TR	26G7TR	27LTRAB	28LTRBC	29BRTR	30WLTR	31BOROC	32LBNDIC	33BYCORN	34BUYHAY	35TRN1	36TRN2	37TRN3	38TRN4	39TRN5	40TRN6	41TRN7	42TRN8	43TRN9	44PURH1	45PURM	47PURLOW	RHS
OBJF	N	C	C	C	C	C	C																									-A	U															
01OPCAP	E	B	B	B	B	B	B	A	B	B	B	B	B	B	B	B	B	B	B	A																												
02INVCAP	L	C	C	C	C	C	C			B	B	B	B	B	B	B	B	B	B											A	B	-1		B	B													
03LNOVJA	L	T	T	T	T	T	T				A	A		A	A	T		A	A											B	C		1												E	E	D	F
04LFEBAP	L	T	T	T	T	T	T	U	U	T	A	A	T	A	A	T	T	A	A																													C
05LMAYJL	L	T	T	T	T	T	T			T	1	1	T	1	1	A	T	A	1																													C
06LAUGOC	L	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T																													C
07LABTR	E										A	A		A	A			A	A	-1																												C
08HIRELA	L																			1																												
09CLASA	L																1	1	1									1																				
10CLASB	L									1	1	1	1	1	1	1												-1	1	-1	-1																	C
11CLASC	L							1	1																				-1																-B	-A	-A	B
12BRUSH	L																													1															-B	-B	-B	C
13WOOD	L																														1														-B	-B	-B	B
14LMBYHA	L																																		1										-A	-A	-A	B
15LMBYCO	L																																	1											-A	-A	-A	B
16A15M1	E	C	C	C	C	C	C		-B	-C			-C				-B				1															-1												B
17M1M15	E	C	C	C	C	C	C	-C	-C	-C			-C				-C				-1	1															-1											A
18MAY 15	E	C	C	C	C	C	C	-C	-C	-C			-C				-C					-T	1															-1										
19JUNE15	E	C	C	C	C	C	C	-C	-C	-C			-C				-C						-T	1															-1									
20JULY15	E	C	C	C	C	C	C	-B	-C	-C	-C		-C	-C			-C	-C						-T	1															-1								
21AUG 15	E	C	C	C	C	C	C	-B	-C	-C	-C		-C	-C			-C	-C							-T	1															-1							
22SEPT15	E	C	C	C	C	C	C	-B	-C	-C	-C		-C	-C			-B	-B								-T	1															-1						
23OCT15	E	C	C	C	C	C	C	-B	-C	-B	-B		-C	-C													-T																-1					
24WINTR	E	D	D	D	D	D	D									-D																												-1				
25NUTPOO	E										-D	-D		-D	-D		-D	-D																-D	-C	1	1	1	1	1	1	1	1	1				

[a]Range of values for symbols presented on next page.

Figure 14 (cont.)

Range of Values for Symbols in Matrix

Symbol in Table	Range of Values		Number of Occurences (incl.RHS)
U	.010000	.099999	2
T	.100000	.999999	50
1	1.000000	1.000000	57
A	1.000001	10.000000	33
B	10.000001	100.000000	53
C	100.000001	1,000.000000	113
D	1,000.000001	10,000.000000	16
E	10,000.000001	100,000.000000	1
F	100,000.000001	1,000,000.000000	1

the only items were selling calves, borrowing operating capital, and lending investment capital. The selling values were gross receipts from calf sales per cow. Expenses for cattle production, forage production, hiring labor, and land development were charged against receipts through the borrow operating capital activity. A preselected interest rate was charged to annual expenses thus incurred. The activity, lending investment capital, allowed the program to set a reservation price on investment capital. Whether it was more profitable to invest in cattle, forage improvements, land development, land purchase or off the farm could be determined by this activity. As the reservation price of capital changed from 0.05 upward to 0.40 percent, changes in the optimal solution could be noted. These solution changes could be read conversely to mean that investment in activities selected would yield returns equal to the reservation price stated.

Labor availabilities referred to operator labor for the four periods defined. Hired labor had to be used for hauling and storing conventional hay. This technique allowed comparison of the field stored system with conventional hay handling systems.

Class A land could be transferred to use in Class B and both could be transferred to Class C. However, Class C (100 acres) or Class B (300 acres) could not be transferred into higher use classes. Brushland and woodland could be transferred to use in Class B or C after charges were incurred for clearing. Purchased land options transferred the defined acreages into all five respective class or use designations, Classes A and B, brush and woodland, which could subsequently be transferred into uses described for owned land.

Cow and calf TDN requirement patterns were defined as nutrient users. Forage production alternatives with their characteristic yield sequences were sources of nutrients. Purchased hay and corn provided outside sources of nutrients. The Period Transfer Activity allowed transfer of stump stored growth between periods. The Nutrient Pool transfer allowed home grown hay or purchased hay and corn to be available in any feeding period. All forage and corn nutrient yields were on an as-fed basis of utilization stated previously.

CHAPTER V

RESULTS AND CONCLUSIONS

Initial Resource Situation-Capital Rationing

The most profitable enterprise combination was determined for each of eight capital rates.[1] These optimum plans provided:(1) comparison of net income to fixed resources and total operation at each rate, and (2) comparison of the optimum enterprise organization at each capital rate. Table 22 presents the optimum enterprise combinations. Limiting the cow herd to 75 head (which the farmers surveyed has maintained) is included in this table.

Capital Rates: 38-35 Percent

No enterprise or combination of enterprises considered yielded a return at the highest capital reservation rate, 38-35 percent; thus all owned resources remained idle at this level.

Capital Rates: 33-30 Percent

With capital rates of 33-30 percent, the optimum organization was 142 fall calving British cross-bred cows utilizing 179 acres of native bluegrass, 108 acres fescue pasture, 178 acres fescue winter pasture, and 114 acres alfalfa-meadow made into one cutting of hay and grazed afterward. Hired labor amounted to 35 hours to haul and

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[1]Rather than a charge on capital utilized, these capital rates may be interpreted as reservation prices; that is, unless the activity returned more to net income than the capital rate charged, it would not enter the solution.

store hay. Non-land capital required was $52,893. No brushland nor woody brush was cleared. Nor was any hay or grain purchased for supplemental feeding. After subtracting 8 percent for the cost on operating capital, 5 percent on non-land capital, $2,000 fixed charges on machinery, and $10,000 operator labor, return to the fixed land investment was 4.1 percent. Returns to the total investment of $185,643 was 3.0 percent.

Herd Limited to 75 Cows

Limiting size of the cow herd to 75 head produced a solution intermediate to the 33-30 and 38-35 percent capital rates. The optimum organization selected similar enterprises but was less intensive; stocking rate was 3.77 acres per cow compared to 3.37 percent capital rate. Returns, before subtracting fixed machinery and operator labor, was reduced to $9,313 from the $17,538 returns generated by the 33-30 percent solution. Calculating zero returns to fixed land, operator labor earned $7,313 annually. Or conversely, an investment return of 4.55 percent yielded zero returns to operator labor.

Capital Rates: 28-25 Percent

When the capital rate was 28-25 percent, two significant changes occurred. First, British crossbred spring-calving cows entered the solution (5 cows) and second, 100 acres of native bluegrass was improved with fertilization. Intensification increased stocking to 2.4 acres per cow. Winter pasture was reduced to 166 acres; alfalfa-meadow cut once then grazed increased to the limit of 80

Table 22: Optimum Forage and Beef Cow Feeder Calf Combinations at Selected Marginal Returns to Capital, Initial Resource Situation

			Required Marginal Returns to Capital (%)								
Operating Capital			.08	.105	.13	.18	.23	.28	.33	limit to	.38
Long-term Capital			.05	.075	.10	.15	.20	.25	.30	75 cows	.35
Activity	Unit	Max Amt.									
British Spring	hd										Resources Idle
British Fall	hd										
Crossbred Spring	hd		229	235	279	220	148	5			
Crossbred Fall	hd		136	127	74	118	168	195	142	75	
Dairy Cross Sp.	hd										
Dairy Cross Fall	hd										
Total Cows	hd		365	362	353	338	306	200	142	75	
Native Bluegrass	a								179	119	
Improve Bluegrass	a	100	100	100	100	100	100	100			
Graze Orch. Grass	a	530									
O.G. Hay 1 Cut	a	530									
O.G. Hay 2 Cut	a	530									
Graze Fescue	a	530	269	263	249	242	211	134	108	53	
Fes. Hay 1 Cut	a	530	229	237	226	222	160				
Fes. Hay 2 Cut	a	530									
Fes. Winter Past.	a	530	25	17		5	29	166	178	94	
Graze Alf-Meadow	a	80								17	
Alf-Med Hay 1	a	80					80	80	14		
Alf-Med Hay 2	a	80	7	2	9	11					
Stocking Rate			1.73	1.71	1.65	1.72	1.90	2.40	3.37	3.77	
Hire Labor	hr	600	600	600	600	600	600	200	35		
Brush Clear	a	100	100	100	100	100	100				
Wood Clear	a	50	50	39	3						
Buy Corn	tn	10	10	10	10						
Buy Hay	tn	40	40	40	40	40					
Added Invest.	$		151,784	147,165	132,888	127,005	120,402	73,570	52,893	28,070	
Gross Receipts	$		84,458	83,529	80,274	78,037	74,200	49,181	35,125	18,525	
Expenses	$		37,371	36,827	35,070	33,694	31,447	19,938	13,835	7,230	
Net Cash	$		47,087	46,702	45,204	44,343	42,753	29,243	21,290	11,295	
Expenses - 8%	$		40,361	39,773	37,876	36,390	33,963	21,533	14,942	7,808	
Net	$		44,097	43,756	42,398	41,647	40,237	27,648	20,183	10,717	
5% on Added Inv.	$		7,589	7,358	6,644	6,350	6,020	3,679	2,645	1,404	
Net to Fixed	$		36,508	35,398	35,754	35,297	34,217	23,969	17,538	9,313	
Mach & Op. Labor	$		12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	
Return to Initial Land Base	$ %		24,508 18.0	23,398 17.2	23,754 17.5	23,297 17.2	22,217 16.4	11,969 8.8	5,538 4.1	(2,687) (2.0)	
Total Invest.	$		284,534	279,915	266,538	259,755	253,152	206,320	185,643	160,820	
Return Tot. Invest.	%		8.6	8.4	8.9	9.0	8.8	5.8	3.0	(1.7)	

acres. Hired labor increased to 200 hours. Non-real estate capital was $73,570 and returns $23,969. Rate of return was 8.8 percent on fixed land and 5.8 percent to total investment.

Capital Rates: 23-20 Percent

At the 23-20 percent rate cow numbers increased to 306 head of British crossbred cows with almost equal numbers calving in spring and fall. Stocking rate was 1.90 acres per cow. Winter pasture reduced to 29 acres, but fescue cut once then grazed entered at 160 acres. Hired labor reached the limit of 600 hours. For the first time it was profitable to bush hog brush land and establish it into fescue production. Non-real estate capital rose to $120,402. Return to fixed resources was $34,217, producing 16.4 percent return to the original land and 8.8 percent overall.

Capital Rate: 18-15 Percent

When the capital rate was 18-15 percent, spring-calving crossbred British cows (220) increased relative to fall calving cows (118); total cow herd was 338 head. Stocking rate was 1.72 acres per cow. Winter pasture was reduced to 5 acres. Fescue cut once then grazed (222 acres) and alfalfa-meadow hay (11 acres) produced winter feed. For the first time the option to buy hay at $25 per ton entered the solution at the maximum allowed. Home produced feeds had been more profitable than relying on purchased hay or corn (at $60 per ton) for supplemental feed. Non-real estate investment was $127,005. Return to fixed resources was $35,297 which generated a 17.2 percent return to fixed land or 9.0 percent total investment.

Capital Rate: 13-10 Percent

At 13-10 percent crossbred British spring-calving cows (279) increased relative to fall calving cows (74), while the total herd increased to 353 head. Stocking rate was 1.65 acres per cow. Fescue hay (226 acres) cut once then grazed, alfalfa-meadow (9 acres), purchased hay (40 tons), and purchased corn (10 tons -- the limit) provided winter feed. For the first time it was economical to convert limited acres of woody brush land (3 acres) into grass production. Non-real estate investment was $132,888; returns $35,754. Rate of return to fixed land increased slightly to 17.5 percent, but overall return dipped to 8.9 percent.

Capital Rate: 10.5-7.5 Percent

The 10.5-7.5 percent rate produced a significant change in organization trends. Crossbred British spring-calving cows (235 head) declined relative to fall calving cows (127) while total cows increased to 362 head. This change occurred because of limits on operator labor time. Spring calves had been relatively more profitable in using the land resources, but fall calving became more profitable when labor became limiting. Winter pasture (17 acres) re-entered the solution but winter feed came mostly from fescue cut once (237 acres). Additional acres of woody brush (39 acres) was profitably cleared and seeded to fescue. Non-real estate investment was $147,165. Returns declined slightly to $35,398; or 17.2 percent on fixed resources, and 8.4 percent overall.

Capital Rate: 8-5 Percent

At the lowest capital level investigated, the solution was very similar to the previous one. There was 3 more cows, totalling 365 head; carrying capacity was 1.73 acres per head. Winter pasture (25 acres) and alfalfa-meadow (7 acres) increased slightly. Most significant at this level, all 50 acres of woody brush were converted into grass production. Non-real estate capital was $151,784. Returns of $36,508 yielded 18.0 percent of fixed resources and 8.6 overall.

Overview of All Optimum Solutions

Over the range of the marginal capital rates programmed, the amount of investment capital increased from $28,070 with 75 cows to $151,784 with 365 cows programmed. Net returns to owned machinery and labor increased from $9,313 to $36,508, after deducting a charge of 5 percent on investment capital and 8 percent on operating capital. Thus the $123,714 of added investment capital raised net returns by $27,195, which was almost a 22 percent return on added investment. Even with high discount rates on additional capital investment, potential returns makes intensification appear attractive.

At the highest marginal capital rates, a non-improved extensive operation with fall dropped calves was most profitable. Value of the extra 110 pounds of calf weight offset the cost of additional feed requirements. It was profitable to establish high yielding fescue for supplemental summer grazing rather than add fertility to bluegrass. Winter pasture of field stored round bales entered because it was the lowest cost alternative for winter feed. At lower capital rates, use of winter pasture declined because higher cost, more intensive systems produced more calves and increased gross receipts. That is to say, profits per calf were greatest with winter pasture systems, but more intensive systems produced more calves thus making the whole farm more profitable.

As the reservation price on capital declined, spring calving increased relative to fall calving until labor became limiting. Spring calves were held 7 months while fall calves are held 10 months; fall calves required more feed but were 110 pounds heavier. With the price relationships given, more cows on a fixed acreage were more profitable than fewer cows with larger calves.

Net income differences among the cow alternatives were small, however. Generally, if straightbred British cows had been substituted in place of crossbred cows, income would have declined between $1.00 and $10.00 per cow; substituting dairy crosses would have caused declines in the range of $14.00 to $30.00 per cow depending upon the resource situation. These differences indicate that type of cow, mating scheme, and calf birth date were not of primary importance in determining profitability, although the dairy crosses need closer evaluation.

Of significantly more importance was the nutrient utilization of forage production in comparison to cow requirements. Small cows producing small calves should be stocked at fewer acres per cow than large cows producing large calves in order to achieve equal utilization rates. Fall calving dairy crosses required 52 percent more nutrients than spring calving straightbred British cows. With the fixed TDN utilization rates programmed, they consequently required 52 percent more land per cow. On this fixed basis, dairy crosses did not enter the solution. However, if cow types and/or calving period combinations had resulted in differing nutrient utilization rates (rather than 60%), then one cow type and one calving date might have been superior.

At the highest capital rate (33-30 percent) Class B land (79 acres) was transferred into Class C, unimproved native bluegrass, an extensive use rather than intensive. Fescue was established on 108 acres to provide rotational pasture to complement native bluegrass. Thus forage improvement was profitable to level out the summer pasture availability curve but improvement of all pastures would not yield 33-30 percent return on the added investment. Fescue winter pasture and field stored round bales (178 acres) provided the least cost alternative for winter feed. These results may be interpreted to indicate that fescue summer pasture to complement bluegrass and field stored winter grazing systems will return 33-30 percent return on capital by allowing stocking rates to increase from about 5 acres per cow to 3.37 acres per cow.

Fertilizing bluegrass pasture became profitable at 28-25 percent rates on capital. However, if the land had been suitable for establishment of fescue it would have gone into fescue production rather than remaining in bluegrass.

Developing land by bush hogging and corrective liming and feritilizing required investment of $80 per acre. It entered the solution at 23-20 percent rate on capital. Developing 100 acres of brush land and stocking it to capacity increased total investment requirements by $46,832 while increasing returns $10,248, or nearly 22 percent return on investment. The land was devoted to fescue production.

Clearing woody brush land was questionable except at the lowest capital rates (8-5 percent). The budgeted investment cost was $200 per acre. Bringing all woodland into use added $24,779 to capital requirements for clearing, establishment and stocking, but added only $1,211 to net returns, or 4.8 percent.

Purchasing hay or corn became profitable when 18-15 and 13-10 percent capital rates respectively were programmed. Home-grown forages, utilizing production practices included in the solutions at higher capital rates, produced nutrients less expensively than purchased feed at the prices chosen.

To further intensify the operation, large amounts of feed could have been purchased at lower rates of return. At the 8-5 capital rate, the winter feed was more profitable when secured from purchased hay at $25 per ton than home produced hay. All land was devoted to grazing rather than hay production. This result would suggest that if a manager can buy hay for $25 per ton, his resources would earn higher returns in other activities rather than hay production.

Forage Management Program

Of particular significance in the optimum solutions was the flow of nutrients from period to period as permitted by both the Period Transfer Activity and the Nutrient Pool. The Period Transfer Activity allowed forage growth to be transferred from one period to subsequent periods without direct cost, but with discounted yields. Typically, excess forage growth was transferred from April, May and June periods for use in July; never did transfer extend beyond July, however. Yield discounts became so great that it was more economical to use some other method of deferral. Usually hay land aftermath became available for July and later. In the autumn months nutrients from September production generally were transferred into October.

In most all solutions supplemental feeding was practiced in the August 15-September 15 period from the Nutrient Pool. Upon occasion, the July 15-August 15 period drew upon the "Pool" also. Nutrients supplied into the pool could have come from purchased hay or grain or from home-produced barn stored hay. Always when home produced hay was drawn upon, the associated costs and time requirements of harvesting storing and feeding, were incurred.

Solutions that utilized a first cutting of conventional hay and pastured the aftermath reinforce the concept of an all season forage system. Excess spring growth which could not be deferred except with excessive yield discount was harvested by conventional means. Labor prices as high as $4.00 per hour (with a productivity of one man hour per ton) did not prohibit this activity.

The activities, yields, and forage management techniques investigated would have permitted profitable intensification to the extent of 1.25 acres per cow. These results suggest that the livestock man must become a forage manager in order to maximize his income. He should calculate the supply of nutrients being produced by forages on a monthly basis, then compare nutrient requirements of his cows and calves with the supply. When production exceeds requirements for the subsequent 4 to 8 weeks, he can profitably harvest the excess growth as hay. The manager can thus establish a bench mark for when to harvest or not to harvest. Nutrient requirements from heavy stocking rates will usually exceed grass production in August. It was more profitable to feed hay during the period than to reduce stocking to fit production or stump store excess growth for use during this slack production month.

Resource and Matrix Modifications

In Table 23 optimal solutions resulting from modifications in prices, activities and resources are compared. All comparisons were evaluated at the 8-5 percent capital rate. The modifications were:

1. Comparison of winter pasture with conventional hay
    a. Utilization rate of fescue winter pasture
    b. Wage rate of hired labor to haul and store hay
2. Cattle price fluctuations
    a. Up 25 percent
    b. Down 25 percent
    c. Down 50 percent
3. Part-time operations
    a. 400 acres total land
    b. 200 acres total land
    c. Labor limited 240 hours per quarter, land 800 acres

Table 23: Optimum Forage and Beef Cow ... and Prices,

	Unit	Initial Solution 8-5%	Fescue Winter Pasture 60%Util.	Hire Hay Labor $4.00/hr	Calf Price Changes Up 25% to 62.5¢/lb	Dn 25% to 37.5¢/lb	Dn 50% to 25¢/lb
British Spring	hd		355	195			
British Fall	hd						
Crossbred Spring	hd	229			229	214	
Crossbred Fall	hd	136	68	176	136	114	127
Dairy Cross Sp.	hd						
Dairy Cross Fall	hd						
Total Cows	hd	365	423	371	365	328	127
Native Bluegrass	a						203
Improve Bluegrass	a	100	100	100	100	100	
Graze Orch. Grass	a						
O.G. Hay 1 Cut	a						
O.G. Hay 2 Cut	a						
Graze Fescue	a	269	212	209	269	234	89
Fes. Hay 1 Cut	a	229	183	78	229	216	
Fes. Hay 2 Cut	a						
Fes. Winter Past.	a	25	135	242	25	15	160
Graze Alf-meadow	a						28
Alf Med. Hay 1	a						
Alf Med. Hay 2	a	7			7	15	
Stocking Rate		1.73	1.49	1.70	1.73	1.77	3.78
Hire Labor	hr	600	457	195	600	600	0
Brush Clear	a	100	100	100	100	100	0
Wood Clear	a	50	50	50	50	0	0
Buy Corn	tn	10	10	10	10	0	0
Buy Hay	tn	40	40	40	40	0	0
Purch.: High	a						
Land: Med.	a	NA	NA	NA	NA	NA	NA
Low	a						
Added Invest.	$	151,784	173,308	154,516	151,784	123,961	47,697
Gross Receipts	$	84,458	89,353	83,083	105,721	56,730	15,803
Expenses	$	37,371	38,715	34,205	37,371	32,285	12,286
Net Cash	$	47,087	50,638	48,878	68,350	24,445	3,517
Expenses + 8%	$	40,361	41,812	36,945	40,361	34,868	13,269
Net	$	44,097	47,541	46,138	65,460	21,862	2,534
5% on Added Inv.	$	7,589	8,665	7,726	7,589	6,198	2,385
Net to Fixed	$	36,500	38,876	38,412	57,871	15,664	149
Mach & Op. Labor	$	12,000	12,000	12,000	12,000	12,000	12,000
Return to Initial	$	24,508	26,876	26,412	45,871	3,664	(11,851)
Land Base	%	18.0	20.2	19.9	34.6	2.8	(negative)
Total Invest.	$	284,534	306,058	287,266	284,534	256,711	180,447
Return Tot. Invest.	%	8.6	8.8	9.2	16.1	1.4	(negative)

[a] Return to 528 hours of operator labor.

ptimum Forage and Beef Cow Production Combinations, Modified Productivity and Prices, with Buy Land Options

Price Changes Dn 25% to 37.5¢/lb	Dn 50% to 25¢/lb	Land limit 400 a.	Land limit 200 a.	Limit labor 240 hrs. per qtr.	Buy land $100/a. labor 240 hrs.	Buy land $100/a; labor 600 hrs.	Buy land $150/a; labor 600 hrs.	Buy land $200/a; labor 600 hrs.	Buy land Capital 8-5% rates
		239	126						
214				63	63	149	134	134	138
114	127			137	137	325	315	315	317
328	127	239	126	200	200	474	449	449	455
	203								
100		50	25	242	242	549	162	162	256
234	89	116	62	123	123	303	462	462	423
216		149	71						
15	160			89	89	220	177	177	187
	28								
15				51	51	138	148	147	145
1.77	3.78	1.32	1.25	2.53	2.53	2.55	2.11	2.11	2.42
600	0	373	177	204	204	552	590	590	581
100	0	50	25	25	25	197	157	157	152
0	0	25	12.5	0		0	0	0	
0	0	10	10	10	10	10	10	10	10
0	0	40	40	40	40	4C	40	40	40
					0	970	567	567	0
NA	NA	NA	NA	NA	0	0	0	0	745
					0	0	0	0	0
123,961	47,697	94,305	49,268	72,476	72,476	280,664	259,763	288,116	287,524
56,730	15,803	48,847	25,752	47,745	47,745	113,291	107,625	107,625	109,003
32,285	12,286	22,765	12,364	20,891	20,891	49,074	46,142	46,142	46,798
24,445	3,517	26,082	13,388	26,854	26,854	64,217	61,483	61,483	62,205
34,868	13,269	24,586	13,353	22,562	22,562	53,000	49,833	49,833	50,542
21,862	2,534	24,261	12,369	25,183	25,183	60,291	57,792	57,792	58,461
6,198	2,385	4,715	2,463	3,624	3,624	14,033	12,988	14,406	14,376
15,664	149	19,546	9,906	21,559	21,559	46,258	44,804	43,386	44,085
12,000	12,000	12,000	2,000	12,000	12,000	12,000	12,000	12,000	12,000
3,664	(11,851)	7,546	7,902[a]	9,559	9,559	34,258	32,804	31,386	32,085
2.8	(negative)	11.4	---	7.2	7.2	25.8	24.7	23.6	24.2
256,711	180,447	160,680	42,750	205,226	205,226	413,414	392,513	420,866	420,274
1.4	(negative)	4.7	---	4.7	4.7	8.3	8.4	7.5	7.6

binations, Modified Productivity
Options

Land limit 200 a.	Limit labor 240 hrs. per qtr.	Buy land $100/a. labor 240 hrs.	Buy land $100/a; labor 600 hrs.	Buy land $150/a; labor 600 hrs.	Buy land $200/a; labor 600 hrs.	Buy land Capital 8-5% rates	Buy land Capital 10.5-7.5% rates	Buy land Capital 13-10% rates
126								
	63	63	149	134	134	138	128	130
	137	137	325	315	315	317	325	298
126	200	200	474	449	449	455	453	428
25	242	242	549	162	162	256	253	216
62	123	123	303	462	462	423	414	312
71								99
	89	89	220	177	177	187	186	185
	51	51	138	148	147	145	150	88
1.25	2.53	2.53	2.55	2.11	2.11	2.42	2.21	2.21
177	204	204	552	590	590	581	600	600
25	25	25	197	157	157	152	151	139
12.5	0		0	0	0			
10	10	10	10	10	10	10	10	10
40	40	40	4C	40	40	40	40	40
		0	970	567	567	0	0	0
NA	NA	0	0	0	0	745	730	552
		0	0	0	0	0	0	0
49,268	72,476	72,476	280,664	259,763	288,116	287,524	284,287	247,073
25,752	47,745	47,745	113,291	107,625	107,625	109,003	108,700	102,493
12,364	20,891	20,891	49,074	46,142	46,142	46,798	46,723	44,055
13,388	26,854	26,854	64,217	61,483	61,483	62,205	61,977	58,438
13,353	22,562	22,562	53,000	49,833	49,833	50,542	50,460	47,579
12,369	25,183	25,183	60,291	57,792	57,792	58,461	58,240	54,914
2,463	3,624	3,624	14,033	12,988	14,406	14,376	14,214	12,354
9,906	21,559	21,559	46,258	44,804	43,386	44,085	44,026	42,560
2,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
7,902[a]	9,559	9,559	34,258	32,804	31,386	32,085	32,026	30,560
---	7.2	7.2	25.8	24.7	23.6	24.2	24.1	23.0
42,750	205,226	205,226	413,414	392,513	420,866	420,274	417,037	379,823
---	4.7	4.7	8.3	8.4	7.5	7.6	7.7	8.0

4. Buy land, per acre prices

    a. $100

    b. $150

    c. $200

Winter Pasture Compared to Conventional Hay

In the initial resource solution at 8-5 percent capital rate, winter pasture was not a viable alternative. It was a lower cost alternative, but high calf values made it profitable to increase cow numbers rather than seek the cheapest source of feed. Conventional hay systems allowed more cows to be carried on the fixed land base.

In this stage of the analysis, the utilization rate on winter pasture was raised to 60 percent from 40 percent, correspondingly reducing winter pasture acreage required per cow from 0.81 to 0.54.[2] Winter pasture became very significant in the optimal solution with 135 acres grown compared to 25 acres at 40 percent utilization. Hay was still made from surplus spring growth on fescue pasture fields (183 acres). Spring calving, straightbred British cows (335 head) constituted most of the herd (423 head), rather than crossbred fall calving cows. Stocking rate was 1.49 acres per cow. High utilization made winter grazing a viable alternative and suggested an organization where more calves rather than larger calves were more profitable on a fixed land base.

In the second comparison, labor cost for hauling and storing

[2]Straightbred British cows with spring calving required about 1,300 pounds of TDN in the 5 month winter period; one half acre produced 2 tons of forage or 2,000 pounds of TDN. Limiting this cow to one-half acre would result in about 60 percent utilization.

conventional hay was raised to $4.00 per hour, holding winter pasture utilization to 40 percent. Significantly less labor was hired (197 hours); but still that price was paid to harvest surplus spring growth from pastures. However, winter pasture (242 acres) almost doubled above the amount employed with 60 percent utilization. The cow mix also changed to 195 spring calving straightbred British cows and 196 fall calving British crossbreds. Compared to the initial situation, higher cost winter feed brought in smaller, spring calving cows with lower winter feed requirements and reduced the stocking rate to 1.70 acres per cow.

Effect of Price Level Changes

A price rise of 25 percent would make $50 per hundredweight 500 pound steers worth $62.50 per hundredweight; a 25 percent decline, $37.50 per hundredweight; and a 50 percent decline, $25.00 per hundredweight. If heifer and weight price differentials remain the same at differing price levels as they are for $50 per hundredweight prices so that gross receipts per cow change by the percentages stated, then the optimum organization changed as price levels changed.

With a 50 percent decline, native bluegrass (203 acres), supplemental fescue (89 acres) and alfalfa-meadow (28 acres) comprised the summer feed, in combination with winter pasture (160 acres). Stocking rate was 3.78 acres per cow for 127 cows. Net returns to fixed land, machinery and labor was only $149. At low prices an extensive system was the most profitable. The owner could not afford to intensify beyond supplemental summer pastures. With the 25 percent price decline, organization and intensity were similar to the $50 price level. But returns were $15,664 or 1.4 percent on the total investment of $256,711 after paying $10,000 labor income. Organization at the 25 percent price level increase was exactly the same as that at the $50 level, but returns to fixed resources were $45,871 or 16.1 percent on $284,534 total investment, after paying $10,000 labor income.

These results indicate that price levels of $50 per hundredweight for 500 pound steers will be required in order to induce southeastern Ohio producers to intensify their operations, if they are to be paid $10,000 labor returns and 8.6 percent on their total investment of nearly $285,000. This is a higher price level for inducing production increases than that projected by ERS.[3] Also indicated is the fact that prices above $50 will not induce further adjustments utilizing the alternatives considered in this study.

Limited Resource Situations

Limiting land to 400 total acres (one-half the initial land base), or 315 acres available for forage production, produced an optimum of 239 spring calving straightbred British cows with a stocking rate of 1.32 acres per cow. All areas of bluegrass pasture was improved (50 acres). Additional grazing came from fescue (116 acres) and fescue aftermath following 1 cutting of hay (149 acres). All brushland and all woody brush was converted to fescue production. Net returns to

[3] John E. Lee, Jr., "Input Requirements."

fixed resources was $19,546 or 4.7 percent to the total investment of $160,680 after paying $10,000 labor income.

Further restricting the total land to 200 acres (one-fourth the initial land base), with 157.5 acres allowable for forage production, resulted in 126 spring-calving straightbred British cow being maintained. Stocking rate was 1.25 acres per cow; the most intensive production of any alternative considered. Twenty five acres, the minimum allowed, was devoted to improved bluegrass. Cows grazed fescue (62 acres) while hay came from fescue cut once and grazed afterward (71 acres). A total of 528 hours of operator labor was required. Net returns to fixed resources was $9,906. After subtracting 8 percent interest on operating capital and 5 percent on total investment capital of $92,018, labor return was $5,767 or about $10.93 per hour.

Both these limited land alternatives suggest that maximizing the number of calves that could be produced was more profitable than producing larger calves. This situation occurred because the largest cow-calf combination required 52 percent more land (page 125) than the smallest cow-calf combination, and land was the most limiting resource.

Starting from a base of 200 acres and allowing land to be either purchased and/or intensified, the optimum solution purchased 1,235 acres of high quality land at $200 per acre and stocked to 2.11 acres per cow. (The optimum solution is the same as allowing the purchase option discussed in the next section.) Operator labor became the limiting resource. The stocking rate of 2.11 acres per cow was a more extensive system than when land was the limiting resource. The conclusion is that it is more profitable to expand through purchase of land than ultimate fertilizer and seeding intensification when similar quality land can be purchased at $200 per acre.

Limiting labor to 240 hours per quarter, or 80 hours per month, made labor more restrictive than the land base of 800 acres. The operator handled 200 cows, made 89 acres of winter pasture hay, and 51 acres of alfalfa-meadow hay with 204 hours of hired labor annually. Operator income, after paying 8 percent on operating capital and 5 percent on total investment capital, was $9,298 or $9.69 per hour.

In general these limited land resource situations showed that small or part-time operators can expect high returns to their labor by adjusting to an optimum forage and cow production system.

<u>Buy Land Options</u>

Buy land alternatives were considered at $200, $150 and $100 per acre price levels. When operator labor was limited to 240 hours per quarter, no land at any price considered was purchased. Labor was more restrictive in the solution than land. The operator needed more labor before he would buy more land.

With 600 hours of labor per quarter and investment cost of $100 per acre for all three qualities of land, he would have profitably bought 970 acres of the highest quality land with capital rates of 8 and 5 percent. He used an extensive system of improved bluegrass (549 acres), rotational fescue pasture (303 acres), winter pasture (220 acres) and 138 acres of alfalfa-meadow. The stocking rate was

2.55 acres per cow with 474 cows, mostly fall calving crossbreds (325 head). He would clear brushland (197 acres) but no woody brushland.

With land not limiting the solution, larger calves were more profitable than more smaller calves.

With land cost of $150 per acre, 567 acres of high quality land were purchased at 8-5 percent capital rates to add to the base unit of 800 acres. Production was somewhat more intensive, with improved bluegrass declining to 162 acres and fescue pasture increasing to 462 acres. Winter pasture (177 acres) and alfalfa-meadow (148 acres) provided winter feed. Stocking rate was increased to 2.11 acres per cow with 449 cows.

Even with land prices of $200 per acre, the optimum solution called for buying high quality land at the 8-5 percent capital rate in order to more effectively use available labor. The organization was exactly the same as that at $150 per acre prices. Net returns were slightly reduced, and return to total investment declined nearly 1.0 percent.

Stocking rates did not rise above 2.11 acres per cow when the buy land options were included. This result indicates that buying land at $200 per acre was a lower cost alternative for expansion than was ultimate intensification. In general the optimum intensification was improved bluegrass (on land that could not be established to other species), fescue pasture, winter pasture, and alfalfa-meadow for hay. Brush was removed, but the high cost of bulldozing woody brushland was not incurred when open land could be purchased.

Buy Land Option: Relative Prices Per Acre

Comparing relative prices on land of \$200 per acre for high quality, \$150 for medium, and \$100 for low quality, the medium quality was a better buy (see Page 95) for description of land qualities). Up to 745 acres of it was bought at the 8-5 percent rate. Even at capital rates of 13 and 10 percent 552 acres could be bought profitably. The reservation price on capital had to rise to 18-15 percent before it was not profitable to buy medium quality land at \$150. This result indicates that the return to land investment on \$150 per acre (medium quality land, economically intensified, and \$50 calf prices) falls between 10 and 15 percent.

These are high rates of return on \$150 per acre land with only 51 percent cleared plus 12 percent in brush or woody brush, suitable for forage production. Conversely, it may be stated that economic incentive exists for herd expansion through farm consolidation at land prices of \$150 per acre with 37 percent of the land in forest not suitable for pasture production.

Price of low quality land had to be \$75 per acre before it was a more profitable investment than high quality land at \$200 per acre and medium quality at \$150 per acre. At \$75 per acre, 1,248 acres were bought; 700 acres remained in forest and 62 acres of woody brush were not cleared.

CONCLUSIONS

Current and projected high beef calf prices make improved forage and beef cattle production practices profitable in southeastern Ohio.

Cattlemen can increase their income by improving forage management. They should develop an all season forage production program, then fit cattle to the forages. Their point of view should be marketing forages most effectively by converting them into livestock products.

Optimum combinations of enterprises (Table 22) for the initial set of resources provides these guidelines for adopting improvements.

1. At rates of 33 and 30 percent on additional capital, supplemental fescue summer pasture and fescue winter pasture were economic practices.
2. Fertilizing native bluegrass pastures, on land areas which could not be converted to more intensive species, was profitable at 28-25 percent capital rates. If the land was not too steep, returns were greater if fescue was established to replace the bluegrass.
3. Alfalfa-meadow hay provided the next most profitable step in intensification for winter feed production at capital rates of 28 and 25 percent.
4. Clipping brush from grown-up land and establishing productive species occurred at 23-20 percent rate.
5. Switching to more expensive production of fescue hay cut once and grazed the remainder of season, entered

at 23-20 percent capital rates. Added returns from additional calves more than offset higher feed costs.

6. The solution purchased hay for supplemental feed at 18-15 percent rates on added capital. Purchased corn allowed further profitable intensification at 13-10 percent rate.

   These results indicate that a manager can expect higher returns on his investment if he uses the above mentioned intensification practices on his land rather than purchasing hay or corn. Extending the interpretation of the results suggests that subsequent methods of intensification yield lower rates of return than purchasing feed, however. At what point the operation should be converted to a feedlot situation was not investigated though.

7. Buying additional land at $150 per acre for medium quality land, rather than further intensification, became feasible at 13-10 capital rate.

8. Woody brushland could profitably be cleared at only 8-5 percent rates on capital and never entered the solution if any of the above alternatives existed.

9. Orchardgrass never appeared in any solution because of its similar cost but lower production relative to fescue.

10. Optimum cow herds were generally British crossbred fall calvers. Their fast growing characteristics on medium feed levels produced 630 pound calves in 10 months; these size calves were not severely discounted in price. Hence, returns per unit of inputs were greatest for this type. Fall calving cows paid the extra feed bill.

    However, the differences in returns among any of the cow alternatives were not sufficient to be considered significant.

11. As production was intensified, particularly in limited land situations, spring calving increased in relative profitability. In severely limited land situations, straightbred British spring calvers yielded the highest net returns by allowing more calves to be produced on a limited feed supply.

After having defined optimal enterprise combinations at selected rates, changing the resource situation, or various coefficients, produced further insights into alternatives considered.

1. Higher utilization rates on winter pasture or higher wage rates made winter pasture relatively much more profitable. In either case, however, a forage production system that harvested excess spring growth as conventional hay was still viable.

2. Price increases 25 percent above $50 levels did not induce further intensificiation but did raise the rate of return on investment to 16 percent. Nor did gross receipts 25 percent lower significantly change optimum organization but they did lower rate of return to 1.4 percent. Receipts 50 percent lower barely paid 8 and 5 percent on added capital, and paid nothing to operator labor or fixed capital. Lower cattle prices signaled for an extensive system of unimproved bluegrass and lower stocking rates.
3. Part-time and small operations reaped high returns for the labor hours required. (Note this statement refers to <u>required</u>, not available hours.) A 200 acre unit required only 528 operator hours and 177 hired hours.
4. Buying additional land to fully employ operator labor time in productive work was a profitable alternative. As land prices increased from $100 to $200 per acre more intensive utilization went hand in hand with purchase of additional acres.

Implications of Results and Conclusions For an Extension Service Educational Program

In the introduction of this dissertation, it was noted that if the pasture land in southeastern Ohio were developed to a carrying capacity of 2 acres per animal unit, the potential cow numbers could approach one million head (page 7). The 1969 Census of Agriculture reported less than 300,000 cows in the region at that time. The gross returns from an additional 700,000 cows could approach $140 million! Returns to fixed land, cattle and machinery investment, and operator labor and management could exceed $100 million.

The significant aspect of this potential is that the technology for implementation already exists. Agronomists and animal scientists at the Ohio Agricultural Research and Development Center have identified and established many of the major techniques. Not all questions have been answered, but enough answers exist to provide a sound basis for implementation.

The chore remaining to be completed is an economic systems approach to problem delineation and solution. This study was an attempt to define an economic system of farm organization.

However, extrapolating the results and conclusions from this research problem into an Extension educational program must be done with caution. Essentially, the point of view in this study has been a single farm or micro-economic approach; an educational program would have a regional or macro-economic approach. The macro effects of expanded production need to be considered.

The most significant economic factors are feeder calf prices and costs of production. According to Dr. Lee's comments (page 8), the USDA projects that $35 per hundredweight prices will be sufficient to elicit the required production response. This study indicates that $50 per hundredweight prices would be required to induce production responses in southeastern Ohio. Other regions of the country may have lower cost structures. Their production response may create sufficient supplies to lower feeder calf prices below the economic level for Ohio producers.

In a second area of caution, readers must remember that this study did not contain any elements of risk and uncertainty. No weather vagarities, labor difficulties, operational problems, timeliness discounts, lack of knowledge, or production inefficiencies were built into the mathematical matrix. Unforeseen operational problems may develop as cow herds are increased in size and farms are intensified. Relatively few herds qualified for the survey of producers that was conducted (page 88). Their herds averaged 75 cows. Herds with 300 cows will require different management concepts and approaches than are currently being practiced.

The hugh capital requirements of $300 to $500 thousand projected for the operations will require changes in thinking by lenders and borrowers.

In another area of managerial consideration, the linear programming model assumes the same input-output responses for 75 cows as for a 350 cow herd. Physically, this assumption may be valid. Some economies of scale will be achieved and some diseconomies may balance them out. However, managerially the assumption of linearity of response may not be valid. Doubling the size of an enterprise may not double the management load, but management demands are increased. Quadrupling size of the herd from 75 cows to over 300 head must greatly intensify the management load. Small errors have large monetary consequences.

The role of management in making the program operative is probably the most critical element. A manager who can put together and operate a $300 to $400 thousand investment will not likely be satisfied with the $10,000 labor-management income assumed in the analysis. Labor available for operating an optimum unit was in the neighborhood of 5 to 7 man-hours per cow. Such intensification requires planning and organization. The type of man who can do those jobs may command twice the salary in other endeavors.

On the other hand, the research identifies some areas where educational emphasis may yield high returns. A part-time operator has an entirely different cost structure than a full-time operator. The farm is his home; he may not charge real estate cost against the cows. His recreation may be riding fences; labor charges are minimal The factor of reduced labor requirements, in the form of two hours per day, may be very important in making a forage management program successful for a part-time operator. The all season forage concept permits a spreading of labor requirements and a reduction in labor demand in peak periods. Returns approach $10 per hour. The additional investment required is not beyond most operator's thinking. An educational program with these operators could help them increase their profits significantly.

The question might arise as to why farmers have not already responded to the high beef calf prices by intensifying their operations and increasing their herds. Several possible factors may be cited: (1) lack of information - they do not know what the intensive methods are; (2) realiability of information - they think the situation fits someone else, and not their resources; (3) inertia on farmers part - they have always produced calves by extensive methods, why shift now; and (4) price expectations - they have seen low prices follow good prices before.

There are situations where the results of this study will yield the returns projected. An educational program needs to be alert to those situations; but users of these findings must also appreciate the limitations that are inherent in a study of this nature.

Further Research

This study was based upon static conditions and derived coefficients. Further research is called for in order to test and refine some of the assumptions employed and to make application more realistic in the time dimension.

Since many development practices require an initial capital outlay and yield delayed returns, a dynamic poly-period analysis reflecting interest changes and time discounted returns would provide a more realistic look at effective rates of yield on capital.

Land development from brush and woody brush into pasture production should be studied and accurate records maintained on the activity. Given an undeveloped situation, what are alternative methods and associated costs of slow development with little capital vs rapid improvement at high capital costs? Cost of bulldozer work has been developed. What about aerial or tractor spraying with chemicals to kill the trees then let them rot down? Will volunteer grass come in under sprayed brush? What fertility and lime rates of application from 0 pounds to so many tons are most economical? Will heavy stocking rates of cows recycling nutrients gradually improve the land? What corrective fertility application, grass seeding technique, and stocking rate combination is most economical over a development period of 5 to 10 years duration. The decision criteria is the compounded cost of the practice compared to discounted returns from anticipated production. Considering the total area in Appalachia that has reverted to non-productive use, a pilot project with 10 units of 100 acres each (1,000 acres) could yield valuable information now that market prices signal the need for increased beef production

Uncertainty should be built into a dynamic analysis. Rainfall and drought change forage yields. Specie tolerance to drought risk may affect the optimum organization. Stocking rates may need to be reduced in the face of drought; or a hay storage versus selling brood stock plan developed.

The impact of price differences on optimal solutions needs further investigation. How fragile are the solutions? At what price ratio for various feeds and various resources do the solutions change?

Broadening the initial resource base to include situations representing a region like southwestern Ohio would allow crop production alternatives to be included. The effects of corn silage or corn-stalk grazing in feeding programs upon costs and organization of the cow herd could be studied. This base would further allow grain finishing of the calves to be an alternative. Economics of the total beef animal production process from conception to slaughter could be evaluated. What age the calf should be weaned and placed on full feed could be determined.

In the area of agronomic and animal production coefficients many questions need to be answered. Agronomists and animal scientists need to think in terms of production surfaces where one input is measured against output, where two inputs substitute for each other and where one production system is compared to other production systems. A production economist as part of a team to design and conduct research would improve the total research effort.

Particular coefficients in this study had to be assumed; the relationships should be investigated in controlled situations in order to establish what the real values are. The biggest question mark was how much of the TDN production from forages can be effectively utilized by livestock. Even in feedlots, some physical waste occurs; much more occurs on pastures from trampling and contamination. Just how much occurs? How can it be minimized? How much of the forage production can cows be forced to utilize?

Harvest, storage, and deferral losses occur also. What is the extent of their occurrence? How can these be economically reduced? How much loss in TDN yield occurs as growth is stored on the stump? What are economical pasture rotations? Will rotating pastures pay the extra fence cost?

The use of alfalfa as a legume in pastures to improve quality and provide a source of nitrogen fertilizeration needs extensive study. Alfalfa pasture did not appear as a viable alternative in solutions in this study. Possibly, the yield coefficients were wrong; they had to be synthesized because so few studies on the subject exist.

Are there other legumes that will replace nitrogen application? Combined nitrogen and legumes may produce the most valuable yield availability curves. At what cost for nitrogen do legume sources shift into the plan?

Fertilizer response functions should be established for all important forage species. What are the yields obtained from varying nitrogen, phosphorus, potash and lime applications, with and without legumes?

What are the effects of recycling nutrients from manure and urine upon pasture fertilization? The fact that soil tests and forage yields at EORDC have consistently improved after only moderate initial applications of phosphate and lime should cause agronomists to rethink their recommendations on pasture fertility. Low prices of cattle and poor utilization of added grass production have caused farmers to limit pasture fertilization. The price situation has changed drastically. How much added fertilization can be sold through added animal weight gain per acre?

Animal scientists can help define economic relationships also. A forage-livestock system connotes nutrient production and nutrient conversion into salable calf weights. Demands upon the feeder calf supply has shortened the life cycle of beef animals. Prices dictate a need to produce more beef, faster. With rapid gaining cattle and high milk production by the dam, how rapidly can beef be produced? Or is it cheaper to feed the calf directly rather than feeding the cow to produce milk to feed the calf? Maybe cows should only be incubators, weaning small calves in three months, or maybe they should be dairy factories producing slaughter calves directly off the dam. The criterion for judgment is not TDN efficiency, but cost vs return - net income. TDN from various sources does not cost the same; therefore TDN efficiency is a poor measure of profitability.

An Ohio observer in the West commented, "We waste more feed then cows out here ever see." Maybe this observation suggests an Ohio cow should have a different role than a Nevada cow.

When are the critical nutrient periods on a cow's production ability? When should she be gaining weight and when loosing? How valuable is a "skinny" cow.

The most profitable type of cow and calving date was not established by this research. But some questions were generated. Will November-December born calves best utilize the spring flush growth or will some other birth month be best? November calving requires February breeding. If high milk producing cows will not rebreed then, can the manager afford supplemental feeding to "flush" them. Earlier cited research shows that British cows require only 4.5 pounds of TDN daily before calving and 16.0 pounds after calving in order to rebreed. Will surplus May forage "flush" heavy milking cows so that they will rebreed in June?

Type of cow and calving date may affect the percent of nutrient utilization from forage. What winter feeding system, calf birth date, and stocking rate combination produces the most net return? Winter pasture systems may require a different cow type and calving date than corn stalk winter feeding.

The fact that optimum solutions in this study often used winter pasture plus some conventional baled surplus spring growth suggests that stored hay may be utilized to supply a source of late winter nutrients to "flush" the cows for breeding in February and March.

Possibly the cow type and calving date question can be settled by research which investigates the percent of nutrient utilization that each alternative achieves. What about conception rates and cow longevity on the different systems?

On the other end of the cycle, when should calves be weaned? Beef cows often loaf for five months; should they feed a calf for ten months, or only four months? Analysis of this question involves nutrient requirements and feed quality for the calf after weaning.

There are two cost areas in cow production where economies can be effected: feed and labor. On the labor side, just how much labor time will a cow pay for? When are highest labor returns earned in cow jobs? (It may be in marketing calves.) Maybe cows do not need to be seen but once a month or once a year. How many cows can one man care for in Ohio and do only those jobs that pay him a decent wage rate per hour? What are labor saving practices and techniques: a handy chute, field layout, fenced-out woods and blind corners, and salt trained cows? Would salt-rationed ground corn and deferred browse be the most economical labor and machinery system of supplying energy to 1,000 cows?

The economist has a role in helping develop forage-livestock farms. He needs to help define critical managerial practices. What kind of man does it take to make an intensive operation successful? What is the time pattern of critical jobs and chores? What are methods for spreading the work load and fitting the load to supply of labor? What kinds of records should a cattleman maintain; how can he obtain the necessary ones? Record keeping yields diminishing returns also.

Some of the optimum organizations required nearly a half million dollars of capital. The economist needs to define capital structures, stock investment plans, investment trusts, leasing, and leveraging methods through which managers can gain access to reservoirs of capital.

The forage production-calf production process is extremely complicated by many variables. Research to date has answered only a few of the questions. Those unanswered ones call for continued work. A team approach with agronomists, animal scientists, and economists is required to define problem areas and define research programs which investigate those problems. Only through cooperation and interaction between disciplines will realistic answers be generated.

APPENDIX A
PASTURE CALENDAR GUIDE

This is only a guide to be used in forage program planning.

Grazing days for the year and by months based upon the anticipated hay yields and for the various crops indicated for one cow equivalent. (one animal unit)

An animal unit is the equivalent of one cow in feed consumption; one diary or beef cow, two heifers or two beef steers, five ewes, one horse, six sows.

An animal unit of pasture in any month is approximately the amount of pasture which a mature dairy or beef animal will eat in a month of grazing. It is here considered to be 600 pounds of dry matter, containing 400 pounds of T.D.N.

Grasses	Annual Hay Yield Equiv. Lbs.	Total A. U. Grazing Days	Animal Unit Grazing Days Per Acre Per Month											
			Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Bluegrass Pasture Untreated-very poor	1000	25	-	9	8	2	1	3	2	-	-	-	-	-
Untreated-poor	2000	50	-	18	16	4	2	6	4	-	-	-	-	-
Untreated-fair	3000	75	-	22	21	9	4	10	9	-	-	-	-	-
Treated (L-P-K)-good	5000	105	6	30	28	10	5	12	10	4	-	-	-	-
Treated (L-N-P-K)-very good	7000	160	10	47	46	15	7	16	13	6	-	-	-	-
Extended Grazing	7000	115	8	15	15	15	15	15	15	10	7	-	-	-
Deferred Winter Grazing	7000	100	6	34	18	-	-	8	10	10	10	4	-	-
Deferred Summer Grazing	7000	95	-	-	-	50	30	10	5	-	-	-	-	-
Orchardgrass +N	8500	210	18	50	50	30	25	17	15	5	-	-	-	-
Tall Fescue +N	11000	280	30	70	60	20	15	40	25	15	5	-	-	-
Tall Fescue +N-Winter Pasture	11000	220	20	-	Bale	-	-	-	-	20	45	45	45	45
Timothy +N	6400	160	16	53	48	7	4	17	10	5	-	-	-	-
Smooth Bromegrass +N	8000	200	18	62	58	8	6	19	21	8	-	-	-	-

APPENDIX A (cont.)

Legumes	Annual Hay Yield Equiv. Lbs.	Total A. U. Grazing Days	Animal Unit Grazing Days Per Acre Per Month											
			Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Alfalfa - grass mixture Pastured all season*	6000	120	3	33	41	18	18	7	-	-	-	-	-	-
	8000	180	5	50	46	35	32	12	-	-	-	-	-	-
	12000	260	5	70	70	45	40	15	-	15	-	-	-	-
After 1st Hay Crop*	6000**	60	-	-	-	26	26	8	-	-	-	-	-	-
	8000**	90	-	-	-	40	38	12	-	-	-	-	-	-
	12000**	125	-	-	5	50	40	15	-	15	-	-	-	-
Red Clover-grass mixture Pastured all season*	3000	70	2	20	25	10	8	5	-	-	-	-	-	-
	6000	130	3	38	42	17	20	10	-	-	-	-	-	-
	8000	180	5	50	50	30	28	12	-	5	-	-	-	-
After Hay Crop*	3000**	20	-	-	-	8	8	4	-	-	-	-	-	-
	6000**	40	-	-	-	16	16	8	-	-	-	-	-	-
	8000**	90	-	-	-	40	33	12	-	5	-	-	-	-
Birdsfoot Trefoil-grass No hay removed	7000	120	5	26	35	29	18	7	-	-	-	-	-	-
	8000	180	5	43	45	40	27	15	-	5	-	-	-	-
New Meadow Seedings	1000	20	-	-	-	-	14	6	-	-	-	-	-	-
Other														
Sudangrass	7500	145	-	-	15	50	47	26	7	-	-	-	-	-
Winter Barley or Rye	3000	80	19	30	-	-	-	-	6	20	5	-	-	-
Wheat	2000	45	15	20	-	-	-	-	-	10	-	-	-	-
Oats	4000	60	-	25	35	-	-	-	-	-	-	-	-	-
Gleaning Corn Stalks	2000	60	-	-	-	-	-	-	-	30	30	-	-	-

* Approximately 30 additional days of grazing can be obtained during September and October if the meadow is not to be maintained for hay the following year.
** Including yield of first harvest.

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APPENDIX B

Assumptions of Linear Programming Model[1]

The assumption of linearity requires that for each activity (process), the ratios between inputs and between each input and the product be fixed and hence independent of the level at which the activity operates. As an example, within the permissible acreage limits for activation of a process indicating production of alfalfa hay, the ratios between inputs such as fertilizer, labor, and water and the ratios between each such input and production of hay in tons per acre are independent of alfalfa acreage. The restrictiveness of this assumption may be reduced by dividing the production function into linear segments which allows incremental shifts in these ratios as total production increases.

The additivity assumption relates to the independent nature of each activity. There is no interaction among the individual activities (processes). This assumption implies, that with the simultaneous operation of two or more activities, the total product produced is the sum of the products produced by the individual active processes and the quantity of inputs required is the sum of the requirements of each individual activity. This assumption may be partially alleviated by combining two or more activities into one composite activity. As an example corn, soybeans, and meadow are commonly rotated on some soils. Rather than have

[1]Quoted from: LeRoy F. Rogers, Organization of Cattle Production on Western Nevada Ranches, B17 (Reno: University of Nevada, August, 1967).

separate processes for each crop, the three could be combined into a rotation. This would permit expression of any complementary relationships between the three crops or avoid any agronomic restrictions against single cropping.

The divisibility and linearity assumptions are closely related in agricultural situations. Indivisibilities of certain factors, such as a tractor or combine, are a major contributor to departure from constant returns to scale. Divisivility means that all non-negative levels of a process are possible. In other words, it is possible for the optimal solution to indicate 302.783 brood cows. This would be no problem since one would likely round such an answer to 300 brood cows. However, if the solution should indicate 1.4 combines, interpretation for management becomes distinctly more difficult.

The assumption of finiteness means that of all the possible activities, only a few may be considered as alternatives. Although there may be many ways to organize a farm, a linear programming model only considers those thought most relevant by the individual constructing the model. This assumption places a heavy judgment burden upon the person responsible for selection of relevant alternatives. However, in a good many cases, familiarity with the industry reduces the restrictiveness of this assumption.

Single-valued expectations is the final assumption to be discussed in this section. This implies that resource supplies, input-output coefficients, and prices are known with certainty. This clearly is a violation of "real world" conditions in the range-livestock industry. The commonly used budgeting process, however, suffers from the same assumption. Linear programming has an advantage over conventional budgeting in that it is possible to determine the stability of the final solution with respect to changing prices, yields, or costs.

Appendix C . Total Digestible Nutrient Requirements, STRAIGHTBRED BRITISH CATTLE
SPRING CALVING

Cow weight 1000 lbs. Average milk production 11.6 lbs. Average calf weaning weight 450 lbs.

Month	TDN for cows					TDN for calf		Total TDN	
	Maintenance	Travel	Reprod.	Milk Prod.	Total	from milk	from pasture	Daily	Monthly
1	6.62	.52		3.92	11.06	2.20		11.06	338
2	6.62	.52		3.99	11.13	2.28	.70	11.85	361
3	6.62	.52		3.99	11.13	2.28	1.50	12.64	385
4	6.62	.52		3.94	11.08	2.20	2.11	13.26	403
5	6.62	.52		3.65	10.79	2.05	2.90	13.70	418
6	6.62	.52		3.14	10.27	1.76	3.80	14.08	430
7	6.62	.52	.06	2.28	9.47	1.28	4.86	14.34	438
8	6.62	.52	.10	1.43	8.66	.82	6.39	14.92	455
9	6.62	.52	.20		7.34			7.35	224
10	6.62	.52	.40		7.54			7.55	230
11	6.62	.52	.74		7.88			7.89	241
12	6.62	.52	1.38		8.51			8.52	260
Annual Total									4,183

Appendix C. Total Digestible Nutrients, CHAROLAIS X DAIRY CROSS, FALL CALVING

Cow weight 1200 lbs. Average milk production 20.7 lbs. Average calf weaning weight 715 lbs.

Month	TDN for cows					TDN for calves		Total TDN	
	Maintenance	Travel	Reprod.	Milk Prod.	Total	from milk	from pasture	Daily	Monthly
1	7.59	.63		6.00	14.22	3.20		14.22	433
2	7.59	.63		6.60	14.82	3.52		14.83	452
3	7.59	.63		7.50	15.72	4.00	1.09	16.81	513
4	7.59	.63		7.19	15.41	3.84	2.27	17.69	540
5	7.59	.63		7.19	15.41	3.84	3.25	18.68	570
6	7.59	.63		6.90	15.11	3.69	4.36	19.48	585
7	7.59	.63	.06	6.30	14.58	3.36	5.57	20.14	614
8	7.59	.63	.10	5.40	13.72	2.88	7.18	20.91	638
9	7.59	.63	.20	4.55	12.96	2.55	8.50	24.02	721
10	7.59	.63	.40	4.00	12.62	2.24	9.75	24.61	738
11	7.59	.63	.74		8.95			8.97	274
12	7.59	.63	1.38		9.59			9.60	293
Annual Total									6,371

Appendix C . Total Digestible Nutrients, CHAROLAIS X BRITISH CATTLE,
SPRING CALVING

Cow weight 1100 lbs. Average milk production 14.5 lbs. Average calf weaning weight 520 lbs.

Month	TDN for cows					TDN for calves		Total TDN	
	Maintenance	Travel	Reprod.	Milk Prod.	Total	from milk	from pasture	Daily	Monthly
1	7.12	.58		5.10	12.80	2.72		12.79	390
2	7.12	.58		5.10	12.80	2.72	.88	13.65	417
3	7.12	.58		5.10	12.80	2.72	1.75	14.54	443
4	7.12	.58		4.95	12.65	2.64	2.66	15.30	466
5	7.12	.58		4.81	12.51	2.55	3.58	16.06	490
6	7.12	.58		4.20	11.90	2.24	4.68	16.57	505
7	7.12	.58	.06	3.30	11.06	1.76	5.91	16.97	518
8	7.12	.58	.10	2.40	10.20	1.28	7.12	17.31	528
9	7.12	.58	.20		7.90			7.90	241
10	7.12	.58	.40		8.10			8.10	246
11	7.12	.58	.74		8.44			8.44	257
12	7.12	.58	1.38		9.08			9.08	276
Annual Total									4,777

Appendix C . Total Digestible Nutrients, STRAIGHTBRED BRITISH CATTLE, FALL CALVING

Cow weight 1000 lbs. Average milk production 9.8 lbs. Average calf weaning weight 550 lbs.

Month	TDN for cows					TDN for calf		Total TDN	
	Maintenance	Travel	Reprod.	Milk Prod.	Total	from milk	from pasture	Daily	Monthly
1	6.62	.52		3.92	11.06	2.20		11.06	338
2	6.62	.52		3.99	11.13	2.28	.70	11.85	361
3	6.62	.52		3.99	11.13	2.28	1.50	12.64	385
4	6.62	.52		3.94	11.08	2.20	2.11	13.26	403
5	6.62	.52		3.65	10.79	2.05	2.90	13.70	418
6	6.62	.52		3.14	10.27	1.76	3.80	14.08	430
7	6.62	.52	.06	2.28	9.47	1.28	4.86	14.34	438
8	6.62	.52	.10	1.43	8.66	.82	6.39	14.92	455
9	6.62	.52	.20	.85	8.21	.48	7.44	16.12	492
10	6.62	.52	.40	.72	8.26	.40	7.86	16.53	504
11	6.62	.52	.74		7.88			7.89	241
12	6.62	.52	1.38		8.51			8.52	260
Annual Total									4,726

Appendix C . Total Digestible Nutrients, CHARCLAIS X DAIRY CROSS, SPRING CALVING

Cow weight 1200 lbs. Average milk production 22 lbs. Average claf weaning weight 590 lbs.

Month	TDN for cows					TDN for calves		Total TDN	
	Maintenance	Travel	Reprod.	Milk Prod.	Total	from milk	from pasture	Daily	Monthly
1	7.59	.63		6.00	14.22	3.20		14.22	433
2	7.59	.63		6.60	14.82	3.52		14.83	452
3	7.59	.63		7.50	15.72	4.00	1.09	16.81	513
4	7.59	.63		7.19	15.41	3.84	2.27	17.69	540
5	7.59	.63		7.19	15.41	3.84	3.25	18.68	570
6	7.59	.63		6.90	15.11	3.69	4.36	19.48	585
7	7.59	.63	.06	6.30	14.58	3.36	5.57	20.14	614
8	7.59	.63	.10	5.40	13.72	2.88	7.18	20.91	638
9	7.59	.63	.20		8.42			8.42	257
10	7.59	.63	.40		8.61			8.62	263
11	7.59	.63	.74		8.95			8.97	274
12	7.59	.63	1.38		9.59			9.60	293
Annual Total									5,432

Appendix C. Total Digestible Nutrients, CHAROLAIS X BRITISH CATTLE, FALL CALVING

Cow weight 1100 lbs. Average milk production 12.7 lbs. Average calf weaning weight 630 lbs.

Month	TDN for cows					TDN for calves		Total TDN	
	Maintenance	Travel	Reprod.	Milk Prod.	Total	from milk	from pasture	Daily	Monthly
1	7.12	.58		5.10	12.80	2.72		12.79	390
2	7.12	.58		5.10	12.80	2.72	.98	13.65	417
3	7.12	.58		5.10	12.80	2.72	1.75	14.54	443
4	7.12	.58		4.95	12.65	2.64	2.66	15.30	466
5	7.12	.58		4.81	12.51	2.55	3.58	16.06	490
6	7.12	.58		4.20	11.90	2.24	4.68	16.57	505
7	7.12	.58	.06	3.30	11.06	1.76	5.91	16.97	518
8	7.12	.58	.10	2.40	10.20	1.28	7.12	17.31	528
9	7.12	.58	.20	1.71	9.59	.96	8.25	18.81	241
10	7.12	.58	.40	1.45	9.55	.80	9.21	19.55	246
11	7.12	.58	.74					8.44	257
12	7.12	.58	1.38					9.08	276
Annual Totals									5,461

Appendix D

Estimated Annual Cost Per Acre for Establishing and Maintaining NATIVE BLUEGRASS SOD, Southeastern Ohio, Sandstone Area, 1973

			Cost	
Establishing costs	Unit	Amt.	Unit	Total
Annual maintenance costs				
Fertility: N	lb.			
P	lb.			
K	lb.			
L	lb.	.3	6.00	1.80
Annual establishment cost				.00
Tractor & mach.				
Clipping (every 3rd year)		.12	2.40	.29
Fence repair	ac.	1		.10
Land tax	ac.	1		1.50
Total				$3.69
Operator labor hours				
Nov. - Jan.	hr.			
Feb. - Apr.	hr.		.1	
May - Jul.	hr.			
Aug. - Oct.	hr.		.12	

TDN Utilization

Total	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
600	0	216	192	48	24	72	48	0

Appendix D (cont.)

Estimated Annual Cost Per Acre for Establishing and Maintaining an IMPROVED BLUEGRASS SOD, Southeastern Ohio, Sandstone Area, 1973

			Cost	
Establishing costs	Unit	Amt.	Unit	Total
None				
Annual maintenance costs				
Fertility: N	lb.	60	.09	5.40
P	lb.	10	.086	.86
K	lb.	10	.051	.51
L	lb.	.4	6.00	2.40
Annual establishment cost				.00
Tractor & mach.				
Clipping		.3	2.40	.72
Fertilizing (1/3 per year)		.07	2.50	.18
Fence repair	ac.	1		.10
Land tax	ac.	1		1.50
Total				11.67
Operator labor hours				
Nov. - Jan.	hr.			
Feb. - Apr.	hr.	.1		
May - Jul.	hr.			
Aug. - Oct.	hr.	.4		

TDN Utilization

Total	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
1468	80	430	397	138	66	167	138	52

Appendix D (cont.)

Estimated Annual Cost Per Acre for Establishing and Maintaining an ORCHARDGRASS Sward for Grazing, Southeastern Ohio, Sandstone Area, 1973

			Cost	
Establishing costs	Unit	Amt.	Unit	Total
Seed	lb.	6	.475	2.85
Spray	gal.	.25	4.00	1.00
Tractor & mach.	hr.	1.8	3.73	6.71
Labor	hr.	2.2	2.50	5.00
Special fencing				——
Total				$15.56
Annual charge, prorated 10 years				$ 1.55
Annual maintenance costs				
Fertility: N	lb.	120 (split)	.09	10.80
P	lb.	15	.086	1.29
K	lb.	15	.051	.77
L	lb.	.4	6.00	2.40
Annual establishment cost				1.55
Tractor & mach.				
Clipping	hr.	.3	2.40	.72
Fertilizing	hr.	.4	2.50	1.00
Fence repair	ac.	1		.10
Land tax	ac.	1		1.50
Total				20.13
Operator labor hours				
Nov. - Jan.	hr.			
Feb. - Apr.	hr.	.3		
May - Jul.	hr.	.3		
Aug. - Oct.	hr.	.4		

TDN Utilization

Total	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
2520	216	600	600	360	300	204	180	60

Appendix D (cont.)

Estimated Annual Cost Per Acre for Establishing and Maintaining ORCHARDGRASS for Conventional Winter Hay Production, Southeastern Ohio, Sandstone area, 1973.

			cost-2 cuttings		cost-1 cutting	
Establishing costs	Unit	Amt.	Unit	Total	Amt.	Total
Seed	lb.	6	.475	$ 2.85		$ 2.85
Spray	gal.	.25	4.00	1.00		1.00
Tractor & mach.	hr.	1.8	3.73	6.71		6.71
Labor	hr.	2.2	2.50	5.00		5.00
Total				$15.56		$15.56
Annual charge, prorated 10 years				$ 1.55		$ 1.55
Annual maintenance cost						
Fertility: N	lb.	120 (split)	.09	10.80	120	10.80
P	lb.	45	.086	3.87	35	3.00
K	lb.	150	.051	7.65	100	5.10
L	lb.	.4	6.00	2.40	.4	2.40
Annual establishment cost				1.55		1.55
Tractor & mach.						
Fertilizing	hr.	.4	2.50	1.00		1.00
Haying	hr.	3.0	2.50	7.50		5.00
Feeding	hr.	3.0	1.55	4.65		3.10
Hay labor	hr.	4.0	2.00	8.00	2.5	5.00
Twine				3.50		2.00
Storage	tn.		3.00	12.00		7.50
Fence repair	ac.	1		.10		.10
Land tax	ac.	1		1.50		1.50
Total				$64.52		$48.05
Manure credit				-9.00		-6.00
Annual cost				$55.52		$42.05

Operator Labor hours			
Nov. - Jan.	hr.	1.4	1.2
Feb. - Apr.	hr.	1.6	1.4
May - Jul	hr.	1.0	1.0
Aug. - Oct.	hr.	.5	.5

TDN Utilization

Total	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.
3200 (2 cuttings)		(2.5 ton)			(1.5 ton)		
2744		(2.5 ton)		300	204	180	60

Appendix D (cont.)

Estimated Annual Cost Per Acre for Establishing and Maintaining TALL FESCUE for Summer Grazing, Southeastern Ohio, Sandstone Area, 1973

			Cost	
Establishing costs	Unit	Amt.	Unit	Total
Seed	lb.	20	.305	6.10
Spray	gal.	.25	4.00	1.00
Tractor & mach.	hr.	1.8	3.73	6.71
Lbor	hr.	2.2	2.50	5.00
Special fencing				.00
Total				$18.81
Annual charge, prorated 10 years				$ 1.88
Annual maintenance costs				
Fertility: N	lb.	120 (split)	.09	10.80
P	lb.	15	.086	1.29
K	lb.	15	.051	.77
L	lb.	.4	6.00	2.40
Annual establishment cost				1.88
Tractor & mach.				
Clipping	hr.	.3	2.40	.72
Fertilizing	hr.	.4	2.50	1.00
Fence repair	ac.	1		.10
Land Tax	ac.	1		1.50
Total				20.46
Operator labor hours				
Nov. - Jan.	hr.			
Feb. - Apr.	hr.	.3		
May - Jul.	hr.	.3		
Aug. - Oct.	hr.	.4		

TDN Utilization

Total	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
3000	300	720	660	240	180	480	240	180

Appendix D (cont.)

Estimated Annual Cost Per Acre for Establishing and Maintaining TALL FESCUE for Winter Pasture, Southeastern Ohio, Sandstone Area, 1973

			Cost	
Establishing costs	Unit	Amt.	Unit	Total
Seed	lb.	20	.305	6.10
Spray	gal.	.25	4.00	1.00
Tractor & mach.	hr.	1.8	3.73	6.71
Labor	hr.	2.2	2.50	5.00
Special fencing	ac.		5.00	5.00
Total				$23.81
Annual charge, prorated 10 years				$ 2.38
Annual maintenance costs				
Fertility: N	lb.	120 (split)	.09	10.80
P	lb.	15	.086	1.29
K	lb.	15	.051	.78
L	lb.	.4	6.00	2.40
Annual establishment				2.38
Tractor & mach.				
Haying	hr.	1.0	2.50	2.50
Fertilizing	hr.	.4	2.50	1.00
Fence repair	ac.	1		.30
Land tax	ac.	1		1.50
Total				22.95
Operator labor hours				
Nov. - Jan.	hr.	.8		
Feb. - Apr.	hr.	.3		
May - Jul.	hr.	1.2		
Aug. - Oct.	hr.	.2		

TDN Utilization

Total	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
1600	160	320	320	320	320	160

Appendix D (cont.)

Estimated Annual Cost Per Acre for Establishing and Maintaining TALL FESCUE for Conventional Winter Hay, Southeastern Ohio, Sandstone Area, 1973

			cost-2 cuttings		cost-1 cutting	
Establishing costs	Unit	Amt.	Unit	Total	Amt.	Total
Seed	lb.	20	.305	6.10		6.10
Spray	gal.	.25	4.00	1.00		1.00
Tractor & mach.	hr.	1.8	3.73	6.71		6.71
Labor	hr.	2.2	2.50	5.00		5.00
Special fencing				.00		.00
Total				$18.81		$18.81
Annual charge, prorated 10 years				$ 1.88		$ 1.88
Annual maintenance costs						
Fertility: N	lb.	120(split)	.09	10.80	120	10.80
P	lb.	45	.086	3.87	35	3.00
K	lb.	150	.051	7.65	100	5.10
L	lb.	.4	6.00	2.40	.4	2.40
Annual establishment cost				1.88		1.88
Tractor & mach.						
Fertilizing	hr.	.4	2.50	1.00		1.00
Haying	hr.	3.0	2.50	7.50		5.00
Feeding	hr.	3.0	1.55	4.65		3.10
Hay labor	hr.	4.0	2.00	8.00	2.5	5.00
Twine				3.50		2.00
Storage				12.00		7.50
Fence repair	ac.	1		.10		.10
Land tax	ac.	1		1.50		1.50
Total				$64.85		$48.38
Manure credit				-9.00		-6.00
Annual cost				$55.85		$42.38

Operator labor hours			
Nov. - Jan.	hr.	1.4	1.2
Feb. - Apr.	hr.	1.6	1.4
May - Jul.	hr.	1.0	1.0
Aug. - Oct.	hr.	.5	.5

TDN Utilization

Total	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
3200			(2.5 ton)		210	(1.5 ton)		
3100			(2.5 ton)			330	360	210

Appendix D (cont.)

Estimated Annual Cost Per Acre for Establishing and Maintaining ALFALFA-ORCHARDGRASS for Conventional Winter Hay, Southeastern Ohio, Sandstone Area, 1973

			Cost-2 cuttings		Cost-1 cutting	
Establishing costs	Unit	Amt.	Unit	Total	Amt.	Total
Seed Alfalfa	lb.	10	.64	6.40		6.40
Orchardgrass	lb.	6	.475	2.85		2.85
Spray	gal.	.25	4.00	1.00		1.00
Tractor & mach.	hr.	1.8	3.73	6.71		6.71
Labor	hr.	2.2	2.50	5.00		5.00
Special fencing				.00		6.00
Total				21.96		$27.96
Annual charge, prorated 5 years				4.40		5.59
Annual maintenance costs						
Fertility: N	lb.	--	--	--		
P	lb.	45	.086	3.87	.35	3.00
K	lb.	150	.051	7.65	100	5.10
L	lb.	.6	6.00	3.60	.6	3.60
Annual establishment cost				4.40		5.59
Tractor & mach.						
Fertilizing	hr.	.2	2.50	.50	.2	.50
Haying	hr.	3.0	2.50	7.50		5.00
Feeding	hr.	3.0	1.55	4.65		3.10
Hay labor	hr.	4.0	2.00	8.00	2.5	5.00
Twine				3.50		2.00
Storage				12.00		7.50
Fence repair	ac.	1	--	.10		.10
Land tax	ac.	1		1.50		1.50
Total				$57.27		$41.99
Manure credit				-6.00		-4.00
Annual cost				$51.27		$37.99
Operator labor hours						
Nov. - Jan. 1	hr.	1.4			1.2	
Feb. - Apr.	hr.	1.6			1.4	
May - Jul.	hr.	1.0			1.3	
Aug. - Oct.	hr.	.5			.7	

TDN Utilization

Total	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
3200(2 cuttings)			(2.5 tons)		(1.5 tons)			
2800			(2.5 tons)	442	290	79		

Appendix D (cont.)

Estimated Annual Cost Per Acre for Establishing and Maintaining an ALFALFA-ORCHARDGRASS Sward for Summer Grazing, Southeastern Ohio, Sandstone Area, 1973

			Cost	
Establishing costs	Unit	Amt.	Unit	Total
Seed Alfalfa	lb.	10	.64	6.40
Orchardgrass	lb.	6	.475	2.35
Spray	gal.	.25	4.00	1.00
Tractor & mach.	hr.	1.8	3.73	6.71
Labor	hr.	2.2	2.50	5.00
Special fencing	ac.		6.00	6.00
Total				$27.96
Annual charge, prorated 5 years				5.59
Annual maintenance costs				
Fertility: N	lb.	--	.09	--
P	lb.	20	.086	1.72
K	lb.	40	.051	2.04
L	lb.	.5	6.00	3.00
Annual establishment cost				5.59
Tractor & mach.				
Clipping	hr.	.3	2.40	.72
Fertilizing	hr.	.2	2.50	.50
Fence repair	ac.	1		.30
Land tax	ac.	1		1.50
Total				15.37
Operator labor hours				
Nov. - Jan.	hr.			
Feb. - Apr.	hr.	.3		
May - Jul.	hr.	.5		
Aug. - Oct.	hr.	.4		

TDN Utilization

Total	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
2375	66	660	607	462	422	158		

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