



Marketing practices and potential impact of hay processing on the Montana hay market
by Clynn G Phillips

A thesis submitted to the Graduate fulfillment of the requirements Faculty in partial for the degree of
DOCTOR OF PHILOSOPHY in Agricultural Economics

Montana State University

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Abstract:

This research study was initiated to make an examination of the general hay market in Montana. Attention was given to the marketing practices of hay buyers and sellers, efficiency of the present market structure with respect to grading, distribution and other price considerations, and finally, the impact of recent developments in hay processing on the Montana hay market.

The "Montana hay market" is characterized by many small, local market areas. Hay, because of its high bulk-low value nature, is limited to a rather small geographic area and to a relatively few potential buyers and sellers. There are three major hay user groups--dairymen, ranchers, and feedlot operators—in Montana and they each tend to value hay for different nutritional aspects. Type of hay and cutting preferred, seasonality of market transactions, and other characteristics of a particular market are related to the dominate hay user group in the area.

As a means of evaluating the performance of the existing market structure for hay, the efficiency criterion of the perfectly competitive marketing system was adopted. Three major obstacles to the achievement of this standard of performance were noted. The first obstacle is posed by the limiting physical characteristics of the typical Montana hay market.

The second obstacle is the general apathy of Montana hay market. The second obstacle is the general apathy of Montana feeders to quality and other productive aspects of hay. The third problem arises out of the lack of reliable and current hay market information. Until these problems are overcome, the efficiency of the Montana hay market will probably be below the idea standard postulated.

Interest in hay processing has grown in recent years. Potential for processing of dehydrated alfalfa meal, sun-cured alfalfa meal and alfalfa wafers in Montana was analyzed. It was determined that Montana could compete only on the home market. The potential for sun-cured alfalfa depends heavily on developments in the export market. The freight-rate structure is instrumental in determining what Montana firms are able to compete on this market. The hay watering machine is the center of much attention as a method of processing hay. Length of the harvest season and volume of output are critical factors in the potential impact of this technique for Montana.

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BY

CLYNN G. PHILLIPS

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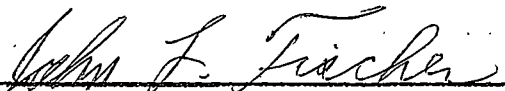
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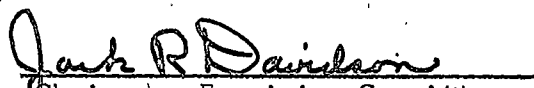
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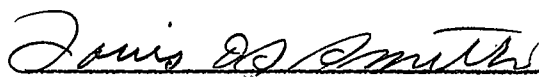
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TABLE OF CONTENTS

	<u>Page</u>
VITA.	ii
ACKNOWLEDGMENTS	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	vi
LIST OF FIGURES	vii
ABSTRACT.	ix
 CHAPTER I. INTRODUCTION.	 1
Historical Perspective.	1
General Hay Market Characteristics.	10
The Research Problem.	12
Objectives.	18
Procedures.	18
 CHAPTER II.	
Theoretical Aspects of Pricing Hay	21
Forage as a Joint Product.	24
Forage as a Joint Input.	26
Pricing Forage as a Crop Output	31
Hay Production Costs in Rotation System	35
Hay Production Costs Under Constant Cropping.	38
Evaluation and Utilization of Hay as a Feed Input	46
Marginal Rates of Substitution and Optimum Hay-Grain Combination	50
Traditional Methods of Estimating Optimum Hay-Grain Combination	60
Current Price Trends and Future Demand for Hay.	66
 CHAPTER III. MONTANA HAY MARKET CHARACTERISTICS.	 71
Description of Hay Producer-Sellers, Buyers and Dealers.	71
Hay Producer-Sellers.	71
Hay Buyers.	74
Hay Dealers	77
Dealer Charges	80
General Buying and Selling Practices	84
Marketing Practices	87
Production Technology and Hay Quality Improvements.	87
Hay Grading and Quality Preferences.	89
Uses of Hay Testing in Montana.	90
Conflicting Requirements of Major Feeding Groups.	91
Organization of a Hay Testing Association	93
Preferences for Various Cuttings and Kind of Hay.	94

TABLE OF CONTENTS (continued)

	<u>Page</u>
CHAPTER IV. HAY PRICES AND PRICING	97
Pricing Hay in Montana	97
Adequacy of Pricing Mechanism	104
Hay Price Trend	106
Seasonal Price Variation	107
Seasonal Price Determination	111
CHAPTER V. IMPACT OF HAY PROCESSING ON THE MARKET FOR MONTANA HAY	120
Growth and Importance of Processed Alfalfa	120
Dehydrated and Sun-Cured Alfalfa Meal	122
Potential of Dehydrated Alfalfa Meal Processing In Montana	139
Marketing Problems	139
Production Problems	143
Production Advantages of North West Central Region of U. S.	144
Production Potential for Montana	148
Sun-Cured Alfalfa Meal	151
Processing Costs of Sun-Cured Alfalfa Meal	154
Wafered Hay	159
Wafering Cost	162
Potential for Wafering in Montana	165
Chapter VI. SUMMARY AND CONCLUSIONS	170
General Market Considerations	170
Theoretical Aspects of Pricing Hay	171
Montana Hay Market Characteristics	173
Hay Prices and Pricing	175
Impact of Hay Processing on the Market for Montana Hay	177
Areas for Further Research	178
APPENDICES	181
APPENDIX A	182
APPENDIX B	184
APPENDIX C	187
APPENDIX D	204
APPENDIX E	208
LITERATURE CITED	213

LIST OF TABLES

<u>Number</u>		<u>Page</u>
I	ALL HAY IN MONTANA, ACREAGE, PRODUCTION, PRICE, TOTAL VALUE, VALUE PER ACRE.	10
II	LIVESTOCK-HAY BALANCE FOR MONTANA.	14
III	AVERAGE 1959 SALES PRICES BY GRADES FOR TILLABLE IRRIGATED LAND IN MONTANA.	40
IV	ESTIMATED HAY PRODUCTION AND HARVESTING COSTS FOR ALFALFA HAY FOR GRADE I B AND GRADE 4 LAND	41
V	HAY PRODUCTION AND HARVESTING COSTS FOR MEADOW HAY WITH ADJUSTMENTS FOR PASTURE VALUE.	45
VI	FEED COMBINATIONS USED IN PRODUCING GIVEN LEVELS OF MILK AND THE MARGINAL RATES OF SUBSTITUTION OF GRAIN FOR HAY.	57
VII	EQUIVALENT VALUE OF FOUR FEED GRAINS WHEN PRICED ACCORDING TO THE VALUE OF T.D.N. PURCHASED THROUGH HAY AT DIFFERENT PRICE LEVELS.	62
VIII	HAY ACREAGE, PRODUCTION AND SALES FOR STATE AND SAMPLE PRODUCERS, 1960.	73
IX	MILEAGE, TONS, DISTRIBUTION AND TRANSPORTATION CHARGES FOR MONTANA HAY DEALERS, 1960.	78
X	MONTHLY INDEXES OF SEASONAL VARIATION IN DEHYDRATED ALFALFA MEAL.	129
XI	ALFALFA MEAL: AVERAGE WHOLESALE PRICES AT SELECTED MARKETS, YEAR BEGINNING OCTOBER, AVERAGE 1957-61, ANNUAL 1957-62.	130
XII	ALFALFA MEAL: PRODUCTION BY REGIONS AND STATES, YEAR BEGINNING MAY, AVERAGE 1957-61, ANNUAL 1957-62	131
XIII	CHANNELS OF DISTRIBUTION USED IN SELLING DEHYDRATED ALFALFA, BY REGION AND BY TYPE OF PLANT, 1954.	133
XIV	SUMMARY OF ALFALFA USE IN RUMINANT FORMULAS BY 43 FEED COMPANIES THROUGHOUT THE UNITED STATES.	152

LIST OF TABLES
(Cont.)

<u>Number</u>		<u>Page</u>
XV	SPECIFICATIONS AND INVESTMENT COSTS FOR A SMALL PELLET- ING MILL.	155
XVI	APPROXIMATE OPERATING COST PER TON FOR A SMALL PELLETING MILL.	157
XVII	RELATIONSHIP BETWEEN PELLETING COSTS PER TON AND ANNUAL OUTPUT FOR SMALL PELLETING MILL	158
XVIII	APPROXIMATE OPERATING COST FOR LUNDELL WAFERING MACHINE .	163
XIX	COST PER TON OF WAFERING HAY WITH TWO TYPES OF MACHINES AT DIFFERENT ANNUAL OUTPUTS.	166

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1	Percent of Total Hay Production Involved in Trade in Montana.	13
2	Hay Surplus Areas in Montana, 1959.	15
3	Hay Deficit Areas in Montana, 1959.	16
4	Relationship of marginal value product to acquisition and salvage value.	25
5	Hypothetical iso-cost curve for hay and grain with iso-revenue line.	27
6	Hypothetical iso-product curve for hay and grain with iso-cost line	29
7	Optimum combinations of hay and grain as joint products and as joint inputs under different assumed prices and levels of production.	32
8	Relationship of expected income of forage crop to expected income of alternative crops where forage enjoys an absolute or comparative advantage.	42
9	Hypothetical expected incomes from two rotation systems--one including a forage crop and one not including a forage crop.	42
10	Relationship of marginal value product to the acquisition cost and salvage value of hay with a marginal cost curve superimposed.	47
11	Hypothetical product contours displaying different marginal rates of substitutions between input factors.	51
12	Estimated production surface for a milk cow showing concentrate and roughage limit lines.	54
13	Milk production surface showing optimum combination of hay and grain for a linear isoquant with an assumed MRS of 2.3017 and a price ratio line with a slope equal to 1.45.	58

LIST OF FIGURES (continued)

<u>Figure</u>		<u>Page</u>
14	Price trends for selected livestock products and feed inputs.	70
15	Index of hay prices deflated and adjusted to a 1947-49 = 100 base.	108
16	Seasonal price movements--all hay baled, 1940-61.. . . .	110
17	Actual and theoretical price patterns for Montana hay. . .	117
18	Alfalfa meal production.	125
19	Seasonal variation in production of dehydrated and sun-cured alfalfa meal.	126
20	Seasonality in alfalfa meal production, disappearances and prices.	127
21	Marketing of dehydrated alfalfa in United State, 1954. . .	134

ABSTRACT

This research study was initiated to make an examination of the general hay market in Montana. Attention was given to the marketing practices of hay buyers and sellers, efficiency of the present market structure with respect to grading, distribution and other price considerations, and finally, the impact of recent developments in hay processing on the Montana hay market.

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As a means of evaluating the performance of the existing market structure for hay, the efficiency criterion of the perfectly competitive marketing system was adopted. Three major obstacles to the achievement of this standard of performance were noted. The first obstacle is posed by the limiting physical characteristics of the typical Montana hay market. The second obstacle is the general apathy of Montana hay market. The second obstacle is the general apathy of Montana feeders to quality and other productive aspects of hay. The third problem arises out of the lack of reliable and current hay market information. Until these problems are overcome, the efficiency of the Montana hay market will probably be below the idea standard postulated.

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CHAPTER I

INTRODUCTION

Hay production and utilization play an important role in the agriculture economy of Montana. Hay is a major feed input in the state's livestock industry and ranks second only to wheat as a harvested crop in terms of value of production. However, only a small percentage of the total annual production enters formal market channels each year. The hay market in Montana lacks many of the characteristics that are thought essential for efficient marketing. There is little known about the mechanism and methods of pricing hay. There is a general lack of knowledge in regards to the marketing practices of hay buyers and sellers and other aspects which effect the size, location, nature and overall efficiency of the hay markets.

The general price-cost squeeze that has characterized agriculture since the early 1950's has caused farmers and ranchers to seek increased efficiencies on all fronts in order that they might maintain their relative competitive position. This study was initiated to describe hay marketing practices in Montana to identify major problem areas, and to make recommendations for improvement where practical.

Historical Perspective

Settlement of Montana had its beginning in the western portion of the state. Fur trappers, missionaries and traders were the first white inhabitants of the Montana territory. Later, discovery of gold at Benetsee Creek (now Gold Creek) west of Deer Lodge Valley created a gold rush of

minor importance which eventually led to a more permanent and complete settlement. Major gold discoveries at Grasshopper Creek in 1862, Alder Gulch in 1863 and Last Chance Gulch in 1864 provided new impetus to the influx of settlers.

Concurrent with the development of most major gold fields was the establishment of necessary trade and service facilities ranging from blacksmith to bartender. Among this list of necessary services, and with high priority, was that of a butcher. The hard working miner wanted meat as a major part of his diet. He seldom had time to hunt game even when it was plentiful. Butcher shops often displayed wild game but most of the miners preferred beef. 1/

Conrad Kohrs, the beneficiary of a butcher shop as a result of the differences his employer had with Montana's famous outlaw-sheriff Henry Plummer, became one of Montana's early cattlemen. In order to meet the demand for meat at his butcher shops in Bannock, Virginia City and Last Chance Gulch, Kohrs began trailing cattle from the Bitterroot, Utah and Oregon. It wasn't long until he and his partner were trading cattle on a sizable scale. To accompany their activities they purchased the Racetrack Ranch in Deer Lodge Valley and later bought out the Johnny Grant ranch

1/ Robert H. Fletcher, Free Grass to Fences, The Montana Cattle Range Story, (New York, New York; University Publishers Incorporated, 1960) p. 18.

and its cattle near the present site of the city of Deer Lodge. In much the same manner and for about the same purpose, the herds of other famous Western Montana cattlemen had their origin at this time. The "outfits" of Poindexter and Orr, D. A. G. Flowerree, Robert S. Ford, and Nelson Story are a few of the noted cattlemen who had their beginning in this era of Montana's history. 2/

The cattle industry in central and eastern Montana didn't develop until about 1880. The resistance of hostile Indians to whites settling on their hunting grounds was usually sufficient to keep any thoughtful person with a desire to live out of this area. However, the massacre of Custer's Army in 1876 and the subsequent breakdown of Indian defenses opened up the area to the settlement of whites. Another inhabiting factor was the expansion of the cattle industry over the Great Plains. It had its origin in Texas and gradually proceeded north as demand for western beef increased. Montana, in a sense, had to wait until stocking of the Plains areas to the south was completed before need for her fertile Plains was felt. When the need did arise, it was deterred by the hostile Indians until sufficient pressure was applied to military personnel and action taken to remove the Indian threat.

By 1879, the setting was right for Montana's "beef bonanza". The "boundless, gateless, fenceless pastures" of the public domain, once

2/ Robert E. Fletcher, Ibid., p. 20.

inhabited by buffalo were quickly being replaced with cattle. Railroad and steamboat records give some inkling of what happened during this period. In 1876, 80,000 buffalo hides were shipped down the Missouri River from Fort Benton; in 1881, 50,000 hides went east via the Northern Pacific Railway. In 1882, some 5,000 riflemen and skinners went to work on the northern buffalo herds and 200,000 hides were shipped out on the Northern Pacific. Rail shipments dropped to 40,000 in 1883 and a mere 300 in 1884, with no shipments reported leaving from Fort Benton. ^{3/}

Vast fortunes were being accumulated by cattlemen from Montana to Texas. Grass on the public domain was free for the taking. Almost anyone who could put enough money together to get a herd of cattle was assured a profit. The only expenses were those for a limited number of cowboys, the needed riding stock and a branding iron. If a degree of permanence was sought, there was the added expense of building a log cabin and a few simple corrals. The price of beef was high and continued to rise throughout most of the period as the demand for cattle to stock the northern plains region competed strongly with eastern slaughter markets.

Magazines and journals carried an increasing number of articles and letters publicizing the romance and riches of western cattlemen. An example of such is an article appearing in the Breeder's Gazette, September 27, 1883

^{3/} Robert E. Fletcher, Ibid., p. 41.

entitled "How Cattlemen Grow Rich."

"A good sized steer," it reads, "when it is fit for the butcher market will bring \$45 to \$60. The same animal at its birth was worth but \$5. He has run on the Plains and cropped the grass from the public domain for four or five years, and now, with scarcely any expense to its owner, is worth \$40 more than when he started on his pilgrimage. A thousand of these animals are kept nearly as cheaply as a single one, so with a thousand as a starter and with an investment of but \$5,000 in the start, in four years the stock raiser had made from \$40,000 to \$45,000. Allow \$5,000 for his current expenses and he is still making \$35,000 and even \$45,000 for a net profit. That is all there is of the problem and that is why our cattlemen grow rich." 4/

The result of such publicity, and a natural one indeed, was the on-rush of men and capital in search of huge fortunes. As Osgood states, "From 1880-1885, the demand for stock cattle on the northern ranges reached to the extreme limits of the available supply." 5/ There is no way of knowing just how many cattle were brought into Montana during this period, but official estimates place the number of cattle in Montana territory in 1880 at 274,316. By 1886 this figure had increased to 663,716. 6/

The flow of capital to the High Plains rapidly brought the number of cattle up to the carrying capacity of the ranges. Considering the fact that weather conditions had been very favorable since 1881, the ranges were

4/ "How Cattlemen Grow Rich", Breeder's Gazette, IV, September 27, 1883 as quoted in Ernest S. Osgood, The Day of the Cattleman, (Minneapolis, Minnesota; The University of Minnesota Press, 1929), p.88.

5/ Ernest S. Osgood, Ibid., p. 89.

6/ Merrill G. Burlingame, The Montana Frontier, (Helena, Montana; State Publishing Company, 1942), p. 283.

probably far overstocked for normal years. As signs of overcrowding became apparent to the more astute ranchers, they began taking action to protect their interests. By selective purchases of railroad land they were not only able to bring under their control a large amount of private land, but they could enclose large tracks of public domain which they were also able to control. The homesteading of land around key water holes and the lush meadow lands along creek bottoms by both rancher and "homesteader" was also being used to control the rangelands. Through these methods the rancher could, for the most part, keep neighboring herds off his own ranges. But he was not entirely protected for he was still vulnerable to the whims of mother nature. In a final attempt to insure himself against loss, the Plains rancher began putting up hay for emergency feed supplies during the winter; a practice ranchers in western Montana had been following for some time.

If there was still doubt in 1886 about the necessity of having a winter feed supply, it was completely removed by the winter of that year. The winter of 1885-86 had been open and warm. It was followed by a hot and dry summer, and as a result, the cattle went into the following fall in very poor condition. To make matters worse, the price of cattle at eastern markets had taken a severe drop and cattlemen were inclined to hold their cattle off the market.

The first severe snowstorm hit the ranges in late November of 1886. It was accompanied by sub-zero temperatures and a cutting wind. The snow was so deep in many areas that the cattle could not dig down to the grass. Those ranchers who had hay, fed all they could, the rest prayed for a chinook. It finally came the latter part of December. By this time winter had already taken a severe toll on the unacclimated "pilgrim" cattle from the East and Midwest. The worst was yet to come however. On January 9, 1887, a new storm moved across the Plains area leaving 16 inches of snow. As if this was not enough, after a slight moderation in temperatures during the latter part of the month, new storms hit in February. 7/

Spring came with a warm chinook in March and cattlemen rode out to face their reckoning. Osgood writes, "The sight of the ranges in the spring of 1887 was never forgotten. Dead were piled in the coulees. Poor emaciated remnants of great herds wandered about with frozen ears, tails, feet, and legs, so weak they were scarcely able to move." 8/

Amount of the total loss was never known for sure. It was estimated at 40 to 60 percent for the entire state. Individual losses, however, ranged as high as 90 percent. 9/ Assessment roles for the state listed

7/ Donald H. Welsh, Pierre Wibaux, Cattle King, Master's thesis, Montana State University, Missoula, 1950, p. 29.

8/ Ernest S. Osgood, op. cit., p. 221.

9/ Donald H. Welsh, op. cit., p. 31.

663,716 head of cattle in 1886. In 1887, they listed only 471,171 head, but this was not a true picture because it does not include calves born after the assessment date and cattle shipped or trailed into the territory during the summer of 1886. 10/

Regardless of the actual loss, the winter of 1886-87 marked the end of an era in cattle operations. The financial losses incurred were so heavy that what eastern money was not wiped out, in a majority of cases, was withdrawn as fast as possible. The speculative fervor that encouraged the building of vast cattle empires was gone. The open range or "free grass" operation was supplanted by an operation with a permanent ranch headquarters and fences ranges. Finally, the winter losses of 1886-87 had the effect of shifting cattle operation from one depending entirely on mother nature for summer and winter feed to an operation where hay and other winter feeds were stocked for use in adverse weather.

Ranchers in the western portion of the state had been putting up hay right from the beginning of their cattle operations. As a result, winter losses were minimized. The total loss in numbers of cattle during the winter of 1886-87 in the Big Hole Basin was estimated to be only about 1 percent. Just when haying got started on a large scale is not known. Robert Ford, one of Montana's foremost pioneer builders, legislators, and cattlemen got his start in Montana as foreman of a haying crew which had

10/ Merrill G. Burlingame, op. cit., p. 284.

contracted to put up hay for cavalry troops stationed at Cow Island. Bill Ennis, Madison Valley pioneer, got his start in Montana by selling wild hay, butter and eggs to the mining camps across the hill. The Big Hole Basin was reported to have been one vast hay field during the summer of 1886, and hay sold for \$8 per ton in the fall. By February of 1887, the price had skyrocketed to \$30 per ton. 11/

The central and eastern regions, unfortunately didn't get such an early start. Some provisions were being made in the early 1880's, however.

Pierre Wibaux and partner were reported by The Glendive Times, July 14, 1883, to have contracted for 160 tons to be put up on their ranch. 12/ This, no doubt, was an exception rather than the rule for this area of Montana. In 1882, the acreage of all tame hay amounted to 16,000 acres. It had risen to 31,000 acres in 1886, 80,000 acres four years later and had increased to 305,000 acres in 1900. 13/

Hay production in Montana has experienced a continuous rise between 1910 and 1950, Table I. It first reached two million acres in 1927 where it remained until about 1932 when acreage was cut to approximately 1,750,000 acres. Production again went up over two million acres in 1942 and has since

11/ Robert H. Fletcher, op. cit., p. 89.

12/ The Glendive Times, July 14, 1883, as quoted in Donald H. Welsh, op. cit., p. 32.

13/ Montana Agricultural Statistics, Montana Department of Agriculture and United States Department of Agriculture, Agricultural Marketing Service cooperating, Helena, December, 1946.

remained between 2.0 and 2.6 million acres. Since its introduction into the state around 1880, alfalfa has grown in importance. In 1961, it accounted for approximately 64 percent of the total production. Wild hay production amounted to 14 percent followed by clover-timothy hay at 13 percent, grain hay at 6 percent and the remaining 3 percent was from other tame forage crops.

TABLE I. ALL HAY IN MONTANA, ACREAGE, PRODUCTION, PRICE, TOTAL VALUE, VALUE PER ACRE. *

Year	Acreage Harvested Acres (000)	Production Yield/acre Tons	Price per Total ton sold Tons	Price per ton sold Dollars	Value of Production Dollars	Value per Acre Dollars
1910	1,125	1.14	1,283	12.20	15,653	13.91
1920	1,738	1.32	2,293	11.23	25,755	14.82
1930	2,193	.98	2,148	10.86	23,330	6.08
1940	1,780	1.16	2,070	5.04	10,433	5.86
1950	2,432	1.12	2,730	24.20	66,066	27.17
1960	2,207	1.31	2,900	24.60	71,340	32.32

* Source: Montana Agricultural Statistics, Montana Department of Agriculture, United States Department of Agriculture, Agricultural Marketing Service cooperating, December, 1946 and December, 1962.

General Hay Market Characteristics

Alfalfa is produced in the irrigated valleys of the western mountainous region and on the irrigated river bottom lands in the Plains area. Leading counties in alfalfa production have traditionally been Gallatin, Madison, Cascade, Carbon, Park, Blaine and Lake. Wild hay production is centered in mountain meadows of western Montana. Beaverhead County leads all other

counties and accounts for approximately one third of the state's production. Powell and Madison counties are relatively large producers of wild hay also.

The gross value of Montana's hay crop has averaged better than 60 million dollars in the past few years. In some areas of the state, forage is the only possible crop that can be grown under the existing soil and climatic conditions. In other areas, hay is produced from forage crops, especially alfalfa, grown in rotation with other farm crops. And in "good hay years" it will be cut from heavy grass areas in eastern and central Montana. Hay is not a primary cash crop in Montana since only about 13 percent enters the market each year. An indication of the amount of hay produced for market in each county can be seen in Figure 1.

Although reliable production figures are available through the state statistician's office, there are no data collected on the consumption of hay on a county basis. Without some knowledge of consumption or the demand for hay it is difficult to visualize the market for Montana hay. Surplus or deficit areas and the resultant flow of traffic will depend on the supply-demand balance for the state as well as each particular county. In previous work at Montana State College these consumption figures were estimated and hay livestock balances derived. ^{14/} Livestock numbers reported in the 1945, 1950, 1955 and 1959 Census of Agriculture Reports

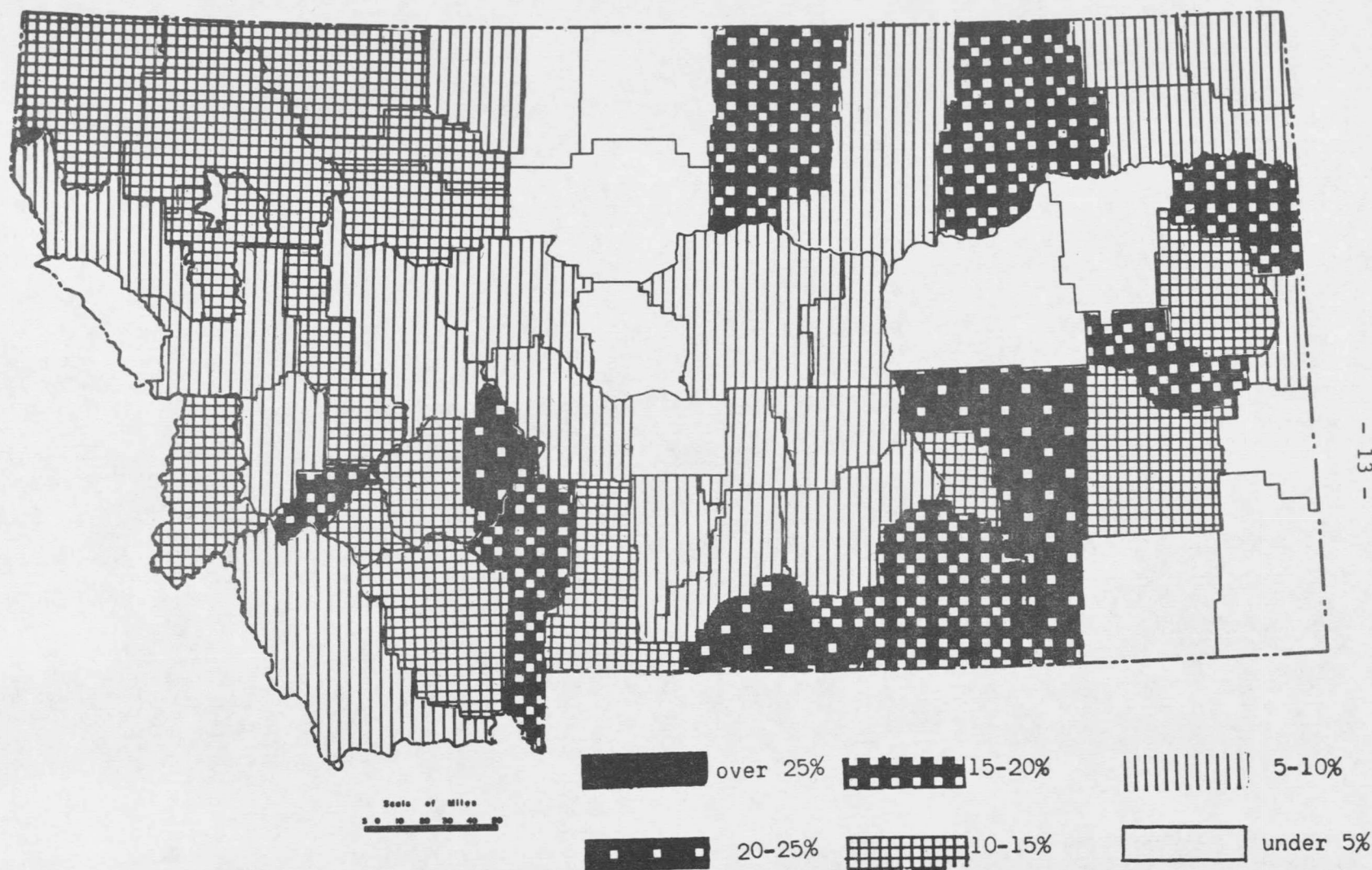
^{14/} Raymond C. Stack, "Marketing Montana Hay", Master's thesis, Department of Agricultural Economics, Montana State College, Bozeman, 1960.

for each county were multiplied by appropriate hay requirements for each class of livestock and a total consumption figure for each of the respective counties was ascertained. From these consumption data and the appropriate production data, Stack was able to derive supply-demand balances. The results of his work are Presented in Table II and Figures 2 and 3.

The hay-livestock balance for any given county depends upon several factors. Weather conditions, livestock numbers, size of hay stocks and condition of the range are instrumental in determining whether a county has a deficit or surplus quantity of hay. In some years these factors may cause a county to be on one side of the ledger and on the other side in other years. In other years they seem only to affect the degree of deficit or surplus. In normal years, however, Montana is considered a deficit hay area as Stack's work indicates. With one possible exception, which will be discussed later, the county balances he derived seem to be representative of normal years.

The Research Problem

The market structure for hay in Montana is characterized by small local markets. These markets lack the formal organization of other commodity markets and have not been able to provide the facilities and services normally available at more advanced markets. In general, trading is carried out in an atmosphere lacking relevant information on current market conditions and under the burden of a poor communications system.



- 13 -

Figure 1. Percent of Total Hay Production Involved in Trade in Montana.

* Source: Raymond C. Stack, op. cit., page 17.

TABLE II. LIVESTOCK-HAY BALANCE FOR MONTANA. *

Year	Total Hay Requirements for Various Classes of Livestock c/					All Hay a/		Percent
	Tons for Milk Cows	Tons for All Other Cattle	Tons for All Sheep	Tons for Horses	Total Production Tons	Tons	Balance	
1945	365,408 b/	1,815,251	678,318	298,022	3,156,999	2,426,030	-730,969	23
1950	311,699	1,756,485	311,965	185,774	2,565,923	1,898,876	-667,047	26
1954	276,405	2,597,505	399,968	123,938	3,397,816	2,784,349	-613,467	18
1959	205,514	2,472,319	422,102	112,294	3,212,229	2,905,350	-306,879	10

* Source: Raymond C. Stack, Marketing Montana Hay, Unpublished Master's thesis, Department of Agricultural Economics and Rural Sociology, Montana State College, Bozeman, 1960, p. 11.

a/ Includes silage.

b/ 1944 data.

c/ Hay requirements for each class of livestock were obtained from Animal Units of Livestock Fed Annually, Statistical Bulletin No. 194, United States Department of Agriculture, Agricultural Research Service, October, 1956, and are as follows: Milk cows 2.8 tons, all other cattle .999 tons, all sheep .2 tons, and horses 1.3 tons.

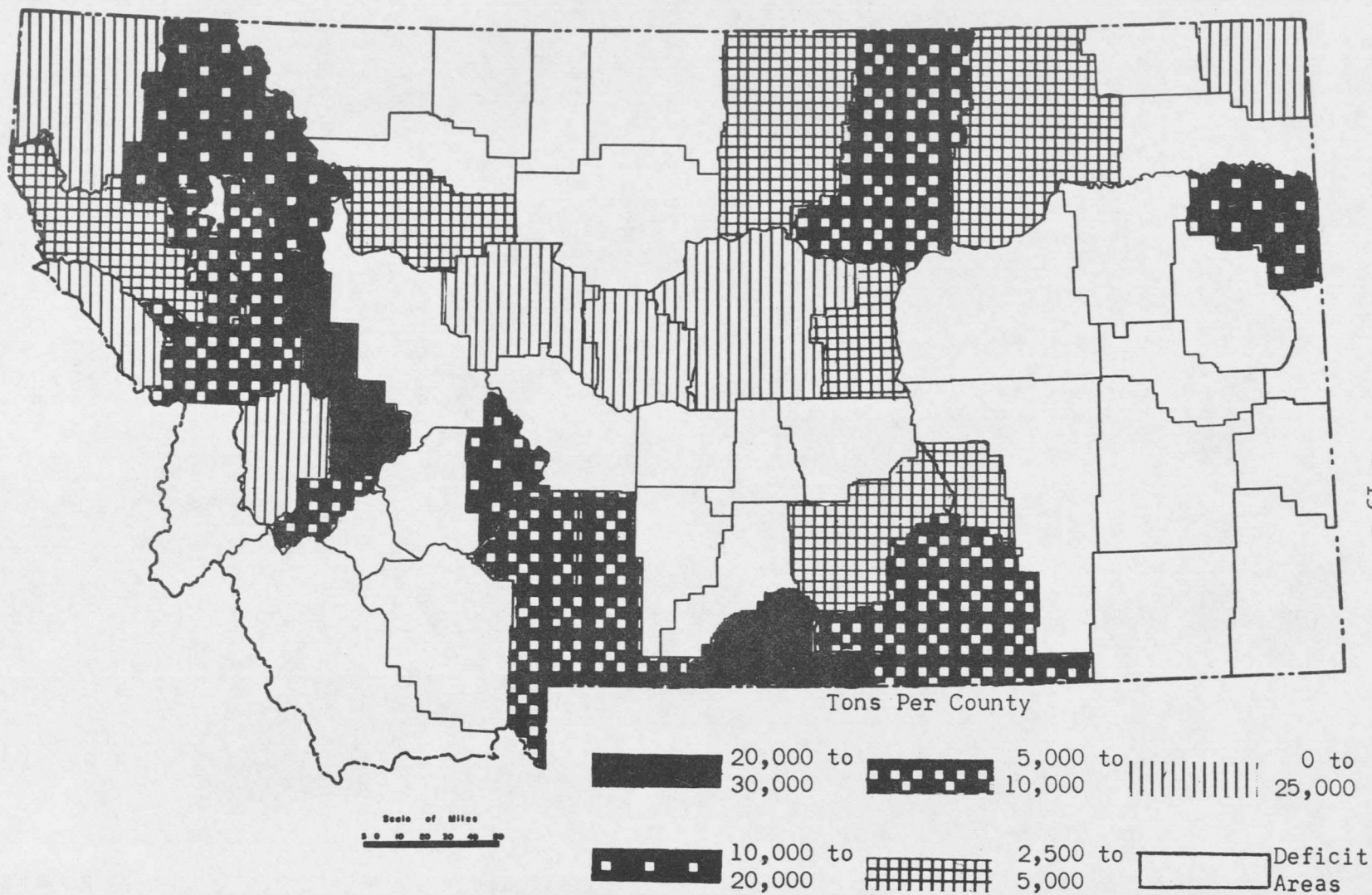


Figure 2. Hay Surplus Areas in Montana, 1959.

* Source: Raymond C. Stack, op. cit., page 12.

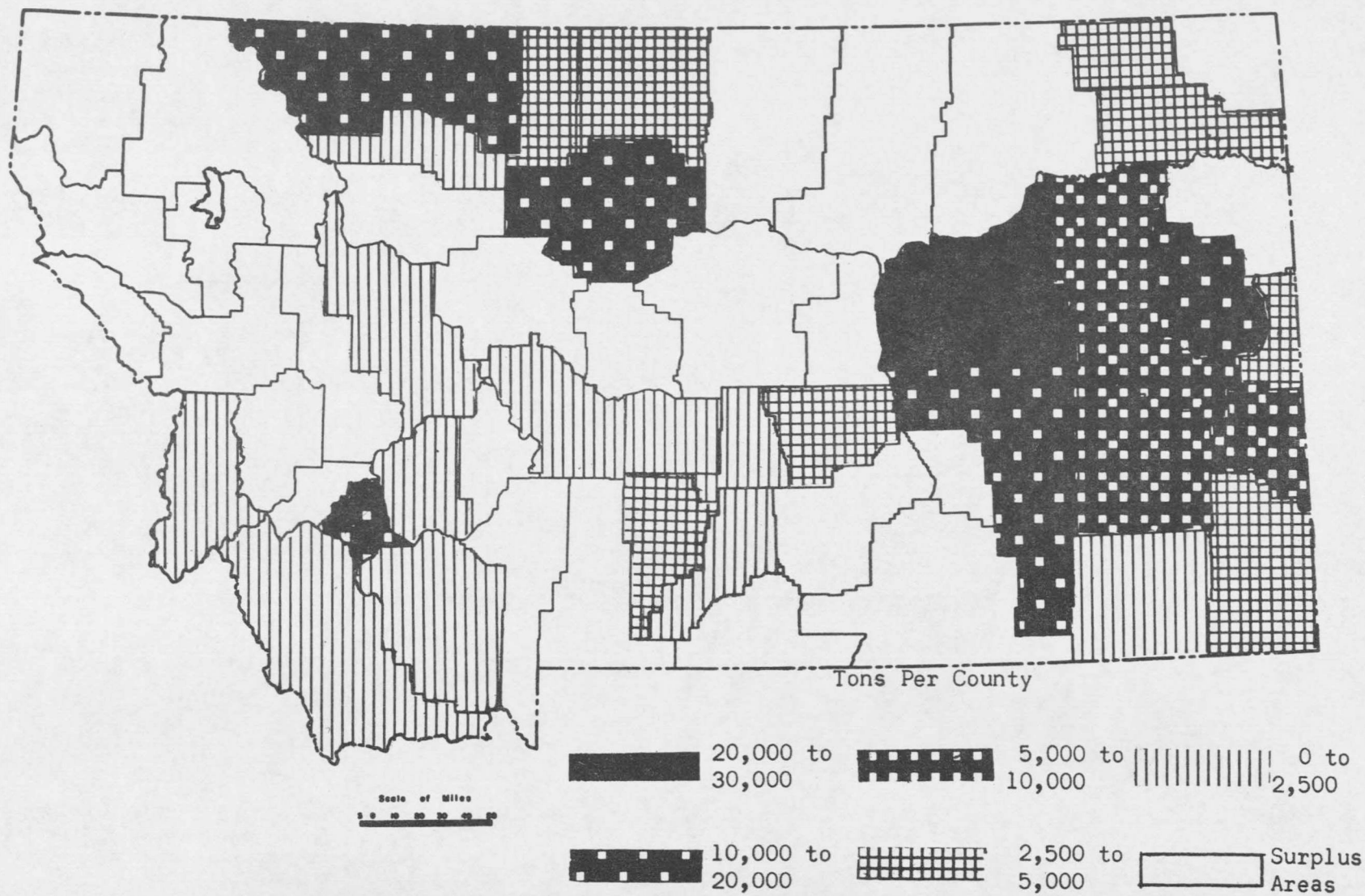


Figure 3. Hay Deficit Areas in Montana, 1959.

* Source: Raymond C. Stack, op. cit., page 13.

Transactions are often so infrequent in some of these markets that a complete evaluation of supply and demand forces must be made for every sale. These and other impediments combine to make most of the local hay markets insensitive to price making forces and render them ineffective in their ability to accurately reflect supply and demand conditions.

The product itself is unique in many respects. In regards to its nutritional value it may be viewed quite differently by dairymen, feedlot operators and ranchers. This makes it difficult to establish an objective quality criterion whereby hay can be graded and priced. It is both a salable product and feed input factor of farm operations. Because of the differences in the value of hay as a feed input and a final product, management decisions regarding its optimum use are complicated.

The market structure for hay has shown little change over the years. Hay has primarily been roughage feed in the production of livestock and livestock products. Because of its bulky physical nature, hay has resisted, in the past, the mechanical and technological developments common to other commodities. Widespread acceptance of dehydrated alfalfa meal as a feed supplement by the formula-feeds industry offers a new market for Montana hay. Compressing hay into a pellet or wafer broadens the market for hay significantly due to decreased costs in handling, storage and transportation. Some of these savings, however, will be offset by higher capital requirements.

Potentially, they all have application in Montana and could alter the market structure for hay significantly.

Objectives

This study was guided by the general hypothesis that the present structure of the Montana hay market has not achieved the general standards of performance thought to characterize more mature markets. A market is considered mature when it achieves the general objectives of a purely competitive system, i.e., that price signals accurately reflect supply and demand conditions and that the productive inputs are remunerated according to value of their marginal product.

Specific objectives will be:

1. To describe the present market for Montana hay and identify major problem areas.
2. To evaluate the performance of the current market structure and offer recommendations and solutions to the problem identified in (1) above.
3. To study price-making forces present in the Montana hay market and to establish guidelines that can be used by farmers and ranchers in decision-making relevant to the input or output of hay.
4. To study the impact and potential impact of recent technological innovations in hay production that might effect the Montana hay market.

Procedures

In the summer of 1961 a survey of hay buyers, sellers and dealers was made by personal interview to gather information pertinent to the

marketing of Montana hay. Usable schedules were obtained from 31 hay buyers, 23 hay producers who sold part or all of their hay, and 10 hay dealers. In addition, valuable information was obtained from individuals indirectly connected with the hay market. County agents were informative in regards to the general hay market in their respective counties and were cooperative in supplying this information. Although commercial feed dealers seldom handled hay other than a few bales for horse and rabbit feed, they were generally well informed on the local hay situation and offered valuable information. Various other interested people were contacted in local areas and their ideas used in describing the market.

No attempt was made to test empirical data obtained in these interviews for statistical reliability. Sampling requisites for these tests would be extremely difficult to meet. The total population of hay buyers hay producer-sellers and hay dealers is not only small but these groups are not evenly distributed throughout the state. In addition, there is no practical means by which qualified persons could be selected randomly. Lists of individuals who normally buy, sell or trade hay are not maintained. Thus, the only method of contacting most of the respondents was to go into the area and search out individuals who would fit into one of the groups.

The information gathered in these interviews was used to describe the markets and sub-markets for hay in Montana. It was used to identify major problem areas, evaluate current market procedures, and as a basis for recommending changes in the existing market structure that would alleviate present problems or improve market performance.

Use of available primary and secondary data was made to study the relevant price relationships. Price-making forces were identified and discussed. Appropriate theoretical models were employed to explain prices and price movements. Price theory was also employed to outline guides that might be of value to farmers and ranchers in making correct input-output decisions.

To accomplish the final objective, a trip was made to Colorado and Nebraska to obtain information regarding the dehydration of alfalfa hay. Fourteen managers of dehydrating plants were interviewed in regards to the operation of their plants. This information, along with that available in related studies and views expressed by Montana dehydrators, was used to measure the impact this process might have on the market for Montana hay. Data from operators of sun-cured alfalfa pelleting mills were collected and with information from studies in neighboring states pertaining to sun-cured operations, a synthetic model was designed to measure the feasibility and market potential this outlet might have for Montana hay. Since reliable cost and production data on hay wafering is not available within the state, the experiences of other states had to be used in measuring the impact of this production process on hay marketing. Valuable assistance was also received from the Department of Agricultural Engineering at Montana State College in work dealing with the hay wafer machine.

CHAPTER II

Theoretical Aspects of Pricing Hay

Perfect competition has been postulated as the efficiency criterion by which the hay market will be judged. Perfect competition has been defined as a market in which all buyers and sellers view themselves as price takers, i.e., price is always given to him by someone else. Two conditions must prevail in the market for this form of competition to be achieved. First, there must be many buyers and sellers, each having full knowledge of the alternatives open to him and completely willing to shift to any one alternative. Secondly, each buyer and seller must be an expert in the appraisal of the goods they buy and sell. Each time they come to the market they must be completely open-minded; prepared and willing to consider alternative offers and able to compare them on their relative merits. Transactions would be made solely on the basis of a rational comparison of price and quality. ^{15/}

The numbers requirement of the first condition would be physically impossible to meet in many of the small local hay markets in Montana. The second condition is not beyond the scope of the Montana hay market. In fact, improvement in the knowledge and ability of buyers and sellers could partially offset some of the weakness resulting from the market not being able to meet the first requirement. The probability of achieving results comparable to the perfectly competitive market would appear

^{15/} Tibor Scitovsky, Welfare and Competition, (Chicago: Richard D. Irwin, Inc., 1951) p. 18.

higher when two experts are bargaining than when one or both have insufficient knowledge.

The purpose of this section will be to bring together pertinent economic theory for evaluation and pricing of hay as a salable product and as a productive input. In some cases the implications of the theoretical analysis will be related directly to problems of producing and marketing hay in Montana. Also, the implications of pertinent research studies will be related to these problems.

Theoretically, two considerations combine to affect price. On the supply side, the cost of producing hay becomes the relevant price consideration and determines the lower limit sellers can accept in the long run. The marginal value product (MVP) of hay is a relevant consideration on the demand side of the picture and establishes the upper limit for its price. Before discussing relevant theory, however, it should be noted that sellers and users of hay may not be distinct entities..

A substantial amount of the hay marketed in Montana is produced on farms where only a part of the total production is used. The reverse situation is true for many of the farmers who buy hay. In any given year farmers who are hay buyers may, in turn, be hay sellers in other years. Under these circumstances, there are three values that will serve as a guide in each farmer's decision. The first of these is the marginal value product of hay, i.e., the addition to gross income from using one more unit of hay as an input. It is the use value of hay at the margin in producing

livestock or livestock products. The forage stand from which hay is produced may also have a use value arising from its fertility contribution to succeeding crop production. Conventional marginal analysis postulates an MVP schedule sloping downward and to the right (at least in the area that will be considered relevant). ^{16/} The shape and position of the MVP schedule will vary from farm to farm depending upon the particular organization, enterprise combinations, production relationships and available markets for the final product.

The farmer will ordinarily face two prices for his hay--one price when he buys hay and another price when he sells hay. The difference between these two prices may be quite high because the cost of transporting hay is high in relation to its value. The relationship of those three concepts is shown in Figure 4.

A farmer producing Q_1 of hay could increase his income by acquiring additional quantities of hay because the MVP of hay is greater than the acquisition price. He would benefit from purchasing hay up to a point (A). Additional purchases beyond this point would be unwise because the MVP is below the acquisition cost. If he were producing Q_2 of hay he would neither acquire more hay nor dispose of any that he already had because the MVP is less than the acquisition price but greater than the salvage

^{16/} This immediate section will draw heavily on work done by Glen L. Johnson and Lowell S. Hardin, "Economics of Forage Evaluation", Agricultural Experiment Station, Purdue University, Lafayette, North Central Regional Publication No. 48, April, 1955.

value. ^{17/} With hay stocks on hand at Q_3 , the farmer would find it advantageous to dispose of quantity Q_3B because the salvage value is greater than the MVP for this quantity.

Forage as a Joint Product

The above analysis is valid only when we consider hay as an individual input. To consider it as one of two inputs or two products requires

^{17/} Technically it is more correct to refer to P_1 and P_2 as the salvage value and acquisition cost rather than the selling price and buying price. These two values actually represent the best alternative available to the farmer for either acquiring more or disposing of what he now has. He may acquire more hay by either off-farm purchases, producing additional quantities on existing forage land, or planting additional land to forage, etc. Likewise, if the farmer wishes to dispose of some or all of his hay he may sell it off the farm, use it in some alternative enterprise not presently being used or he may plow up the forage stand and use it for a green manure crop. In the short run, buying or selling are probably the best alternatives. In a case where other alternatives are used, the two price lines are not likely to be straight. The acquisition price line would be the marginal cost curve of producing hay by some method other than off-farm purchases and would probably demonstrate a typical MC curve. The salvage price line would represent the MVP of hay in some other alternative use and would normally slope downward and to the right.

a new set of analytical tools. The first of these is an iso-cost map for two enterprises, one of which must be hay. Figure 5 represents such a map. All points on a given contour line represent combinations of Y_1 "hay" and Y_2 "grain" that can be produced from a given outlay. For example, in the hypothetical situation represented in Figure 5 combination (AB) of hay and grain or combination (A_1B_1) or any other combination defined by a point on the iso-outlay curve can be produced for the same total cost. The slope of the iso-outlay curve at any given point is a measure of the substitutability of the products for each other. Since we are working with a constant cost, our major concern will be to maximize the income it will generate. This point is attained when:

$$\frac{MVP}{P_{X_1}} \frac{(X_1) Y_1}{Y_1} = \frac{MVP}{P_{X_1}} \frac{(X_1) Y_2}{Y_2}$$

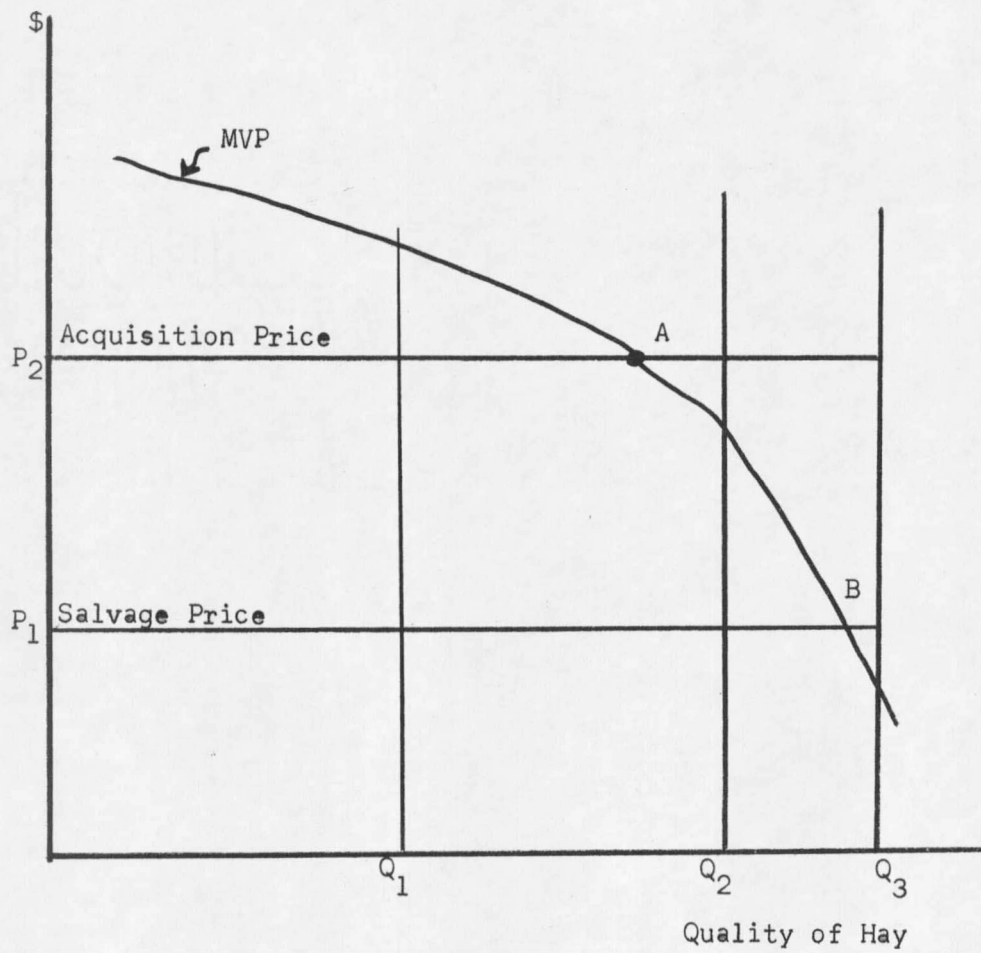


Figure 4. Relationship of marginal value product to acquisition and salvage value.

The geometric parallel of this condition is the point of tangency between the iso-revenue line and the iso-outlay curve. The slope of the iso-revenue line is defined by the price ratio $\left(\frac{P_{Y2}}{P_{Y1}}\right)$, while the slope of the iso-outlay curve is defined by the ratio $\frac{\Delta y_1}{\Delta y_2}$. At the point of tangency

$$\frac{P_{Y1}}{P_{Y2}} = \frac{\Delta y_1}{\Delta y_2} \cdot \frac{18}{19}$$

Forage as a Joint Input

The second analytical tool needed is an iso-product map, Figure 6. The iso-product curve is similar to the iso-outlay curve, except in this case grain and hay are considered inputs in a productive process and all points on the iso-product curve represent combinations of the inputs that will produce a given product output. The slope of the iso-product line measures the substitutability and/or complementarity existing between the two inputs.

Since in this situation production is at given output levels, concern will be to do so at a minimum cost. The point of minimum cost will occur at the tangency point between the iso-cost line (slope of which will be defined by the price ratio $\frac{P_{X2}}{P_{X1}}$ of the input factors) and the iso-product curve defined by a ratio of $\frac{\Delta X_1}{\Delta X_2}$. In Figure 6 this occurs at point E, where

$$\frac{\Delta X_1}{\Delta X_2} = \frac{MPP_{X2}}{MPP_{X1}} = \frac{P_{X1}}{P_{X2}} \cdot \frac{19}{18}$$

18/ For proof of this condition see L. A. Bradford and G. S. Johnson, Farm Management Analysis, (3rd Printing; New York: John Wiley & Sons, 1962), Chapter XI.

19/ Proof of this condition is offered in Bradford and Johnson, op. cit., Chapter IX.

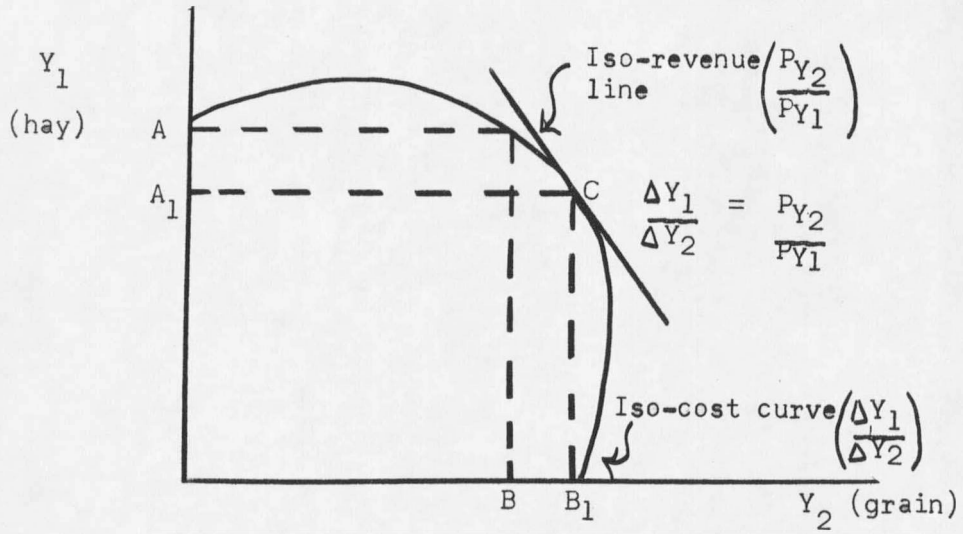


Figure 5. Hypothetical iso-cost curve for hay and grain with iso-revenue line.

Forage as an Input and an Output

In Montana most of the hay either being sold or purchased comes from or goes to farms and ranches both of which are producing hay and feeding some type of livestock. Using the two analytical tools introduced, it is possible to illustrate graphically situations with which they may be faced. In A of Figure 7, a farm with a livestock-feed balance is described. The iso-cost, iso-revenue line may be irrelevant for farms on which there is little opportunity to market their hay and/or grain other than through livestock. The same would be true for ranch operations faced with limited capital where they could not afford to purchase off-farm feed. In both cases the optimum product combination and input use combination would be determined by the point of tangency between the iso-outlay and iso-product curves. ^{20/}

In Figure 7B, this is not the case. The iso-revenue and iso-cost lines are relevant to management decisions. In this operation OA of hay and OB of grain would maximize the revenue from crops, as determined by the tangency point between the iso-outlay curve and iso-revenue line. Since these farm produced commodities are the products of the crop enterprise and at the same time inputs in the livestock enterprise with

^{20/} For a good discussion of alternatives open to farmers in this situation see, Earl O. Heady, Economics of Agricultural Production and Resource Use., (New York: Prentice Hall, Inc., 1952) pp. 262-4.

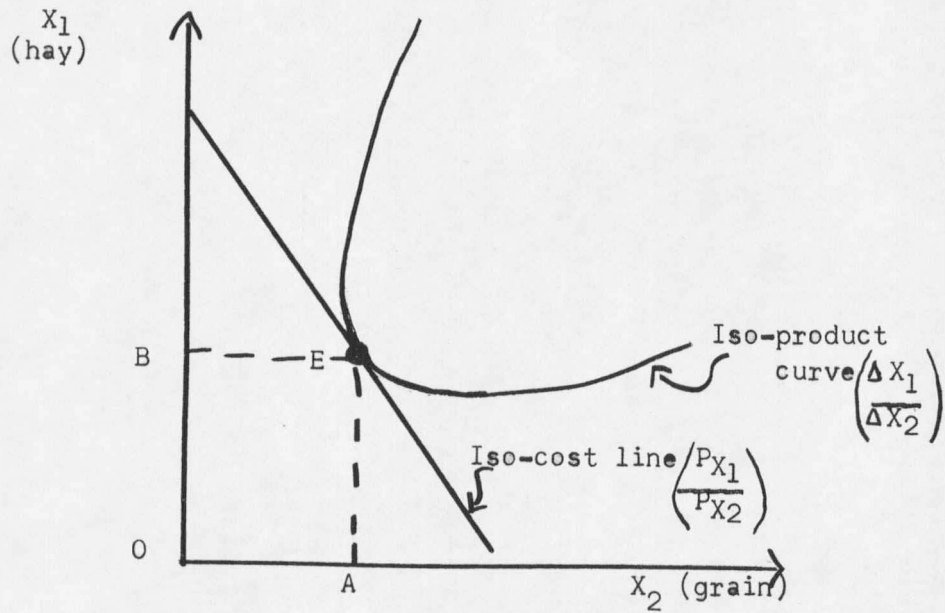


Figure 6. Hypothetical iso-product curve for hay and grain with iso-cost line.

no marketing charge involved, the iso-revenue line would also be the iso-cost line. Although there may be alternative ways of arriving at internal prices for hay and grain produced on the farm, they will be considered equal to their salvage value here. In this event, the tangency point between the iso-cost line and iso-product curve would indicate an optimum input combination of OA_1 of hay and OB_1 of grain. If the operator were to sell grain and buy hay, as indicated, he would face a new iso-cost line; the slope of which would be determined by the ratio of the acquisition price of hay over the salvage value of grain. The new iso-cost line would lead to an adjustment in the combination of inputs used with AA_2 of hay being purchased and BB_2 of grain being sold.

In C of Figure 7, the opposite situation is presented. The farm operation would sell AA_2 of hay and purchase BB_2 of grain. The slope of the new iso-cost line would be tilted in an opposite direction to that in B because it would be determined by the ratio of the salvage price of hay over the acquisition price of grain.

Two other situations, D and E, could exist also. In D, the livestock enterprise is too small to use the total production of either commodity. Quantities AA_1 of hay and BB_1 of grain could be sold. Because no amount of either feed input is purchased, both the iso-revenue and iso-cost line would have the same slope and it would be determined by the ratio of their salvage prices. In situation E, the crop enterprise is not capable of producing sufficient feed inputs for the livestock

operation. Purchase of quantities AA_1 of hay and BB_1 of grain would have to be made to meet the needs of the livestock enterprise. In this case the relevant lines for economic decisions would probably not have the same slope. The iso-revenue line would be defined by the ratio of their salvage values. The iso-cost line, would be defined by a ratio of their acquisition prices. It is doubtful that these two ratios would have the same value since the marketing costs of hay are high in relation to its value and would generally cause the price of hay to rise relative to the price of grain. In the above example, this would cause the iso-cost line to be flatter than the iso-revenue line.

Pricing Forage as a Crop Output

Although a review of situations in which hay transactions might be expected to occur is pertinent to the pricing problem, it does not deal with it directly. As was pointed out in the forepart of this section, the relationship of three values will determine what course a farmer or rancher should take. These were the salvage value, the acquisition price and the marginal value product. The marginal value product of hay in relation to the salvage and/or its acquisition price will guide an operator in his decision to buy, sell or keep what hay he has. However, these relationships are somewhat superficial in reality if real values are not assigned to them.

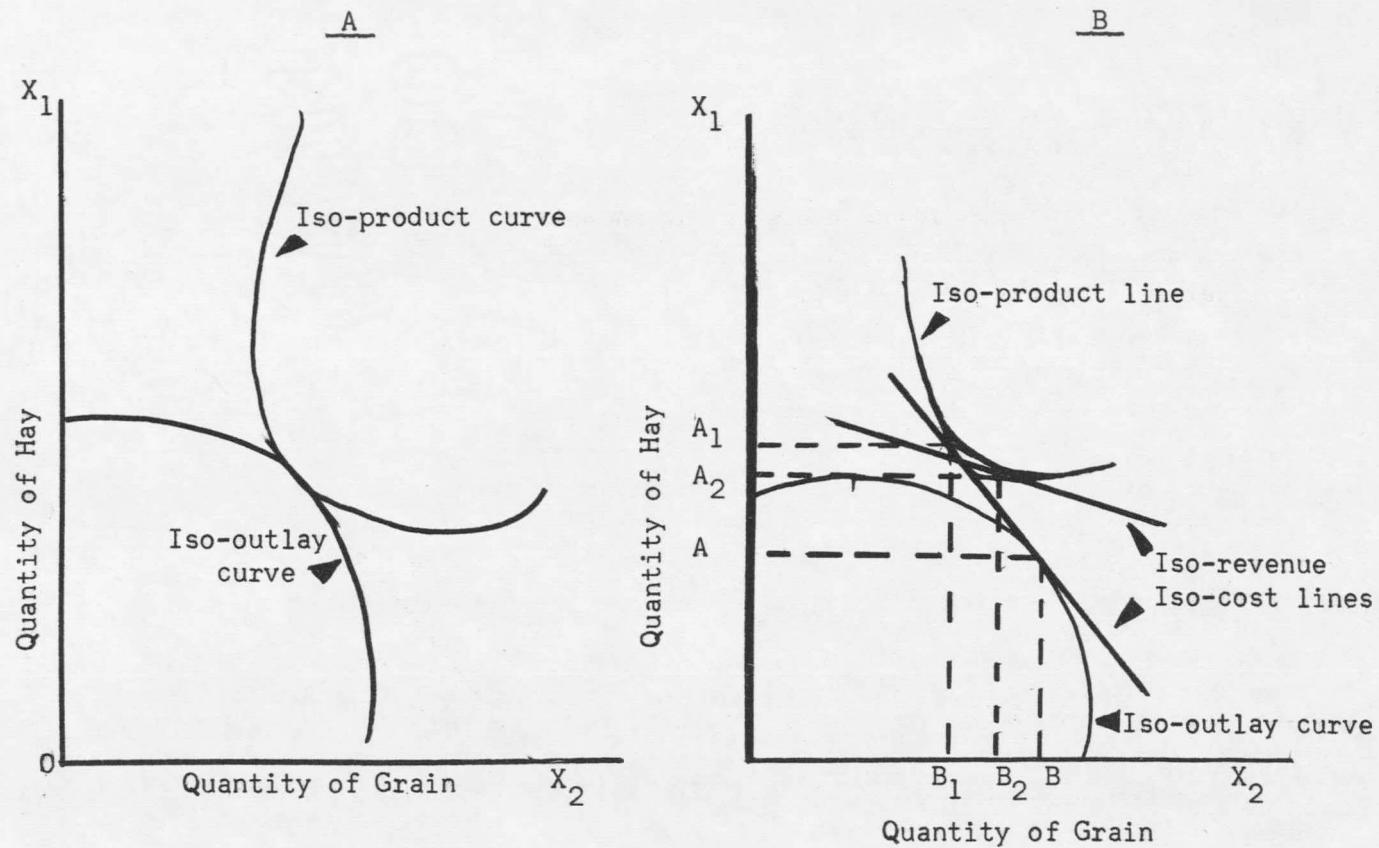


Figure 7. Optimum combinations of hay and grain as joint products and as joint inputs under different assumed prices and levels of production.

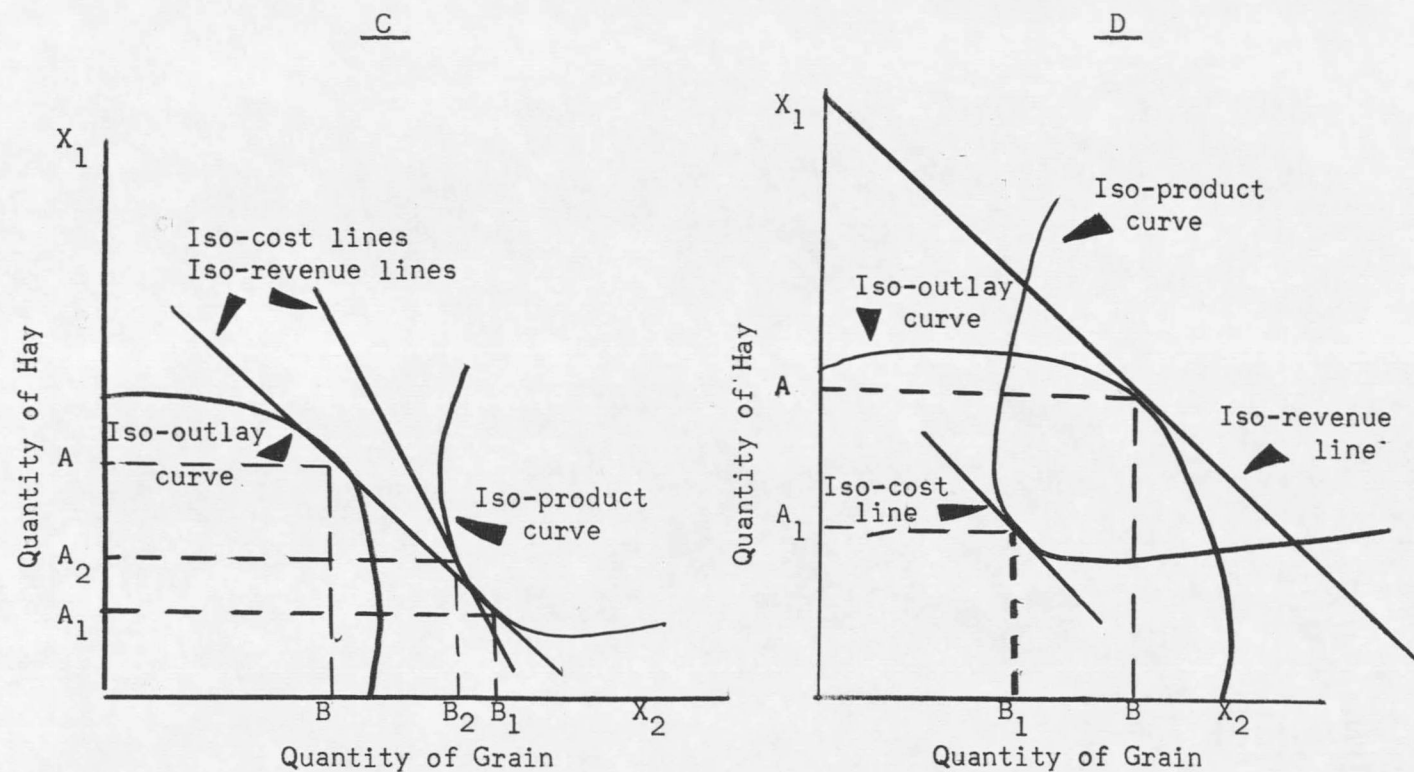


Figure 7. Optimum combinations of hay and grain as joint products and as joint inputs under different assumed prices and levels of production.

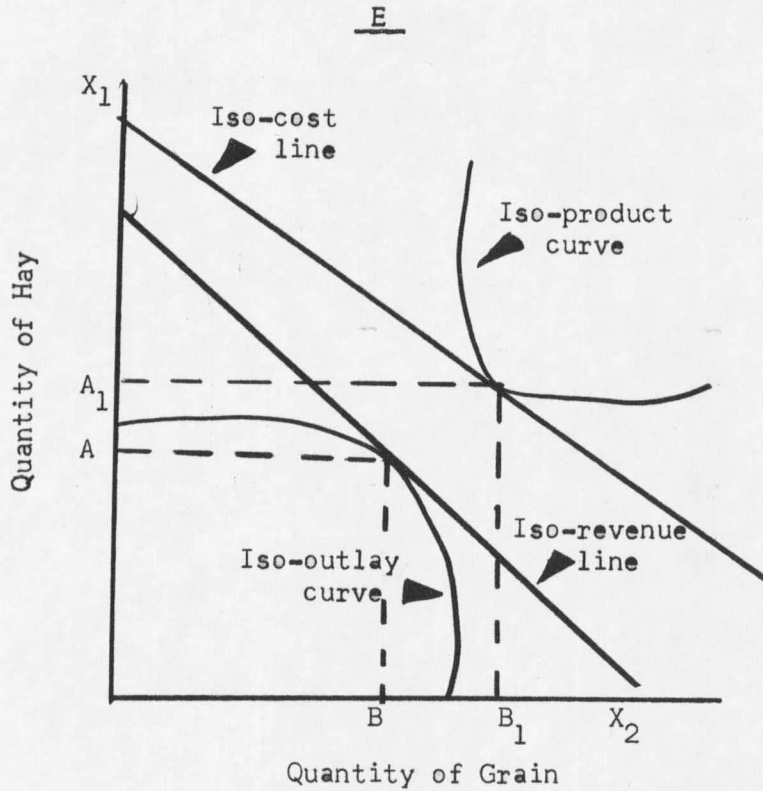


Figure 7. Optimum combinations of hay and grain as joint products and as joint inputs under different assumed prices and levels of production.

In the long run, there are two price limitations that will affect the market for hay. First, production will not continue if the price of hay and other benefits of hay production do not cover the long-run average costs of production. On the other hand, use of hay will be profitable only if the price of hay does not exceed its own marginal value product in a particular enterprise. 21/

The long-run average cost will vary throughout the state. Area differences, type of farming, and differences in methods of handling hay will all have an influence. In Montana, there are three separate groups of hay producers. Farmers producing hay on irrigated diversified farms, commercial hay producing farms, and ranchers who sell hay when production on their farm is plentiful, but will keep what hay they have or buy additional stocks when it is in short supply. Each of these groups will have a different schedule of costs. A similar situation exists on the demand side. The dairy industry, the feedlot industry and ranchers all have particular demand schedules for hay.

Hay Production Costs in Rotation System

The Soil Conservation Service has made some estimates of the cost of producing hay. Its estimates are for particular counties and may not be appropriate for the state in general. Using its basic cost data for

21/ In the long-run the price of hay will also be limited to that portion of its MVP curve lying below or equal to the AVP curve if its use is to be profitable.

counties in Western Montana in which two forage crops are normally harvested an average fixed cost of \$11.79 per acre was ascertained. ^{22/} In those areas where three crops are normally harvested an additional allowance of \$1.50 per acre is made to cover the added expenses of irrigating. The average fixed costs in these areas would be \$13.29 per acre. Interest on investment is not included in the above figures because land values and/or opportunity costs vary considerably.

Another factor that will affect average cost is yield per acre. As the units (tons) of production per acre increase, the lighter the proportion of total fixed costs each unit of production will bear. In 1961, alfalfa production on irrigated land ranged from a low average yield of 0.90 tons per acre in Petroleum County to a high average yield of 3.75 tons per acre in Flathead County. The state average yield for 1961 was 2.39 tons per acre. ^{23/}

A study conducted at Montana State College to determine the average sales price of Montana agricultural land by grade and class provided the basic data needed to arrive at an interest on investment charges. ^{24/}

^{22/} Since hay is a product of forage, all the variable costs as well as the fixed costs associated with forage production become fixed costs to hay. This would include costs of establishment as well as all costs associated with the growing of forage. Hay production begins when the forage crop is cut.

^{23/} Montana Agricultural Statistics, op. cit., 1962.

^{24/} Layton Thompson, "Sales Prices of Montana Agricultural Land by Class and Grade," Department of Agricultural Economics and Rural Sociology, Montana State College, Bulletin 583, 1963.

Most of the sales data used for tillable irrigated land in this study were for the period 1953 to 1961. All sales prices were converted to a 1959 base through use of the index of real estate values for Montana. This index has increased 8.6 percent since 1959 and all values in the following analysis will be adjusted accordingly.

Classification of tillable irrigated land is based on the average yield of alfalfa hay per acre. Grades for this class of land run from one to eight with corresponding yields of 4.5 tons and over to less than 1.0 ton per acre. (Table III)

Assuming that \$11.79 and \$13.29 are reasonable estimates of the appropriate average fixed costs per acre (excluding interest on investment) for the state, an estimate of the cost of producing hay can be made. Variable costs will be figured at current custom rates as reported by the Soil Conservation Service. It will also be assumed that land yielding 3.5 tons and over will be harvested in three crops, that land yielding between 2.0 and 3.5 tons will be harvested twice and land yielding less than 2.0 tons per acre will be harvested once. Cost estimates for three different grades of land are presented in Tables IV and V using an opportunity cost of 5 percent on the land investment.

In Table IV, an allowance is made for the fertility contribution of alfalfa to succeeding crops in the rotation. The proper allowance is still quite uncertain that should be made for this beneficial element. Johnson and Hardin made an allowance of \$20 per acre in the Midwest and

this is the figure used here. ^{25/} This amount is allocated evenly over the 6-year life of the alfalfa stand.

In their estimate, Johnson and Hardin attempted to measure the amount of basic nutritive elements supplied by the forage crop (from both above ground and root growth) and value it at its current market value. They credited the forage crop with supplying 210 pounds of nitrogen and assumed that approximately two thirds of it would be retained in the soil for later use. When a market price of 14.5 cents per pound for nitrogen spread on the ground is assumed, a fertility figure of around \$20 per acre is obtained. Although they made reference to the contribution of forage to the organic matter in the soil, no allowance was made for this contribution.

Hay Production Costs Under Constant Cropping

In areas where forage production enjoys an absolute or comparative advantage over other crops no fertility allowance need be made. ^{26/} Such a situation is presented in Figure 8 where the schedule of expected income for forage is greater than that for other crops.

^{25/} Johnson and Hardin, op. cit., p. 17, see also A. R. Schmid, A. C. Caldwell and R. A. Briggs, "Effect of Various Meadow Crops, Soybeans and Grain Crops on the Crops Which Follow", Agronomy Journal, Vol. 51, March, 1959.

^{26/} This is not a true application of the "law of comparative advantage" because only one area is of concern here. The law of comparative advantage is appropriate to a situation where two areas with explicit limitations are being compared in their ability to produce a given commodity or commodities. This is an ex post decision to this analysis. Forage, if it is included in the rotation for rational economic reasons, will always have a comparative advantage. In the short run it may not appear to have a comparative advantage but this is only because sufficient time has not elapsed for the full benefits to be realized.

In cases where forage production does not enjoy a distinct advantage, the decision is not so clear, Figure 9. Whether to include a forage crop in the rotation will be contingent upon the relative cost of income foregone (area A) compared with the added income (area B) in subsequent crop production. If the compounded cost of income foregone is smaller than the discounted increase in receipts then forage should be included in the rotation. If it is not, it will not pay to include a forage crop in the rotation. The difference between these two values will be the net value of the benefits derived from a forage crop. In the cost schedules presented in Table IV, no allowance was made for this increment of income foregone. It is assumed that farm operators are acting rationally and if a forage crop is included in the rotation, the compounded cost of area A must be less than the discounted value of area B.

A cost schedule for farms producing less than two tons of hay per acre was not included in Table IV because the implicit assumptions of the above analysis were not applicable to farms in this category. Farms or ranches which generally experience these low yields are usually large operations with relatively large hay acreages. They produce hay on a scale considerably different from the irrigated diversified farm. Their normal plan of operation is to harvest one crop of hay and then use any aftermath growth as fall pasture. In many instances, the hay is stacked loose and fed right on the farm. Hay that is expected to be sold will be baled with the exception of a few cases where it is sold but fed on

TABLE III. AVERAGE 1959 SALES PRICES BY GRADES FOR TILLABLE IRRIGATED LAND IN MONTANA. *

Grade of Irrigated Land	Yield of Alfalfa Hay	Midpoint of Grade	Average Sale Price Adjusted to 1959 Land Value a/
I A	4.5 and over	4.75	- - -
I B	4.0 - 4.4	4.25	298.29
2	3.5 - 3.9	3.75	291.00
3	3.0 - 3.4	3.25	193.37
4	2.5 - 2.9	2.75	174.40
5	2.0 - 2.4	2.25	128.81
7	1.0 - 1.4	1.25	110.08
8	less than 1.0	.75	97.59

* Source: Layton S. Thompson, "Sales Prices of Montana Agricultural Land by Grade and Class", Department of Agricultural Economics and Rural Sociology, Montana State College, Bulletin 583, 1963, p. 26.

a/ This value is actually a composite value of land and water. If the cost of water combined with this land were capitalized and subtracted the net land value would be lower. In a case of high water costs the capitalized value would be quite significant and may result in a relatively low net land value even for the higher grades. Since our concern here is to get an estimate of the proper allowance for interest on investment, which consists of both land and water, for various grades of land, this composite value will suffice.

TABLE IV. ESTIMATED HAY PRODUCTION AND HARVESTING COSTS FOR ALFALFA
HAY FOR GRADE I B AND GRADE 4 LAND.

Grade I B Land	Cost/Acre	Grade 4 Land	Cost/Acre
Fixed Costs (S.C.S. est.)	\$13.29	Fixed Costs (S.C.S. est.)	\$11.79
Interest on Investment		Interest on Investment	
298.29 x 108.6% = 323.94 ^{a/}		174.40 x 108.6% = 189.40 ^{a/}	
323.94 x .05 =	<u>16.19</u>	189.40 x .05 =	<u>9.47</u>
Total Fixed Costs/Acre	<u>\$29.48</u>	Total Fixed Costs/Acre	<u>\$21.26</u>
Mowing (3 cuttings)	6.00	Mowing (2 cuttings)	4.00
Raking (3 cuttings)	3.00	Raking (2 cuttings)	2.00
Baling		Baling	
4.25 tons at 4.80/ton =	20.40	2.75 tons at 4.80/ton =	13.20
Hauling and stacking		Hauling and stacking	
4.25 tons at 2.00/ton =	<u>8.50</u>	2.75 tons at 2.00/ton =	<u>5.50</u>
Total Variable Costs/Acre	<u>\$37.90</u>	Total Variable Costs/Acre	<u>\$24.70</u>
Total Costs Per Acre	67.38	Total Costs Per Acre	45.96
Less Fertility Allowance	<u>3.33</u>	Less Fertility Allowance	<u>3.33</u>
Total Adj. Cost/Acre	<u>\$64.05</u>	Total Adj. Cost/Acre	<u>\$42.63</u>
Total Cost Per Ton		Total Cost Per Ton	
64.05/4.25 =	\$15.07	42.63/ 2.75 =	\$15.50

^{a/} Sale prices reported in Table IV were adjusted upward 8.6 percent to account for the increase in land values between 1959 and 1962.

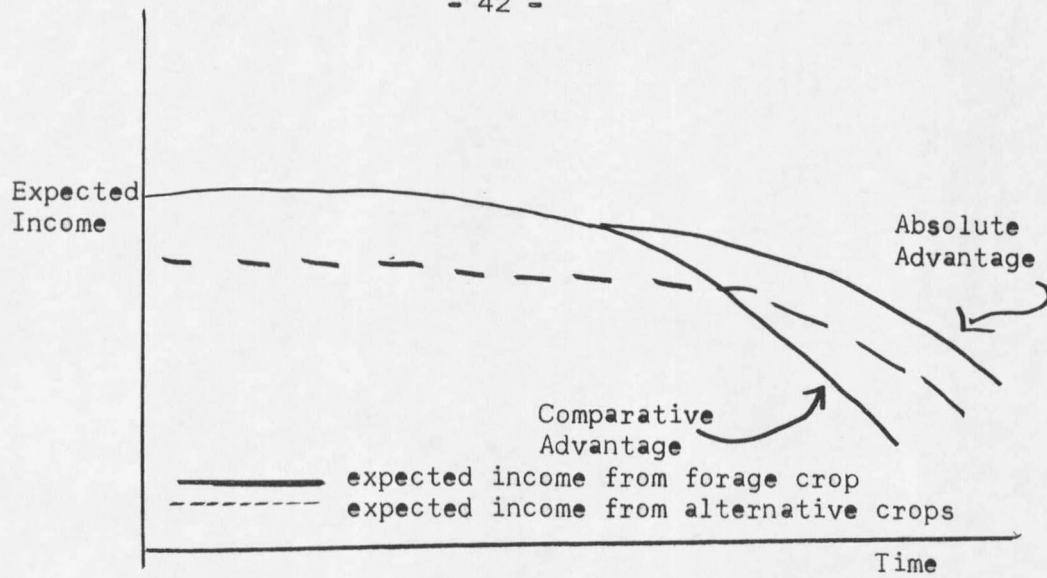


Figure 8. Relationship of expected income of forage crop to expected income of alternative crops where forage enjoys an absolute or comparative advantage.

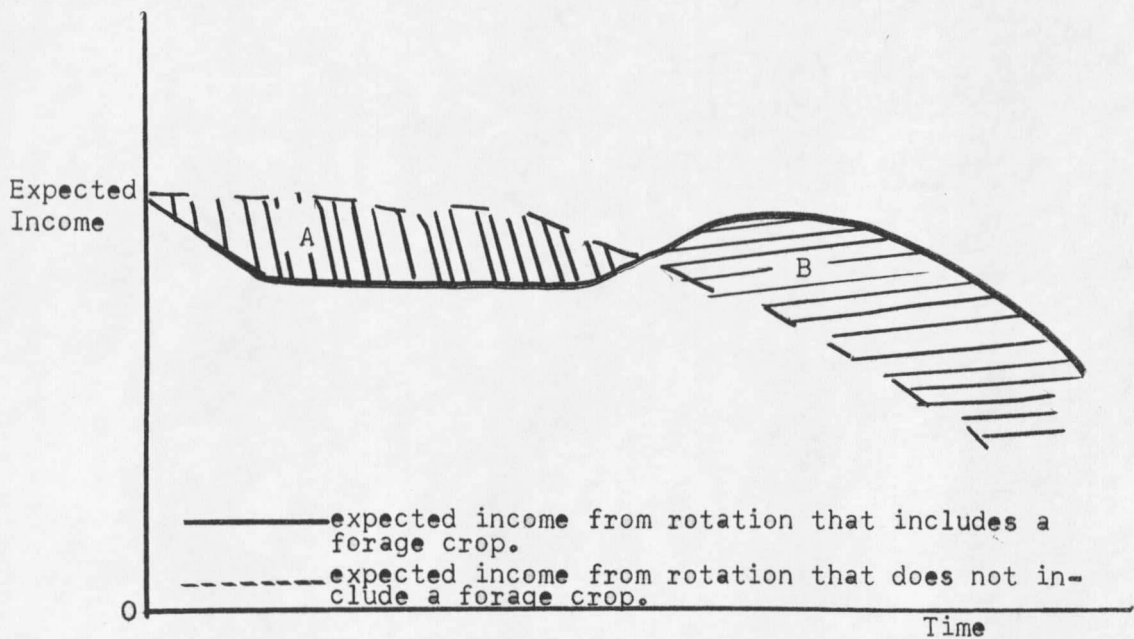


Figure 9. Hypothetical expected incomes from two rotation systems--one including a forage crop and one not including a forage crop.

the farm where it was produced.

In a study of hay production costs under conditions similar to farms in this category, Clarence Jensen ascertained a total cost of \$21.87 per acre. 27/ An average yield of two tons per acre was assumed in his work, which would break the total cost down to \$10.94 per ton. The average yield for the major grass-hay producing counties in the state is approximately 1.25 tons per acre. At this yield, assuming costs remain constant, the average cost would be \$17.50 per ton. This figure appears unreasonably high when compared to production costs for other types of hay. One factor that was not taken into account in Jensen's study was the use of the hay land as fall pasture. In a report on wild hay management practices in California, the value of the aftermath growth used for pasture was credited as being equal to from one-half to full value of the hay itself. 28/ Their findings were based on the hay equivalent needed to supply the same feed value as the aftermath pasture.

27/ Clarence W. Jensen, "Hay Production and Harvesting Cost," Unpublished research report, Department of Agricultural Economics and Rural Sociology, Montana State College, December, 1959.

28/ L. W. Fluharty, and J. C. Hays, "Wild-Hay Management Practices in Modoc County," University of California, Berkeley, Bulletin 679, July, 1943.

To assume that fall grazing accounted for one third of the total feed produced on these hay meadows would not seem unreasonable. Appropriate adjustments are made in Jensen's figures to account for the pasture value of these lands and are presented along with his original cost figures in Table V.. Allowing for a portion of the fixed costs to be allocated to the pasture brings the cost of hay produced on these farms in line with that on irrigated diversified farms. There was no fertility allowance made in this cost schedule because the forage crop on this type of farm is seldom used in a rotation.

There are strong arguments for lowering some of the cost items for the meadow-hay operation still further. Cost of establishment in the Jensen study was allocated over an 8-year period. This figure is probably short of the average length of life of this type of forage stand. To the extent that some machine and labor costs would have to be met regardless of the haying operation, the opportunity costs for machinery and labor may be lower than assumed in this analysis. It was also assumed that all hay was baled. A majority of farms that harvest meadow hay for their own use stack it loose and baling costs would not be included as a cost item. Skinner found that the cost of harvesting and stacking loose hay was only 72 percent as much as for baled hay. 29/

29/ Skinner, H. M., Comparative Costs and Losses Involved in Harvesting, Storing and Feeding Hay in Montana, Agricultural Experiment Station and Agricultural Marketing Service, USDA Cooperating, Montana State College, Bozeman, Bulletin 554, October 1960.

TABLE V. HAY PRODUCTION AND HARVESTING COSTS FOR MEADOW HAY WITH ADJUSTMENTS FOR PASTURE VALUE. *

Cost Item	Original Costs		Adjusted Costs	
	Per Acre	Per Ton	Per Acre	Per Ton
Fixed Costs:				
Cost of Establishment	1.50	1.20	1.13	.90
Machine Depreciation	3.27	2.62	2.45	1.96
Taxes on Machinery	.41	.33	.31	.25
Int. on Mach. Invest.	1.06	.85	.80	.64
Taxes on Land	.70	.56	.53	.42
Int. on Invest. Land	4.25	3.40	3.19	2.55
Irrigation Water & Labor	<u>1.62</u>	<u>1.30</u>	<u>1.22</u>	<u>.98</u>
Total Fixed Costs	12.81	10.26	9.63	7.70
Variable Costs:				
Gas, oil and grease	.90	.72	.90	.72
Machine Repairs	1.10	.88	1.10	.88
Baler Twine	1.18	.94	1.18	.94
Haying Labor Including Room and Board	5.80	4.64	5.80	4.64
Liability Insurance on Labor	<u>.08</u>	<u>.06</u>	<u>.08</u>	<u>.06</u>
Total Variable Costs	9.06	7.24	9.06	7.24
Total Costs	<u>21.87</u>	<u>17.50</u>	<u>18.69</u>	<u>14.94</u>

* Source: Clarence W. Jensen, "Hay Production and Harvesting Cost", Unpublished research report, Department of Agricultural Economics and Rural Sociology, Montana State College, December, 1959. He assumed an average yield of 2.0 tons per acre in deriving per ton costs. Yield here will be assumed at 1.25 per acre.

On farms which normally produce their own hay supplies, the purchase price of hay may be a better figure with which to compare their haying costs than the production costs presented here. In general, however, a producer cannot afford to be unaware of his relative efficiency of producing hay. The marginal cost curve for producing hay on a particular farm represents the opportunity costs of acquiring hay as an alternative to off-farm purchases. By superimposing a marginal cost curve on Figure 4 (page 25), it can be demonstrated that it may be profitable for an individual to continue producing hay even though his production costs are higher than the price he would receive for it in the market.

In Figure 10, the cost of producing hay is higher than its market price (salvage value) over the total range of the marginal cost curve. However, it would pay the farmer to produce quantity (Q_1) of hay--the point where the cost of the marginal unit is just equal to the value of its marginal product. If the hay was purchased instead of produced on the farm, profits would be maximized at quantity (Q_2). In this illustration however, profits could be increased by producing quantity (Q_1) of hay.

Evaluation and Utilization of Hay as a Feed Input

In previous discussions it was noted that the marginal value product of hay would determine its worth and would serve as an upper limit on the price any individual would be willing to pay. The MVP is the marginal physical product of the input multiplied by the price of the product, and

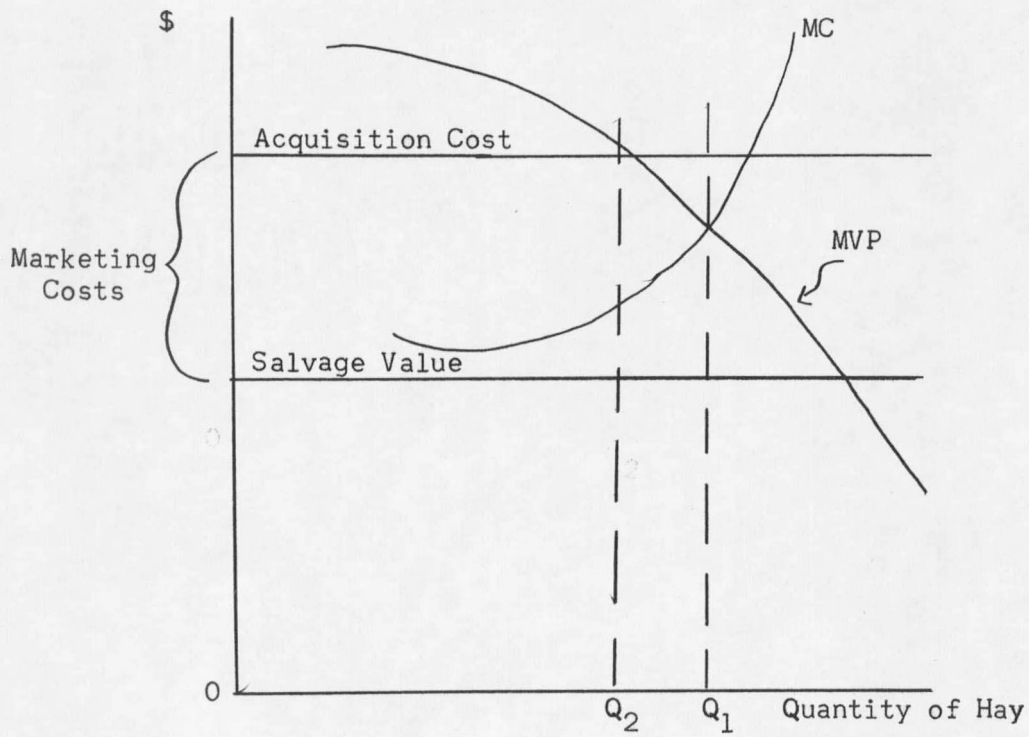


Figure 10. Relationship of marginal value product to the acquisition cost and salvage value of hay with a marginal cost curve superimposed.

they are probably not the same for different firms. In Montana, there are three primary feeding groups--dairymen, feedlot operators and ranchers. The elasticity of production 30/ for hay is probably not the same for any two of the above enterprise groups. This would cause different marginal value productivity schedules and, consequently, each group theoretically should be willing to pay a different maximum price for any given quantity of hay. For the dairyman, hay provides the bulk of his cows' nutritive requirements and is indicative of a relatively high elasticity of production. On the other hand, the feedlot operator has decreased the use of hay in his fattening ration until only a minimal amount is now included to provide needed roughage. This would indicate a relatively low elasticity of production, although the efficiency of hay in this enterprise may be greater over a portion of the MPP schedule. Price of the output is just as important as the MPP in determining the MVP of hay. A relative increase in the price of meat or milk will cause the MVP for hay to rise and should lead to an increase in the amount of hay a feeder is willing to use.

Use of marginal value product analysis is complicated by the difficulty of measuring the contribution of productive inputs. A method often

30/ This term is borrowed from Arthur Bunce's book entitled, Economics of Soil Conservation, (Ames: Iowa State Press, 1945). Bunce defined it as the ability of an enterprise to maintain its average product as additional units of the variable input are added.

$$Ep. = \frac{\% \text{ change in total product}}{\% \text{ change in units of input}}$$

used is that of assigning to all other factors their current market value and allowing the residual value to accrue to the input in question. Although this method has certain practical advantages, it still has many inherent weaknesses. Problems are often encountered in obtaining market values, especially for some of the intangible factors such as management skills. The market value of the fixed factors may not be equal to their value in a particular enterprise, and, thus, there is a good chance that the residual value will not reflect accurately the contribution of the input under consideration. Finally, even if it is assumed that the possibility of these errors occurring is minimized, the residual method provides a value for only one point on the MVP curve. As such, it does not provide the same guide for decision making as does the complete MVP schedule.

Another limitation to the residual method is encountered in working with an input that accounts for only a small amount of the total input base. A mistake in assigning correct values to other factors, even though it may be very minor, could easily cause the magnitude of the residual value to be distorted far out of its correct proportion. Underestimating the value of one of major inputs and allowing the difference to accrue to the minor input through the residual value would result in a significant overstatement of the value of the minor input. For this reason the residual method may not be a reliable tool for computing the MVP of hay in feedlot operations and on ranches where little hay is fed.

Thus, what little work has been attempted in this area has been concerned with dairies. 31/

Marginal Rates of Substitution and Optimum Hay-Grain Combinations

In addition to the relative value of hay as a productive resource, the relative price of substitute inputs also affects the price an operator is willing to pay for hay. In Montana there are three primary substitutes for hay. 32/ There are pasture, corn silage and concentrates. At times pasture of high quality may be considered a near perfect substitute for hay. In A of Figure 11, a situation where hay and pasture are perfect substitutes is represented. If the price ratio was represented by line A, the least cost method of production would be to use pasture. 33/

31/ In spite of the difficulties involved in estimating the MVP of an input factor there have been several studies in recent years which have estimated the MVP for forage. For example, see Vance Wagley, "Marginal Productivities of Investments and Expenditures on Selected Ingham County Farms, 1952", unpublished M.S. thesis, Department of Agricultural Economics, Michigan State University, 1953, and P. E. Robbins, "An Economic Evaluation of Pasture in Central Indiana", unpublished Ph.D thesis, Purdue University, 1953. The highlights of both these studies are reported in Johnson and Hardin, op. cit. Also see Earl O. Heady, et. al., "Milk Production Functions, Hay/Grain Substitution Rates and Economic Optima in Dairy Cow Rations", Agricultural Experiment Station, Iowa State College, Research Bulletin 444, October, 1956.

32/ The number of effective substitutes for hay will depend to some extent on the use hay is being employed in and the geographic location of this use. Corn silage may, for example, be a very good substitute for hay on the dairy farm in irrigated valleys. On the other hand, it may be a poor substitute for hay in a cow-calf operation in the eastern plains region of the state due to prohibitive costs of transportation and the physiological difficulties encountered when range livestock are placed on a relatively rich succulent feed.

33/ It is assumed in this discussion that the relevant area for decision making is one of increasing total product. If that area of the production surface where total product is decreasing is allowed, then the conclusions reached in this section would have to be altered. Production would be increasing as one moves toward the origin in the graphs in Figure 11, instead of away from the origin.

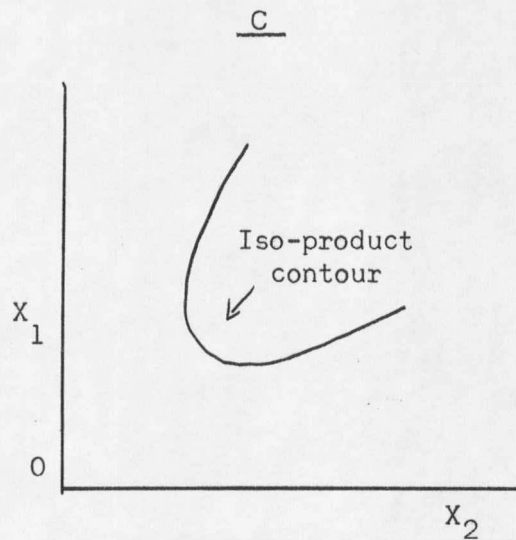
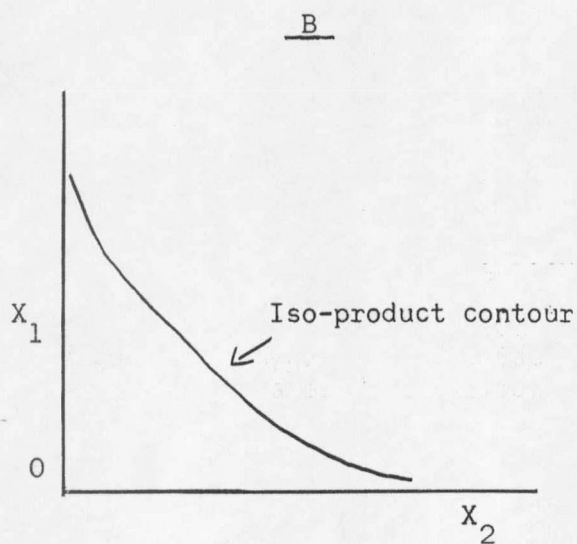
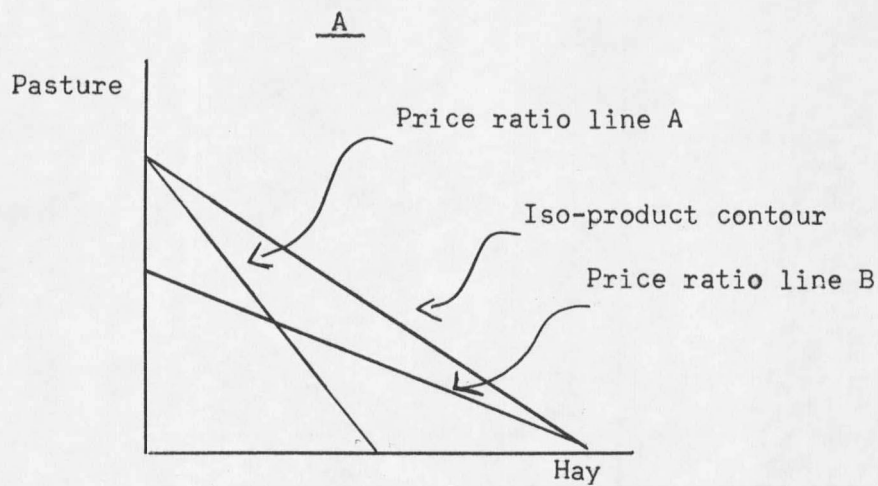


Figure 11. Hypothetical product contours displaying different marginal rates of substitutions between input factors.

If it were line B, the economic choice would be to feed hay. A common practice among Montana farmers is to use pasture whenever it is available. This would imply a price ration line favoring pasture.

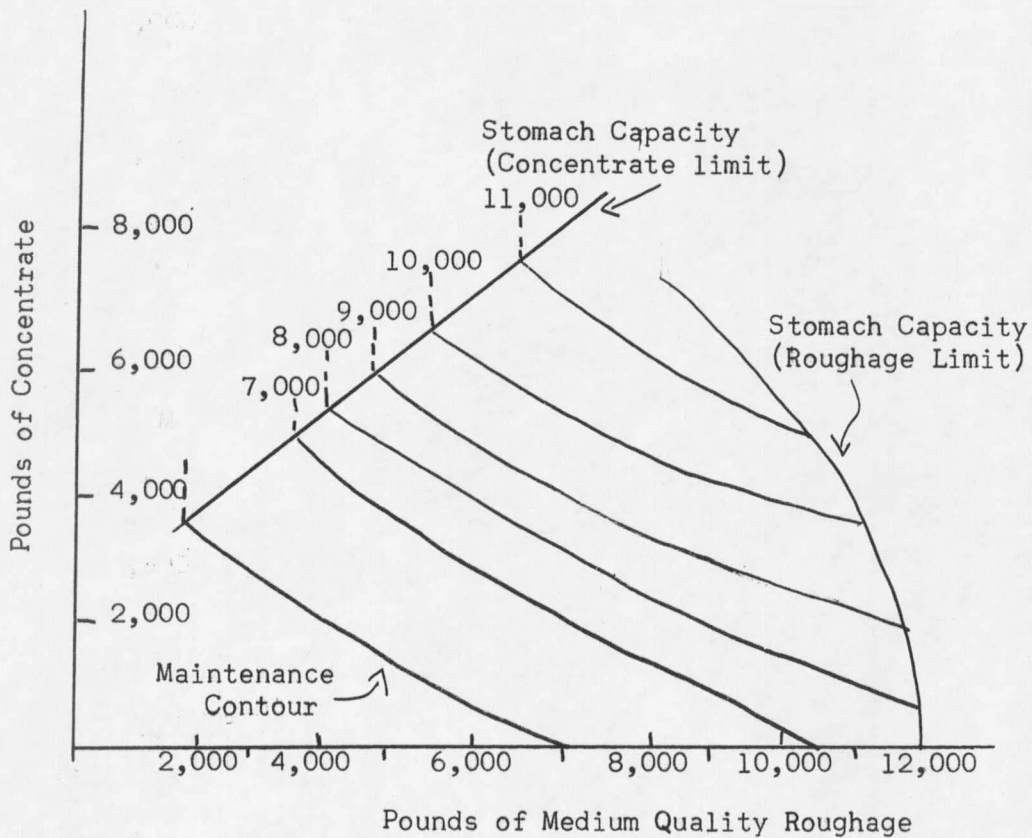
Other feeds probably do not exhibit a linear substitution relationship (perfect substitutes) for hay. As has been previously pointed out, the slope of these non-linear isoquants is a measure of the substitutability existing between the two feeds. Feeds which are good substitutes for each other will exhibit a rather low marginal rate of substitution over a wide range of the isoquant and may, in fact, approach linearity over a portion of the curve as in B, Figure 11. In the case of relatively poor substitutes, the rate of change over the isoquant will be rapid, giving it a pointed effect, C, Figure 11.

There have been a limited number of studies which have attempted to establish milk isoquants using hay and grain as the variable input factors. Redman and Olson made estimates of the marginal rates of substitution for forage and grain at various levels of production for three different qualities of cows. ^{34/} The results obtained in that study were synthesized from data derived from feeding experiments and estimates by dairy scientists and other agricultural economists. Roughage of medium quality was used in developing their estimates. Results of the Redman and Olson study are presented in Table I, Appendix B, and illustrated graphically in Figure 12. The data represent average substitution relationships over an entire year. It is likely that the shape of these contours will change over the year as stage of lactation and quality and type of feed change; however, these adjustments were not within the scope of the Redman and Olson study.

^{34/} John C. Redman and Russel O. Olson, "Economic Problems in Feeding Dairy Cows", Kentucky Agricultural Experiment Station, University of Kentucky, Lexington, Bulletin 648, July, 1956.

There are three critical limits in their synthetic model which delineate the relevant area in which substitution can occur. The first of these is the maintenance contour. This curve does nothing more than define the amount of feed needed to maintain the life of the cow. It may be considered a locus of all feed combinations that will just come short of producing any milk. The "stomach capacity line" for forage sets the limits within which it is practical to feed hay. Milk can be produced on an all forage diet, but the amount produced will be less than maximum production of the cow. To reach the point of maximum production, grain will have to be included in the ration. As grain is added to the ration, and consumed, the stomach capacity for forage is reduced and a backward sloping stomach capacity line is ascertained. A stomach capacity line is obtained for grain or concentrates also. However, there is a difference between it and the stomach capacity for hay. The stomach capacity line for concentrates does not begin from a point on the concentrate axis. This indicates, as available evidence suggests, that a cow cannot be maintained on a ration entirely of grain or concentrates. Because this restriction is more physiological than a capacity limit, it has been more appropriately labeled a "physiological limit for grain" by other researchers. ^{35/}

^{35/} Heady, et. al., op. cit., p. 900.



* Source: Redman and Olson, op. cit., p. 12.

Figure 12. Estimated production surface for a milk cow showing concentrate and roughage limit lines.

Heady, et. al., also estimated the marginal rates of substitution between hay and grain. The data used to test their hypothesis, however, was taken from an experiment designed specifically for this purpose, whereas Redman and Olson made their test using a synthetic model. The basic hypothesis in these two studies was very similar. The data collected in the Iowa State study were tested with several mathematical equations. They decided the most satisfactory equation was a modified quadratic equation:

$$M = 0.4304 (H - 0.00001H^2) + 1.5008 (G - 0.00007G^2) + 0.9265A - 665.49$$

$$\frac{dh}{dg} = \frac{1.5008 - 0.000210G}{0.4304 - 0.0000086H} \cdot \frac{36}{36}$$

The marginal rates of substitution of grain for hay predicted by the above equation is presented in Table II, Appendix B. A linear function was also estimated and the marginal rates of substitution for this equation are presented in Table III, Appendix B. The estimated marginal rates of substitution for each of the above three methods for one level of milk production are shown in Table VI. It should be noted that in the Iowa State study grain was varied in discrete units whereas in the Kentucky study hay was the discrete variable. One could be converted to the same base as the other by interpolation, but since only the marginal rates of substitution are important to the rest of this analysis, this conversion was not made.

^{36/} Heady, et. al., op. cit., p. 407 equation (9a). The R value for this equation was 0.8755 and all regression coefficients could be accepted at the 1 percent probability level.

It was pointed out in a previous section that the cost of a given level of production would be minimized at the point of tangency between the iso-product curve and the iso-cost line, i.e., where $\frac{dH}{dG} = \frac{MPP_G}{MPP_H} = \frac{P_G}{P_H}$. Thus, if the relative prices of the two inputs changed, one would expect the optimum feed combination to change also. The direction of change would be toward the input having a relative price decrease.

The cost of rolled barley will generally fluctuate between \$30 and \$40 per ton. The price of hay ^{37/} has ranged from \$16 to \$32 per ton over the past ten years. If the midpoint of both price ranges is used, a price ratio ($P_G/P_H = \$35/\$24$) line with a slope of 1.45 is ascertained. If the isoquant estimated by the linear function ($MRS = 2.3017$) is accepted, the least cost combination of hay and grain would lie at the intersection of the physiological limit line for grain and the 7300 lb. milk isoquant, point A, Figure 13. When the price ratio line is greater than 2.3017, the least cost combination would be an all hay ration. If it were equal to 2.3017 the choice would be immaterial. Because the optimum feed combination will likely be located at one end or the other of the linear isoquant, it is not as well suited for most analyses as are the non-linear functions. Available evidence suggests that the optimum

^{37/} Since most of the hay in Montana is both produced and fed on the same farm the price data used will be prices received. In cases where both inputs are purchased it would be better to use prices paid data.

TABLE VI. FEED COMBINATIONS USED IN PRODUCING GIVEN LEVELS OF MILK AND THE MARGINAL RATES OF SUBSTITUTION OF GRAIN FOR HAY. *

Iowa State Study 7300 Lb. Milk Level						Kentucky Study 7000 Lb. Milk Level					
Modified Quad. Equation Results				Linear Equation Results							
		MRS of				MRS of				MRS of	
Lbs. Grain	Lbs. Hay	Grain for Hay d/H d/G a/	Lbs. Grain	Lbs. Hay	Grain for Hay d/H d/G a/	Lbs. Grain	Lbs. Hay	Grain for Hay d/H d/G a/	Lbs. Grain	Lbs. Hay	Grain for Hay d/H d/G a/
1	1,000	11,138 ^{b/}	3.86	1,000	10,010 ^{b/}	2.3017	100	10,000			2.6
2	1,500	9,328 ^{b/}	3.39	1,500	8,859 ^{b/}	2.3017	290	9,500			2.5
3	2,000	7,738 ^{b/}	2.97	2,000	7,708 ^{b/}	2.3017	490	9,000			2.3
4	2,500	6,345	2.60	2,500	6,557	2.3017	705	8,500			2.2
5	3,000	5,130	2.25	3,000	5,406	2.3017	930	8,000			2.2
6	3,500	4,080	1.94	3,500	4,255	2.3017	1,160	7,500			2.1
7	4,000	3,182	1.64	4,000	3,105	2.3017	1,400	7,000			1.8
8	4,500	2,428	1.36	4,500	1,954	2.3017	1,675	6,500			1.7
9	5,000	1,813	1.09	5,000	803	2.3017	1,975	6,000			1.5
10							2,300	5,500			1.4
11							2,650	5,000			1.2
12							3,050	4,500			1.1
13							3,500	4,000			1.0
14							4,025	3,500			0.8

* Source: Heady, et. al., op. cit., Tables IX and XI and Redman and Olson, op. cit., Table I.

a/ This is the average marginal rate of substitution of grain for hay, i.e., amount of hay (forage) replaced by one pound of grain.

b/ These figures were outside their range of observation.

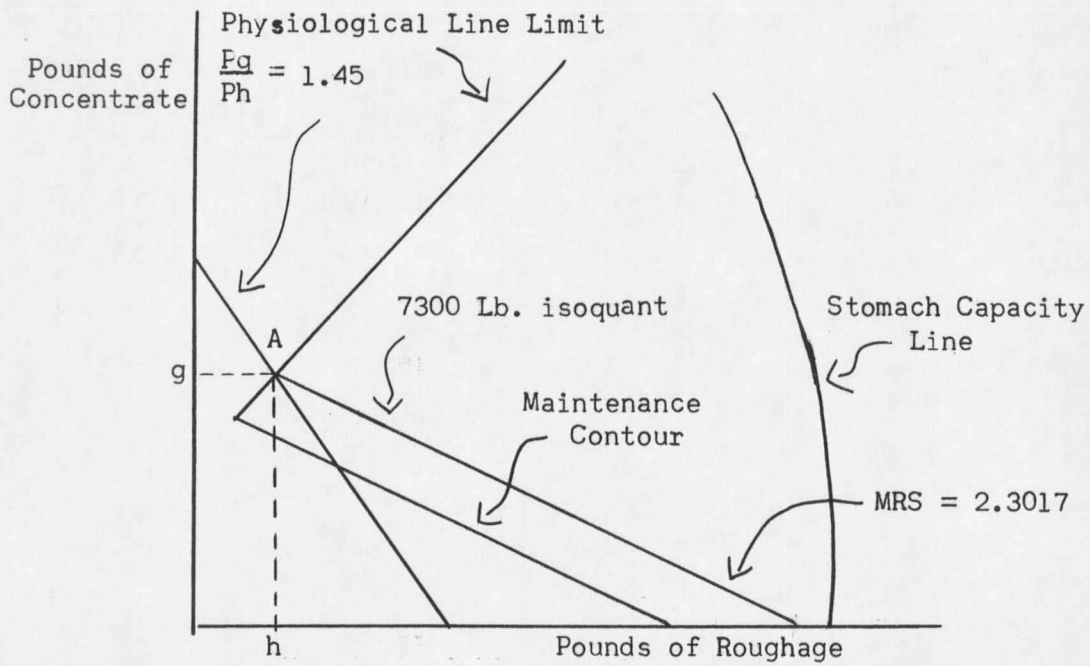


Figure 13. Milk production surface showing optimum combination of hay and grain for a linear isoquant with an assumed MRS of 2.3017 and a price ratio line with a slope equal to 1.45.

combination normally lies within the two extremes which the linear function allows only in the special case; and then any given combination is indifferent to all others.

If the non-linear functions were used as guides, a price ratio line with a slope of 1.45 would indicate a feed combination between combinations seven and eight for the Iowa State study and between combinations nine and ten in the Kentucky study. In a year where production is high the price of hay will usually fall relative to the price of barley. Assuming the price of barley remains constant and the price of hay is \$16 per ton (which is not uncommon for a good hay year like 1958 when the annual average price of all hay baled was \$16.23 per ton ^{38/}) a price ratio line with an approximate slope of 2.2 will be obtained. This would locate the optimum position close to feed combination five in the Iowa State study and between four and five in the Kentucky study. In 1960, the price of hay was high relative to that of barley. The annual average prices received figure for hay was \$24.69 per ton, while barley growers received \$0.66 per bushel or approximately \$27.50 per ton for their product. If we allow an additional \$5.00 per ton for processing and other charges that may be encountered in transforming barley into a feed that is normally competitive with hay, a price ratio of $\frac{\$32.70}{\$24.69}$ 1.32 is derived. This ratio would cause the least cost combination to

^{38/} Maurice C. Taylor, *et. al.*, "Prices Received and Prices Paid by Montana Farmers and Ranchers-1949-58", Montana Agricultural Experiment Station and Agricultural Marketing Service, USDA, Montana State College, Bulletin 554, October, 1960.

shift to that portion of the iso-product curve favoring a higher proportion of barley in the ration.

The optimum combination of hay and barley may vary significantly from farm to farm due to the various prices which are appropriate to a given farm. On a farm with adequate homegrown supplies the effective price ratio would be determined by the salvage price for both hay and barley. In other situations it may be determined by the salvage price for one commodity and the acquisition price for the other, or various other combinations that may be appropriate. Since a substantial quantity of hay is wasted in handling and feeding, the price of hay used in the ratio should be adjusted to account for it.

Traditional Methods of Estimating Optimum Hay-Grain Combination

Nutritionists and farm management specialists have been using various price comparison techniques in feed recommendations for some time. Most of these techniques are simplified versions of the more complicated factor-factor approach presented above. One of these methods is to compare the cost per pound of a certain nutritional element in various feeds. Frary and Kercher use this method for making recommendations to ranchers wintering beef cattle. ^{39/} They assume that approximately 50

^{39/} Robert F. Frary and Conrad J. Kercher, "Grain or Hay; Economics of Feeding Feed Grains for Wintering Beef Cattle", Wyoming Agricultural Extension Service, University of Wyoming, Laramie, Mimeo Circular No. 21, 1960. In this study T.D.N. is the balancing criterion being considered, but this method will work equally well for protein or any element.

percent of the required T.D.N. must be supplied by a roughage to meet minimum nutritional requirements. The additional T.D.N. requirements needed could be supplied by any of various available feeds. If hay were selling at \$20 per ton and had a T.D.N. level of 50 percent, the cost of T.D.N. acquired through hay would be \$2.00 per cwt. With corn, barley, oats and milo running at 82, 78, 70 and 80 percent T.D.N. respectively, a feeder could afford to pay up to \$1.64 per cwt. for corn, \$1.56 for barley, \$1.40 oats and \$1.60 for milo and still not pay more than 2 cents per pound of T.D.N. The price a feeder could afford to pay for these four feed grains as the price of hay varies is presented in Table VII.

If the cost of hay were \$30 per ton, again taking in consideration the waste involved, a feeder could afford to pay up to \$2.34 per cwt. or \$46.80 per ton for barley. If barley could be purchased for less than this amount, a savings could be realized by substituting barley for hay. A possible weakness in these recommendations is the implicit assumption of a linear relationship between hay and barley in their ability to substitute for each other. ^{40/} If T.D.N. is the only critical nutritive element being considered, then the recommendations can be followed without concern for other aspects of the ration. This will not be the case in most instances, however. The substitution of grains for

^{40/} The linear relationship assumed in this case is not as reliable as the one estimated by Heady, et. al., p. 35. In this case the slope of the iso-product curve would rely on the ability of T.D.N. in barley to substitute for T.D.N. in hay. The linear iso-product curve in the Heady study took into account all nutritive elements; not just one.

TABLE VII. EQUIVALENT VALUE OF FOUR FEED GRAINS WHEN PRICED ACCORDING TO THE VALUE OF T.D.N. PURCHASED THROUGH HAY AT DIFFERENT PRICE LEVELS. *

Price of Hay	Equivalent Value of Feed Grains Per Cwt. <u>a/</u>				
	<u>Ten</u>	<u>Corn</u>	<u>Barley</u>	<u>Oats</u>	<u>Milo</u>
20		1.64	1.56	1.40	1.60
25		2.05	1.95	1.75	2.00
30		2.46	2.34	2.10	2.40
35		2.87	2.75	2.45	2.80
40		3.28	3.12	2.80	3.20
45		3.69	3.51	3.15	3.60

* Source: Frary and Kercher, op. cit., p. 2.

a/ T.D.N. of alfalfa and native hay 50 percent, T.D.N. of corn 83 percent, barley 78 percent, oats 70 percent and milo 80 percent.

hay, especially alfalfa hay, will usually reduce the amount of protein and minerals available to livestock unless a supplement is fed with the grain. If a supplement is needed, the price comparison would then be between the price of a nutritive element contained in hay and the cost of the same element when purchased through some other feed plus the cost of the required supplement.

Because of the limited scope of this method, a technique called the "Peterson method" has been used by many nutritionists. Peterson, in his work at Minnesota, devised a means of evaluating feeds on the basis of their ability to substitute for two basic feeds. In Peterson's original work, corn and cottonseed meal were used because they were the most common carbohydrate-rich concentrate and protein supplement used in this country. For each feed there are two relevant values. The first is a "constant for corn" which is a measure of the nutritive relationship, in terms of a carbohydrate-rich substitute, between corn and the feed in question. The second figure is a "constant for cottonseed meal" which is a measure of the nutritive relationship existing between cottonseed meal and a particular feed in terms of a protein supplement. Morrison, using this technique but using soybean oil meal instead of cottonseed meal, has calculated these constants for most of the important feeds. 41/

41/ Frank B. Morrison, Feeds and Feeding, Abridged, (Eighth Edition, Ithaca, New York: The Morrison Publishing Company, 1954) Appendix Table II, p. 565. A list of these constants for some of the more important feeds in Montana are given in Appendix D, Table I.

An example can best illustrate how the Peterson method of evaluating feeds can be used. Suppose, for an example, dent corn (Grade No. 2) is \$45 per ton and soybean oil meal is \$75 per ton. The relative values of hay and barley can now be found by multiplying the price of the two base feeds by the appropriate constants for hay and barley. For alfalfa hay the "constant for corn" is 0.285 and the "constant for soybean oil meal" is 0.232. Multiplying these constants by the appropriate feed prices ($0.285 \times \$45.00 = \$12.82$ and $0.232 \times \$75.00 = \$17.40$) we arrive at a value of \$30.22 for hay. This represents the approximate value of alfalfa hay per ton in comparison with corn and soybean oil meal at the prices assumed. Performing the same calculation for barley ($0.747 \times \$45 = \$33.62$ and $0.136 \times \$75.00 = \$10.20$) we get a value of \$43.82 per ton. At the prices assumed for the base feeds, the calculated barley-hay price ratio would be $\frac{43.82}{30.22} = 1.45$. If the Montana market price of barley and alfalfa hay were less than the values computed by the Peterson method and their price ratio less than 1.45 it would pay to feed the maximum amount of barley. If their price ratio were greater than 1.45, it would pay to feed the maximum amount of alfalfa hay.

This same procedure can be used for other alternative feeds. There are some problems with this method, however, and they should be kept in mind. First, the price ratio used in the previous example will change slightly as the price of the two base feeds change. Thus, when comparing two feeds, such as hay and barley in our example, it should be noted that

their price ratio is dependent on the price of the two base feeds and will vary with them. Secondly, even though the constants used in this method were derived from actual feeding trials and take into consideration most nutritional needs, it doesn't account for all.

A simple example will illustrate. Suppose in the previous example the actual barley-hay ratio was less than 1.45. This would suggest that barley is the better buy and that it should be substituted for hay. However, if there is a need to maintain a certain roughage content or supply a certain amount of vitamin A in the ration, it may be necessary to include a minimum amount of alfalfa hay. Therefore, the relevant area of substitution may lay within a range of the production surface and not over the total surface as the Peterson method might suggest without any qualifications or limitations. To some extent, this limitation was placed on previous models by the "capacity limit line" and the "physiological limit line for grain". The third problem is the assumption of a linear iso-product curve or constant rate of substitution. Although it removes a major objection inherent in the first price comparison method--that of considering only one nutritional element--it does not recognize the presence of diminishing marginal rates of substitution that are believed to exist. It does offer a relatively simple method of making price comparisons for feeds whose productiveness has been established by feeding trials and, therefore, should be a valuable guide in management decisions. When more information is available about the production surface

and reliable iso-product contours are established for the major feeds, then management decisions with even more precision can be made. But until such time arrives, the Peterson method is probably the best technique available.

Current Price Trends and Future Demand for Hay

In review, there are two primary factors that will affect the price that a farmer or rancher is willing to pay for a feed input. First of all, the marginal value product of the feed input will set the upper limit a feeder is willing to pay and the amount that can profitably be used at various price levels. The MVP will depend on the enterprise (dairy, feedlot or ranch operation) in which the input is employed, organization of the fixed inputs within this enterprise, and the level of use of the variable input.

The second factor that will yield influence on their pricing decisions is the price of substitute feeds. The relevant decision here is not whether "to feed or not to feed" but a decision regarding the least cost combination of feeds. ^{42/} It may involve the selection of a feed that will furnish a particular feed nutrient at the lowest marginal

^{42/} In actual practice these two decisions are probably not as independent as they are implied in this presentation. They are broken into two separate parts here for two reasons: First, it is easier to discuss each as though it were independent of the other and, second, it is much easier to handle them theoretically if they are separate.

cost or, in other cases, selection of a combination of feeds that will supply a composite of nutrients at the lowest marginal cost. Nutrient requirements, nutrient content of the available feeds and relative price ratios are key factors in this decision.

As was pointed out earlier, it is sometimes difficult to determine the MVP of a feed input. And since it was not the intent of this study to ascertain MVP's for hay, no resolute judgments can be made about the relative productiveness of hay. In an enterprise like dairying, where alfalfa hay is the major feed and probably the major cost component, some indication of the future demand for hay may be found by looking at hay-milk ratios. There are some underlying assumptions in this approach that are necessary if it is to be useful, however. It is assumed that hay, as a feed input, is used for rational economic reasons, i.e., it is profitable in the long-run for farmers and ranchers to feed hay. It must be assumed that cost relationships will remain constant or nearly so, and that no new technology will be introduced that will change physical production relationships.

Price trends for milk, beef, hay and barley are presented in Figure 14. 43/ The price trends were estimated from the price series charts in

43/ A price trend for beef was calculated, although it may not be as reliable an indicator as are milk prices. The cost of hay in relation to other cost factors is so small in some beef producing areas that the price of either varies considerably without having any negligible effect on the price or quantity taken of the other.

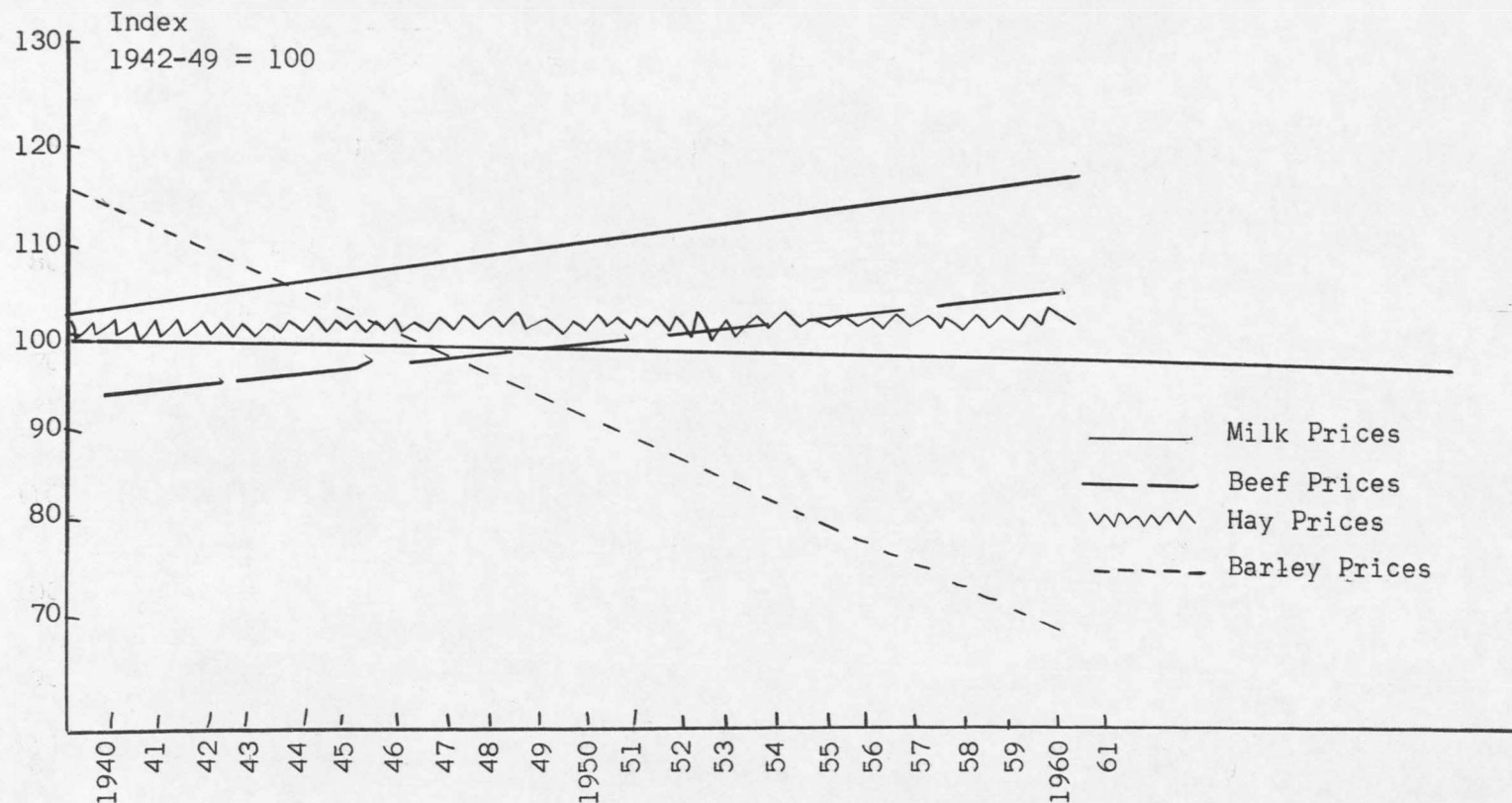
Appendix IV. The slope of these individual trend lines, as estimated by the regression equation $Y = a + bX$, was .13, -2.1, .54 and .67 for hay, barley, beef and milk prices respectively. If the aforementioned assumptions are in effect, then two separate forces may be noted that will affect the demand for hay. The price of hay has remained almost constant over the 21-year period under consideration. Although the price trends for milk and beef are not statistically significant from zero over the period tested, they do show a significant increase over the last five to seven years of the period. ^{44/} If they have been rising, then it will cause the demand relationships for hay to change. In terms of the single input analysis reviewed earlier, this would mean that the MVP of hay was increasing relative to its MFC and, consequently, demand for hay would be expected to rise. Comparing the price trend of hay with that of barley, which is the most commonly used substitute for hay in Montana, the opposite would be expected. The price of barley, especially in the last ten years, has declined significantly. As barley prices fall relative to hay prices, the demand curve for hay can be expected to shift to the

^{44/} The slope of all these trend lines were tested for significance. The (b) values for milk, beef and hay prices were not significant from zero even at the 10 percent level, Appendix IV.

left until maximum concentrate rations are reached. At this point barley and hay are no longer substitutes for each other and further decreases in the price of barley will have no affect on the demand for hay. 45/

The correct weight that should be given to these two forces is difficult to discern. To a large extent it will depend on the physical productivity relationships existing between the two inputs and the relative location on the production surface as indicated by the price ratio line. However, the evidence now available seems to indicate that hay and grain are reasonably good substitutes for each other and that a price decline in one would curtail demand for the other. If the price of barley continues to fall relative to the price of hay, demand for hay can only be expected to diminish.

45/ This is only true if the cross-elasticity of demand between hay and barley remains perfectly elastic. However, for these two factors the cross-elasticity of demand becomes negatively soped at some minimum level of prices. After reaching this minimum level, a price decline in one factor would result in an increase in demand for the other.



* Source: Price trends were estimated from the price movements in Appendix C, Figures 1, 2, 3, and 4. The formula used to estimate these trend lines uses the simple regression equation $Y = a + bX$ (b) values were .13, -2.1, .54 and .67 for hay, barley, beef and milk prices respectively.

Figure 14. Price trends for selected livestock products and feed inputs.

CHAPTER III

MONTANA HAY MARKET CHARACTERISTICS

Description of Hay Producers-Sellers, Buyers and Dealers

Hay Producer-Sellers

Because of the relatively high water requirements needed for raising grass and alfalfa hay, production is concentrated in the western mountainous region of the state and along the Missouri and Yellowstone river valleys. Leading hay producing counties in 1959 were Beaverhead, Madison, Gallatin, Fergus and Carbon.

These high hay producing counties are also among the leading cattle and sheep producing counties. In addition their location in the mountainous regions dictates higher requirements per animal than in the Plains region. These two factors require that large stocks of hay be kept on hand to satisfy local needs. Intra-county hay transactions may be quite extensive but normally hay will not move out of the area.

Although production figures are available, estimation of the supply-demand balance of hay for a given county is difficult since consumption data is not reported on either a county or state basis. Consumption of hay in a given year depends on numbers of cattle on farms, range conditions, weather conditions, price of substitute feeds and other factors. These items vary considerably from year to year and cause consumption to vary considerably also.

Stack estimated average consumption on a county basis by multiplying county hay requirements by the appropriate number of animals in each live-stock class reported in the Census of Agriculture Preliminary Report for each county. The resulting county hay requirement figures were then compared with hay production data and a surplus or deficit balance was determined. 46/

When consumption and production are estimated by this procedure, one of the five leading surplus counties is included in the five top hay producing counties in the state.

To provide additional insight into hay production and usage patterns, 23 hay producers were interviewed for the present study. The hay producers farmed a total of 38,247 acres, of which 5,816 acres were used in hay production, Table VIII. Of the total hay acreage 3,460 acres (approximately 60 percent) was in alfalfa, and the remaining 2,356 acres (40 percent) was in wild or grass hay production.

Production on the 3,460 acres was reported as 10,486 tons of alfalfa hay for an average yield per acre of approximately 3.0 tons. Grass hay production on the 2,356 acres was reported at 2,715 tons for an average yield per acre of 1.1 tons.

These yields per acre compare with state estimates of 1.8 tons per

46/ Raymond C. Stack, op. cit., County hay requirements were figured on the basis of the length of the winter feeding period. This period is approximately 120 days in the mountain valleys, 100 days in the foot-hill and lower valley regions and 90 days for the Plains region.

TABLE VIII. HAY ACREAGE, PRODUCTION AND SALES FOR STATE AND SAMPLE PRODUCERS, 1960. *

Item	State	Percent	Sample	Percent
Acres in Farmland	8,422,500		38,247	
Acres in Hayland	2,207,000	<u>100</u>	5,816	<u>100</u>
Alfalfa Hay	979,000	44	3,460	60
Wild Hay	553,000	25	2,356 <u>a/</u>	40
Clover-timothy	276,000	13	<u>a/</u>	
Other	399,000 <u>b/</u>	18		
Total Production	2,900,000	<u>100</u>	13,201	<u>100</u>
Alfalfa	1,762,000	61	10,486	79
Wild Hay	470,000	16	2,715 <u>a/</u>	21
Clover-timothy	331,000	11	<u>a/</u>	
Other	337,000 <u>b/</u>	12		
Total Sales	348,000 <u>c/</u>	<u>100</u>	6,223	<u>100</u>
Alfalfa	211,440	61	5,015	80
Wild Hay	56,400	16	1,208	20
Clover-timothy	39,720	11		
Other	40,440 <u>b/</u>	12		

* Source: Montana Agricultural Statistics, Montana Department of Agriculture cooperating with Statistical Reporting Service, United States Department of Agriculture, Helena, Montana, December, 1962 and from interviews with 23 hay producers.

a/ Grass and wild hay were combined because they tend to be viewed as similar products in the market.

b/ Includes grain and other tame hays.

c/ Sales figures for the state were derived by multiplying appropriate production figures by 12 percent--Stack's estimate of total hay production that enters the market.

acre for alfalfa, 0.85 tons per acre for wild hay and 1.2 tons for clover-timothy hay. The primary explanation for the differences is the area where the schedules were taken. General surplus production localities where a majority of the producer schedules were taken, are in relatively productive irrigated areas where higher than average yields would be expected.

Alfalfa hay sales amounted to almost 50 percent of the reported production. Grass hay sales accounted for about 45 percent. There were only three producers who sold all of their hay.

Hay Buyers

Although hay buyers were found to be located in a more diverse area than producers, a majority of the buyers were located in the mountain valleys and along the river bottoms in the Plains region--the headquarters for most Montana farms and ranches.

For this study, a total of 31 buyers were interviewed. This group has purchased a total of 11,292 tons of the 1960 hay crop, 5,730 tons alfalfa hay and 5,562 tons grass hay. During this same period the buyers reported they had fed approximately 9,177 tons of grass hay and 7,455 tons of alfalfa hay. They were raising approximately 23 percent of their alfalfa hay requirements while purchasing the remaining 77 percent. Buyers of grass hay were raising approximately 39 percent and purchasing 61 percent. These buyers reported a 280-ton carryover of alfalfa hay but indicated they had fed all of their grass hay.

Hay purchases are generally from local areas with only a small portion coming from outside the county. Even in inter-county transactions hay usually moves within a 100-mile radius of the production point. There were, of course, exceptions to this general practice. An example of this is a buyer in eastern Montana who has been shipping in hay from South Dakota and Minnesota and another buyer in the Great Falls area who has shipped hay in from southern Idaho. However, the majority of the hay transactions take place between close neighbors.

Glacier, Toole and Chouteau in the northwestern part of the state were cited by Stack as deficit counties. ^{47/} In the east-central region, the counties of Garfield, Rosebud, Custer and Dawson were cited as generally deficit counties. According to observations and information gathered at the time of these interviews, the deficit in this area may have been over-estimated by Stack.

Two choices are available to ranchers in this east-central area. The traditional operation is the rounding up of cattle and sheep in the fall and bringing them to a central place where hay can be fed during the winter. This requires adequate water supplies, feeding and handling facilities and labor to meet the needs of this type of operation. The second choice, to keep the animals scattered in small bunches over the

^{47/} Stack, op. cit., p. 13.

entire range, is more common. This method requires a minimum of labor to feed, a minimum in facilities for handling the feed and livestock and a minimum water supply. Because feeding hay would be time consuming and expensive, and in many cases impossible, ranchers adopting this operation have come to rely on a protein supplement to furnish any additional nutrients needed. To these ranchers hay has become a feed of last resort.

The method chosen will depend on the size of the ranch. On a small ranch where land is the most limiting factor, feeding hay may be a means to increase carrying capacity by permitting the rancher to save all his rangeland for summer grazing. On the larger ranches, labor is probably the most limiting factor. Here the ranch operation will rely heavily on open ranges for the winter feed supply. Labor will be used primarily to keep the cattle spread over the range and to distribute a protein supplement to these small bunches of livestock during adverse weather conditions. In this case labor per head of livestock will be minimized, whereas, in the case of the small ranch land, per head of livestock will be minimized.

There appears to be a trend to use less hay in this area. The real cost of labor has been rising relative to farm product prices. In addition a shortage of satisfactory labor, during periods when labor requirements are high, has led most ranchers in this area to shift away from heavy reliance upon hired labor.

Hay Dealers

The ten hay dealers interviewed reported a total volume of 18,750 tons during the 1960 hay marketing year, Table IX. Two dealers reported hauling approximately 3000 tons each for the highest volume while one dealer reported hauling only 400 tons for the lowest volume. 48/

Dealers' hay distribution was quite even among user groups, with ranchers accounting for approximately 38 percent, feedlot operators 35 percent, and dairymen 27 percent.

Trade patterns of individual dealers usually reflected the relative importance of local type of use.

In the Billings-Red Lodge-Hardin area, ranches and commercial feeding concerns bought approximately 92 percent of the hay handled by local dealers. In the Jordan area dealers reported selling only to local ranchers. In the Havre-Harlem-Chinook area approximately 88 percent of the dealers' business went to ranches and the remaining 12 percent went to dairies. Dealers in the Ravalli County area were hauling alfalfa hay from southern Idaho primarily to dairies in the Bitterroot Valley. They reported that 90 percent of their sales went to dairy farmers and 10 percent to ranches.

48/ Hay dealers were considered to be individuals engaged in both trading and trucking hay. There are some firms within the state which transport hay but never engage in buying and selling activities. The volume of business they do is usually small so they were not included in this study.

TABLE IX. MILEAGE, TONS, DISTRIBUTION AND TRANSPORTATION CHARGES FOR MONTANA HAY DEALERS, 1960. *

Area	Hay Mileage 1960	Total Tons Hauled 1960	Ranches	Hay Sales Dairies	Feedlots	Transportation Charges Per Ton Mile <u>a/</u>					
	<u>Miles</u>	<u>Tons</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>	0-50 \$	51-100 \$	101-150 \$	151-200 \$	201-250 \$	251-300 \$
Ravailli Area	120,000	4,600	10.0	90.0	0	<u>b/</u>	<u>b/</u>	<u>b/</u>	<u>b/</u>	.043	.040
Harlem, Havre, Chinook Area	2,400	1,050	88.0	12.0	0	.155	.110	.100	<u>b/</u>	<u>b/</u>	<u>b/</u>
Jordan Area	9,000	900	100.0	0	0	.095	.080	<u>b/</u>	<u>b/</u>	<u>b/</u>	<u>b/</u>
Billings Area	222,000	12,200	42.0	7.0	51.0	.100	.086	.078	.058	.058	<u>b/</u>
Total	1,353,340	18,750	38.0	27.0	35.0						

-78-

* Source: Personal interviews with ten hay dealers.

a/ Figures in this column represent one-way mileage.b/ No hauls in this range.

All of the dealers reported buying hay only on order. Speculative buying was not a common practice. Reasons given included: wide variations in prices, unpredictable prices and lack of funds to finance speculative purchases. Few hay transactions are financed by the dealers themselves.

Areas having supply-demand balance apparently do not warrant services of full time hay dealers even though there may be considerable intra-area movements. One reason is that local movements tend to be sporadic. Also, many of the transactions take place between close neighbors and the hay is not moved over any great distance. Ranchers and farmers transport their own hay if hauling distances are short.

Areas of surplus or deficit stocks, on the other hand, warrant the services of hay dealers. Because of alternative uses for their time and equipment, farmers and ranchers can effectively use the services of a hay dealer. Dealers usually have knowledge of potential buyers or sellers outside the immediate area. Locating potential sales may become quite costly to individuals who wish to buy or sell only a small lot in terms of time and energy. Also by using specialized equipment the dealer can, in many cases, provide transportation services cheaper than those who sell or buy the hay.

The hay dealer in many respects is the most efficient link in the Montana hay market. First, more hay moves by dealers than any other channel. He probably has more information regarding potential buyers and

sellers than any other group in the state. Also, with his greater knowledge of the hay market, the dealer is in a good position to grade and price hay according to its relative quality.

In some areas, the dealer is placed in a position of assuming a highly significant role in price formulation for hay. It is often to his advantage to initiate trading as early in the marketing year as possible. To accomplish this, he must establish a "going price". The dealer occupies a precarious position as price initiator. He has an obligation to establish a price that will bring the market into balance. But, since his livelihood is somewhat dependent upon the price of hay, he will attempt to set a price that will assure him the continued patronage of his clientele. In years when there is considerable difference between buyers and sellers price expectations, the dealer may have to persuade one or both sides to alter their expectations so that an effective price can be established.

Dealer Charges

Transportation charges were found to be quite consistent within an area. However, there was considerable variation between areas. Several factors account for rate variations and any direct inter-area comparisons require appropriate adjustments. A minimum charge of \$4.00 to \$5.00 per ton was cited by all dealers for distances under 40 or 50 miles. This charge is primarily to cover handling costs. Hauling costs are small

relative to handling costs for these short distances. Charges for additional distance uses was found to depend upon length of haul, type of roads, size of truck and availability of backhauls. Hauls made over paved highways were usually less expensive than similar hauls over dirt or gravel roads. Distance off main roads and relative accessibility to loading and unloading points affect the hauling charge. Dealers whose customers consisted mainly of dairymen and feedlot operators had a lower rate schedule than dealers selling mostly to ranchers.

Size of truck used affects the rate schedules. If the average haul was relatively long and loading and unloading points accessible such that a truck-trailer combination could be used, costs per mile were substantially lower. On short hauls or in cases where accessibility to loading and unloading points were relatively difficult, a smaller truck provides lower costs per ton than the larger truck-trailer combinations.

The final factor influencing transportation rates is the availability of return loads. The return trip essentially becomes a fixed cost. Finding a back-haul will permit the operator to lower his fixed costs per unit of goods transported and allow him to charge a lower rate for transportation of hay. On short trips within a small area the chance of acquiring back-hauls is almost nil. The opportunity for back-hauls exists quite frequently on longer inter-area hauls, permitting the operator to lower his rate schedule.

Transportation charges were found to be lowest for hay hauled in the Ravalli area, Table IX. Contributing factors were: Hay was being hauled the longest distance on the average, truck-trailer combinations were being used to transport the hay, and a back-haul was often available. Transportation charges averaged highest in the Havre-Harlem-Chinook area. Most of the hay deliveries in this area were to ranches on the north and south benches of the Milk River Valley. These ranches are relatively short distances from the hay production areas, but scattered and accessible only by dirt or gravel roads. Often ranchers have truckers make deliveries to feeding bunks on the ranges. This adds substantially to the time required to make deliveries. The short hauls and the rough terrain being traveled require the use of small single axled trucks. This reduces the volume of hay that can be hauled per trip and raises the transportation rate.

Hay is hauled to Jordan area ranchers from the Yellowstone river-bottom lands around Kinsey and Terry. Also, some grass hay is hauled from around Wolf Point and some from the Hardin area. Hauling conditions were quite favorable and transportation costs in this area were comparable to charges in the Billings-Red Lodge-Hardin area.

Hay dealers were most active in the Billings-Red Lodge-Hardin area. Hay shipments were made within all but one of the mileage ranges, shown in Table IX. Only a small amount was shipped over 200 miles however. The general hay movement in this area is from outlying farming

districts to the dairies, feedlot operators and the livestock yards in the Billings vicinity. A large amount of grass hay is shipped to the Billings Livestock Yards from the Red Lodge area; alfalfa hay, from the Bridger-Belfry area and from the Heart Mountain irrigation project near Powell, Wyoming, comes into the dairies and feedlots. Some hay is shipped to Billings from Hardin also. Hay movements in this area are made over reasonably good roads. Most of the loading and unloading points are relatively accessible with the exception of a few outlying ranches..

There has been little research work done on hay transportation charges. However, a recent study made in Washington indicates hay hauling charges were comparable to those accessed by Montana dealers. Costs were obtained from three dealers who were hauling hay from the east-central part of the state to the west coast region. The dealers were all using tractor-trailer combinations and hauling an average distance of 225 miles one way. The most common hauling rate for this distance was \$10 per ton.^{49/} This is comparable to the charge Montana dealers were making for the same distance.

^{49/} Milton David and Martin Waananen, "Costs of Hauling Hay by Truck in Washington," Unpublished report, Washington Agricultural Experiment Station, Institute of Agricultural Sciences, Washington State University, Pullman, Washington, 1960.

General Buying and Selling Practices

Buying and selling practices are similar throughout the state. Differences which are observable appear to be related to the predominance of a particular buying group in a particular area.

A total of 112 hay transactions were reported for the 1960 hay crop by the 54 buyers and sellers contacted. These transactions were divided into three 4-month periods. Approximately 46 percent of the transactions occurred in the summer harvest period of June through September, 27 percent in the period October through January and 18 percent during the spring period, February through May. The remaining 9 percent were distributed throughout the year. These figures are in general agreement with dealers who reported the period from about July to January as their busiest season.

Two exceptions to the typical seasonal sale pattern were noted. In the Ravalli County area many of the hay transactions did not occur until the late fall and winter months. A large number of the buyers in this area were dairymen who produced some hay on their own farms. Hay purchases were delayed until their own production was known and they could estimate needed supplies. In some cases purchases were not made until their own stocks were exhausted. The other exception was in the Billings market area where a majority of the hay was bought by the cattle yards and commercial feeders. Neither of these buyers normally produce any of their

hay needs. Estimates of hay needs can be made early and at least a minimum supply purchased during the harvest season. Trading in this area tends to be slightly earlier than in the rest of the state.

The dairymen interviewed averaged 2.6 hay transactions during the 1960 hay crop year. Ranchers averaged 1.1 hay transactions. Average tonnage per transaction was from 80 to 100 tons, respectively. Variation in the purchasing and feeding practices among the different feeding groups is due primarily to the importance of hay in their respective feeding programs. To the dairyman, hay is the main source of feed and he will generally feed it year around. Income from the dairy enterprise is received monthly or semi-monthly and many dairymen, gear their hay purchases to their income period. Also dairymen tend to delay purchases until their own supplies are gone. This leads them to purchase hay in smaller lots, buy more often and at regular intervals after their own stocks are depleted.

The rancher, on the other hand, relies on his range for the bulk of his livestock feed. A minimum stock of hay is stored for winter feed and emergencies. It is often advantageous for the rancher to purchase needed hay supplies during or shortly after harvest when hay prices are relatively low. Also his ranch is usually accessible to heavy trucks and hay can be placed at desired locations without any undue inconveniences. The typical rancher will purchase sufficient hay each fall to bring his stocks on hand up to an average year's use. He will normally not make further purchases unless inclement weather causes him to feed more heavily than anticipated.

Ranchers and farmers producing hay in the ranching areas surveyed preferred to sell in late summer or fall. By this time the market is active and has been fairly well established. Farmers selling in predominately dairy regions were undecided as to any preferred time. The most common answer was that there was no specific time; they just had to wait and see how the market developed.

Farmers usually reported several alternative selling opportunities but these were usually with other buyers in the same feeding group. Location of the farmer with respect to the type of buyer in his area is important. However, the type of hay the farmer produces also plays a role in determining who potential buyers might be. Dairymen and feedlot operators have a strong preference for alfalfa hay while ranchers, livestock yards and auctions prefer grass hay.

Dealer activity is determined by uses for hay in their locale. Dealers in predominately dairy areas have their busiest season later than those who supply ranchers. Dealers in the Billings area especially shift from one group to another as the season progresses. The period just before the new crop is harvested is usually slack. During the months of May, June and the 1st of July, livestock are out on pasture. This terminates the need for old hay, and the new hay crop has not come onto the market yet. Hence there is little demand for the dealer's services.

Marketing Practices

There was little evidence of use of special marketing practices in the area surveyed. Twelve hay buyers and 11 hay sellers reported they were using no special practices to assure realization of a desired price. Eight buyers felt that buying during the harvest season would assure them lower prices. Only one seller thought that selling during a specific time period would assure top prices. Buying from or selling to the same individual year after year was the factor most often mentioned as a method of assuring desired prices.

Thirty six of the 54 buyers and sellers replied that normal buying or selling practices are not affected by years of above or below normal production. Buyers who indicated they did change their purchasing habits, bought early in short years and late in long years. Sellers, on the other hand, tried to sell early in years of above normal production and indicated they held back in years of below normal production. However, in years of below normal production hay tends to move earlier. In above normal years it tends to move later.

Production Technology and Hay Quality Improvements

Sellers indicated that changes in hay production technology has affected marketing very little since the widespread adoption of the hay baler. Balers have been used rather extensively in Montana for the past

decade. One minor change during this period that has affected marketing, is the use of twine to tie bales. Earlier bales were tied with wire. The shift to string-tied bales was a move to lower costs at the farm level. However the string-tied bale is smaller and lighter than the wire-tied bale and some of the cost saving advantage is offset by increased transportation costs. Truckers are unable to haul the same tonnage with string-tied bales as they are with wire-tied bales. Many commercial hay producers still use the wire baler for this reason.

The quality of hay marketed over the last decade has probably improved slightly since farmers have become more aware of quality factors. Management practices have been altered as quality is accorded greater importance. Hay ground is fertilized, hay is cut earlier, and more care is taken in baling and stacking than in years past. Improvements in the baler and other harvesting equipment have allowed more timely harvesting of the hay crop. Hay crimpers and hay rollers immediately after mowing, are being used in some areas. These machines crush the hay stems and significantly reduce the required drying time. Conditioning hay by this method results in a more even drying rate between leaves and stems and permits the hay to be baled several hours earlier than is otherwise possible. When hay is uncrimped the leaves will reach optimum baling condition several hours before the stems are sufficiently dry. Unless special precautions are taken on uncrimped hay, many of the leaves will be knocked off during baling because they are too dry. Therefore crimped or crushed hay often

brings a premium. In addition some feeders feel that crimped hay is more palatable, because of the crushed stems.

Hay Grading and Quality Preferences

Two methods are used to grade hay in the western states. One is having a trained inspector grade the hay according to standards set forth by the United States Department of Agriculture. This is a subjective test relying on the judgment of the inspector. The second tests the hay for certain nutritive elements by chemical analysis. The hay is graded according to the relative content of a certain nutrient (or nutrients) found in it. The element used most often to determine grade is protein. Sample lots of hay are tested for protein content and then compared to the average protein level of hay in the area to determine its relative grade. The hay is then priced according to its relative grade.

The latter method is gaining popularity in commercial hay producing areas of the western states. However, neither is used extensively in Montana. Size and diffusion of hay marketings within most areas of Montana make costs of services of a United States Department of Agriculture hay inspector prohibitive. Inspectors are available in other western states but the cost and time involved in sending samples to them or having them come into the state to grade various lots of hay makes the use of their services impractical. The cost of the protein test is also relatively high and the lapse of time between sending in the sample and getting the results back is discouraging to users of this system.

Use of Hay Testing in Montana

In the interviews five sellers and one buyer indicated they had tested their hay at least once in the last five years. No one reported they had tested their hay every year. The usual practice was to use the result of the last test made as a general indication of the nutritive value of hay in succeeding years. The results of a test on one lot of hay is of questionable value as an indicator of quality in other lots. Studies point out that the level of protein can vary substantially from one year to the next, from one cutting to the next and even from one field to the next. Stage of maturity, type of hay, condition at time of baling, fertility of soil and various other environmental factors all effect the protein content of hay. None of the buyers or sellers reported using United States Department of Agriculture inspectors to grade their hay.

There is an increasing amount of interest in some areas of the state for a practical hay testing program. Dairymen especially, are expressing interest in a low cost test where results could be made available within a few days after the hay was sampled. They have, of course, more at stake than other hay feeders. High milk production requires a liberal supply of protein and T.D.N. Forage is the principle source of these constituents in the dairymen's ration. Additional quantities are usually supplied through high protein or other high energy feeds which are normally higher in price than good forage. Without knowledge of the nutritive value of his hay, the dairymen may be feeding a ration deficient in certain nutrients

and, producing well below the potential of his herd or producing at a high level but supplying more nutrients than required. In either case he is not operating at optimum economic efficiency.

Conflicting Requirements of Major Feeding Groups

A major obstacle to grading hay is that a test has not been developed that is equally meaningful to the three principal feeding groups in Montana. Dairymen's interest lies in a test designed to ascertain the level of T.D.N. and protein. ^{50/} Feedlot operators value hay from a different viewpoint. Hay is not used extensively in the fattening ration because the ratio of protein or T.D.N. to bulk is low. After a conditioning period where the cattle adjust to the high energy fattening ration, hay is included in the ration only as a source of roughage. The feedlot operator is probably more interested in the palatability and roughage characteristic of hay than in any specific nutritive element. Since these aspects of hay can be estimated fairly accurately by visual inspection, the feedlot operator may not be willing to assume the cost of testing hay.

^{50/} At present, the protein test is probably the most popular in the western states. It has the advantages of being relatively inexpensive, is a good indicator of nutritive value, and it tests directly for one of the critical nutritive elements. Other single constituent tests which have been used quite extensively are the lignin and crude fiber (or modifications) tests. The lignin test has shown the best correlation with digestibility in recent years. However, this test is relatively difficult and time-consuming. Crude fiber has been used extensively in the past but has been replaced by tests more precise in their predictive capabilities. For more specific information in this area see Howard Gilbert and Martin Waananen, "Hay Quality; A Literature Review", Washington State University, Pullman, Station Circular 341, July, 1961. Also, J. K. Patterson, "Chemical Components of Forages as Predictors of Forage Quality", Paper delivered at the annual meetings Western Division, American Dairy Science Association, Moscow, Idaho July, 1961.

The rancher wintering livestock is in somewhat the same category. His main interest in feeding hay is maintaining the body weight of his livestock and to see that they get sufficient vitamins and minerals for normal fetus development. The rancher prefers clean, palatable hay with a minimum of waste. He likes hay that is similar to the native range forage in order to reduce the risk of bloat or scours, or of having his cattle go off their feed. Thus, he is willing to sacrifice some nutritive aspects for desired feeding qualities. These can also be satisfactorily estimated by visual inspection.

It would be difficult to establish an economical grading system in many areas of the state except where there is a relatively high concentration of dairymen. Dairymen in the counties of Gallatin, Lake, Ravalli and Yellowstone could probably form successful testing associations in conjunction with local hay suppliers to test and grade the hay they purchase.

They can use hay testing groups and associations currently operating successfully in other western states as models. California and Washington particularly, have made progress in organizing and establishing facilities for testing hay. The advantages accruing to participants are many. Sellers have an objective basis whereby they can price hay according to its quality and be rewarded for special steps taken to produce high quality hay. Buyers, on the other hand, have an objective basis for paying quality premiums. Feeders, feeding either their own hay or purchased hay are in a

position to provide their livestock a minimum costs diet with the assurance that it has adequate nutritive requirements.

Organization of a Hay Testing Association

A hay testing association is not difficult to organize. A typical association is one operating out of Benton County, Washington. This association was organized by the Local Farm Bureau in 1956. It was so successful in its first years of operation that it was expanded to three neighboring counties. The association's fieldman does all the sampling. In 1961 he sampled more than 5,000 tons of hay at a cost of 65 cents per ton. The association indicated that if the volume could be increased to approximately 15,000 tons, the cost would be reduced to around 50 cents per ton.

The fieldman collects 20 samples from each lot of hay. The samples are blended and sent to a commercial lab for testing. At the laboratory, samples are tested for crude protein--the nutrient the Washington association feels is most important. From this test an estimate of digestible protein is made and the association is informed of the result. The level of digestible protein provides the basis for association members to make adjustments in the price of their hay. The base price for hay is established in accord with the current market price and for each 1 percent increase in digestible protein above 15 percent, \$1.50 is added to the price of hay per ton.

Testing the hay for moisture content is another feature the Washington

association provides. The base content has been established at 16 percent. Sale weight of the hay is adjusted for any reading above or below the base. For example, if hay is sold out of the field at a moisture reading of 20 percent, a 4 percent adjustment in weight is made. On the other hand, if the moisture content is 12 percent, a 4 percent upward adjustment is made in the sale weight. Actually, many growers have purchased their own moisture tester as an aid in determining the optimum baling time. This battery powered apparatus can be purchased for about \$25. It takes about 20 minutes to make the necessary test.

In addition to the crude protein test, the laboratory will make other tests. They are often made to determine the carotene content, and the pesticide residue on the hay. However, additional laboratory fees are charged for this service. 51/

Preferences for Various Cuttings and Kinds of Hay

There was no general consensus on the part of the buyers and sellers interviewed as to which cutting of hay was best.

In areas where three crops are normally harvested, the first and third crops are finer textured, have a higher leaf to stem ratio and are generally more palatable than the second crop. When only two crops of

51/ George Blosser, "How to Organize a Hay Testing Association", Western Dairy Journal, (December, 1960), p. 26.

alfalfa are grown the reverse is true. Since only one crop of grass is usually harvested in Montana, it was not considered.

Buyer preferences for hay with different characteristics were evident. Dairymen, sheep ranchers, purebred cattle feeders and feedlot operators generally preferred the finer textured, more leafy hay because of its higher productivity. At the same time, hay with these characteristics is more likely to cause animals to bloat or scour unless they are accustomed to it. Therefore, cattle ranchers prefer a more coarse hay. In areas where late June rains are common, second and third crops are often preferred because the first crop is usually put up under adverse haying conditions. Moldy hay is dreaded by all feeders.

Physical characteristics such as stem texture, leaf-stem ration, stage of maturity, foreign matter, green color and general condition of the bale were commonly mentioned as quality indicators by both sellers and buyers. Buyers frequently mentioned their preference for hay that had been raised on new or well fertilized ground and which has been sprayed for weevil. Other quality factors that were listed by one or more individuals were: Hay from irrigated land, hay that had been crimped or conditioned and in some cases hay mowed with a swather.

Grass hay sold for a premium over alfalfa hay in all but one area reporting both alfalfa and grass hay transactions. The Miles City area was the exception. Most of the grass hay comes to this area from out-of-state and is of poorer quality than that produced in Montana. Price differentials

between grass and alfalfa hay were commonly explained by the higher production costs and the greater relative strength of demand of the feeder.

CHAPTER IV

HAY PRICES AND PRICING

Prices are often used as a measure of market performance. Price, however, is the product of forces operating in the market. If performance is to be measured, then one must ultimately look to the operative forces responsible for price. The objective of the following analysis is to set forth hay price characteristics and to examine the mechanism by which they are formulated.

Pricing Hay in Montana

Many factors influence price determination in the Montana hay market. Some of these are latent at the time price must be determined. Individuals or groups who play important roles in price determination must evaluate the effect these latent factors will have throughout the marketing year. Because of uncertainty with respect to these forces the market at the beginning of a hay marketing year is usually marked by price rumors, speculation on future conditions and discussion as to what prices should be but with few transactions. Later, as the effect of these forces become more apparent a "going price" will materialize.

Areas of the state differ with respect to the time it takes to establish a going price. In areas where individuals or firms move more resolutely to make price offers, the market becomes established soon after harvest. In areas where hay dealers are most active, the "going" price for hay becomes established relatively early. It is to their benefit to initiate trading as

soon as possible and they have generally been willing to accept considerable responsibility in pricing. In areas of the state where one or more buyers dominate the local market the price of hay also tends to become established early. To assure themselves of sufficient hay stocks these large buyers will advertise their offering price before harvest has begun. Although their first price offer may not set the level of prices, reactions soon occur and a general consensus on price emanates.

The various livestock auctions and cattle yards around the state often help initiate price. The hay dehydrating plants in Gallatin and Phillips counties have a similar influence. Since these latter firms attempt to assure themselves of needed supplies by contractual agreements made prior to the harvest season and subsequent marketing year, their influence is more indirect than the firms dealing directly in the market. The contractual price between the dehydrating plant and its customers probably serves more as a point of departure for price negotiations than as a market force exerting immediate price pressures.

A significant factor in the early development of these local hay markets is communication. In markets with one or two large buyers and many sellers, and in some cases aggressive hay dealers as "go-betweens", many of the barriers to effective communication in other areas are removed. In effect, existing forces of supply and demand are able to converge relatively easy on one central agent and a price that initiates trading is determined.

The price influence of markets that develop early often extends further than the boundaries of their physical extent. In some areas of the state the volume of hay marketing is so low and infrequent that a so-called "going price" is never established. One of the best alternative means of pricing for these areas is to adopt the price structure of the more advanced markets. The possibility that the adopted price structure will not reflect accurately local demand and supply conditions is always a threat. Inter-area demand and supply conditions may vary significantly. If both markets adopt the same price structure trading will not be undertaken and a disparity in the general market will occur.

This same problem exists in intra-area trading to some extent. This is especially true in areas with a centralized market. Once a market price is established it tends to become a going price for the whole market area. Dealers have encountered difficulty in getting farmers to accept reductions in the going price sufficient to cover costs of transporting hay to the central market. In the absence of a strong market agency to determine price, interpretation of the going price is often confusing. In some cases a delivered price to some point may be representative; in other cases the farm gate price may be involved. In this confusion, there is a tendency for each party to make interpretations to its own advantage.

The buyers, sellers, and dealers interviewed were asked specifically how they arrived at a price. Answers varied from individuals who claimed prices were dictated to them, to those who relied on numerous avenues of

information to formulate price. Twenty one respondents indicated the use of the going price as a guide in market transactions. Others used the going price as a base but adjusted it for quality factors. Twelve reported that price was determined solely by the other party.

Dealers and farmers in the Billings area claimed that prices were set by the buyers. Dealers in the Ravalli County area, whose hay business consisted almost entirely of transporting hay from southeastern Idaho into Montana, claimed that markets around Salt Lake City, Utah indirectly set the price of hay.

Hay dealers serving the Salt Lake City and Ogden, Utah markets come into Idaho shortly after harvest to buy hay. This early buying pressure tends to establish a market price which reflects demand and supply conditions existing in northern Utah. Montana dealers, who do not begin shipping until later, take a relatively small amount of the total supply of hay in this area of Idaho. They have only a slight effect in determining the price of Idaho hay. Their influence in determining price in Montana is quite the reverse, however. There is a strong preference for Idaho hay in Ravalli County and its price acts as an umbrella for pricing local hay. Dairymen especially, have developed a strong preference for the Idaho hay and have fixed in their minds some quality differential which they use to discount the price of local Montana hay. 52/

52/ For further discussion of this see, R. Kaye Bergman and Art Jacobs, "Summary of Survey made on Western Montana Hay Problems", unpublished report, Montana State Extension Service.

The previous year's price adjusted for present conditions is often used as a basis for determining current hay prices. Even though many did not list this as a factor, it was evident from their conversation that this is one of the most important influences. Last year's prices and contributing conditions are history at the beginning of the new hay crop year. It is easy to start with last year's price and prevailing conditions as a norm and adjust it for deviations existing in the current year to arrive at a price.

Other sources of price information were the local bankers, truckers and feed mill operators. All of these individuals tend to keep well-informed in matters related to the hay market and can usually provide information pertinent to the pricing of hay. In fact, several respondents felt that the banker was often quite influential in price determination. Owning financial obligations against both the hay producer and hay buyer puts him in a position where he has an economic interest in both. When he controls the purse strings of a large number of both buyers and sellers he can often effectively arbitrate a price satisfactory to both groups.

Although the existence of relatively wide price differentials among various local hay markets are not uncommon, the current price reported by the individuals interviewed showed little variation. Differences did exist between buyers, sellers and dealers, however. Hay buyers reported a current average price of \$19 per ton. Hay sellers reported an average price of approximately \$23 while dealers reported a price of about \$22 per ton.

The price discrepancies are probably due to anticipated or expected prices. A majority of the schedules were taken before the hay market had been established firmly and a "hope" factor was probably built into the current prices reported.

The Crop Reporting Service publishes an annual all hay prices received for the state. During the 5-year period preceding the 1961 hay crop, this price had varied from a high of \$24.60 per ton in 1960 and a low of \$16.90 per ton in 1957 and 1958. Hay purchasers reported an average price paid to farmers over the same 5-year period of \$21 per ton. 53/ Highest price paid during this period averaged \$26 and the lowest averaged about \$14 per ton. Comparable price figures for hay sellers averaged \$21, \$28, and \$16 respectively.

The buyers and sellers surveyed, reported that current and reliable hay market information was almost nonexistent and that this was a major problem area in their marketing efforts. The Crop Reporting Service publishes a report on general growing conditions for hay and grass on a district basis. Also, a general crop report is published annually from this office which includes hay information. Many of the western farm magazines periodically report general feed conditions. Doanes Digest and other bulletins make these general reports also. Unfortunately, the information in these sources is too general to be of use to local hay producers or buyers.

53/ All prices were converted to a prices received at the farm gate for baled hay out of the stack.

County agents attempt to keep abreast with the local hay situation and often maintain lists of farmers wishing to buy or sell hay. Individuals from out-of-county can contact the county agent and frequently line up prospective buyers or sellers or at least be brought up-to-date on market conditions in that area. Truckers in transit, supply information on other areas to local dealers and farm and ranch operators.

When asked if they would cooperate in reporting hay sales information all the buyers and sellers replied they would. Four of these individuals, however, felt that it would be of little help in their own operations because they only bought and sold in their own county. These four are from an area that usually has a hay balance.

Hay dealers were generally not receptive to a method of collecting and disseminating hay market information. They were of the opinion that the extra bookkeeping to make these reports would not be worth the additional information they might receive. Also, there was a general feeling of suspicion that more information in the hands of buyers and sellers may be harmful to their business. One advantage a dealer has is knowledge of potential hay supplies and outlets. If more information on market volumes and prices were to erase this advantage they feared the potential need for their services would be decreased. Several dealers indicated that additional information might call attention to price discrepancies and draw outsiders into their areas to compete for local markets. Either these dealers failed to realize this would work two ways or they felt they were operating in an area where they enjoyed some special market privileges.

Adequacy of Pricing Mechanism

Is the pricing mechanism of the Montana hay market efficient, i.e., does the price of hay reflect the value of its marginal product? Examination of the process of pricing suggests that while the price negotiated for any given hay transaction may satisfy this criterion, there is little evidence that the pricing mechanism in operation will assure this result.

An important indication that the performance of the hay market is inefficient stems from the widespread apathy of Montana feeders to quality and other productive characteristics of hay. In general, hay users are not aware of the relative contribution of hay as a productive input. As a result the hay market has generally been slow to respond to market forces and in many cases it has allowed special interest groups to dominate its functions.

A second major obstacle to efficient hay marketing is the number of physical limitations. Hay is a high bulk-low value product that does not lend itself to modern marketing techniques. The geographic area of the market is usually small and the number of potential buyers and sellers are normally few. In addition to these restrictions, the same lot of hay may be viewed as quite a different product by the major hay feeding groups.

A third major obstacle to efficient hay marketing is the lack of current and reliable market information. A solution to this problem however, will be difficult to find. The market for hay in Montana is normally confined

to a relatively small local area. The market volume, with the possible exception of the Billings area, is low with only a few buyers and sellers involved. It is further complicated because the hay which does enter the market never passes through a central trading point where information on prices and volume traded can be collected.

It has been suggested by several people interested in hay marketing that techniques similar to those employed by the state statisticians office be used to estimate hay prices and volumes at various markets in the state. Two major obstacles are encountered in this approach. First, the cost of a sample to provide reliable estimates of current average prices and volumes for each of the major market areas would be prohibitive. Secondly, to ascertain statistically reliable figures the sample would require approximately the same number of observations for each market area as are being made on a state-wide basis. It is questionable if this would be physically possible in some areas of the state because of the lack of hay transactions and the difficulty encountered in locating them.

Even if a method could be devised whereby sales data could be reported on a market area basis, the problem would only be partially solved. Almost every buyer and seller contacted during the summer of 1960 expressed a desire for additional information, but he also wanted this information to indicate the type and quality of hay. Without an effective grading system this is practically impossible.

Every local hay market in the state is probably lacking one or more of the necessary conditions for a perfectly competitive marketing system. To the extent that these conditions cannot be compensated for, performance of the hay markets must necessarily be below the efficiency criterion.

General Hay Market Price Relationship

To this point, pricing has been analyzed with primary reference to the individual buyer or seller with special emphasis on form and place. An analysis of price in a broader context is also necessary. Especially important is the relationships of hay market prices over time and their implications.

Hay Price Trend

The weighted average price of hay in Montana shows considerable variation over the past two decades. During this period prices ranged from a low of \$7.39 per ton in 1940 to a high of \$32.76 per ton in 1952. In 1960 the weighted average price was \$24.69 per ton. Price variation from year to year has averaged 16 percent. When prices are adjusted for changes in the price level, the price farmers received for their hay shows less variation. The low in this instance is \$17.64 per ton in 1958, while the high is \$28.38 per ton in 1960. ^{54/} Average year to year variation on this basis is approximately 14 percent.

If the price adjusted data corresponding to this 21-year period are

^{54/} Prices quoted in this section represents prices received by farmers for baled hay. Unless otherwise noted this procedure will continue throughout this manuscript. The price data used were taken from various statistical publications by the State Statistician's office.

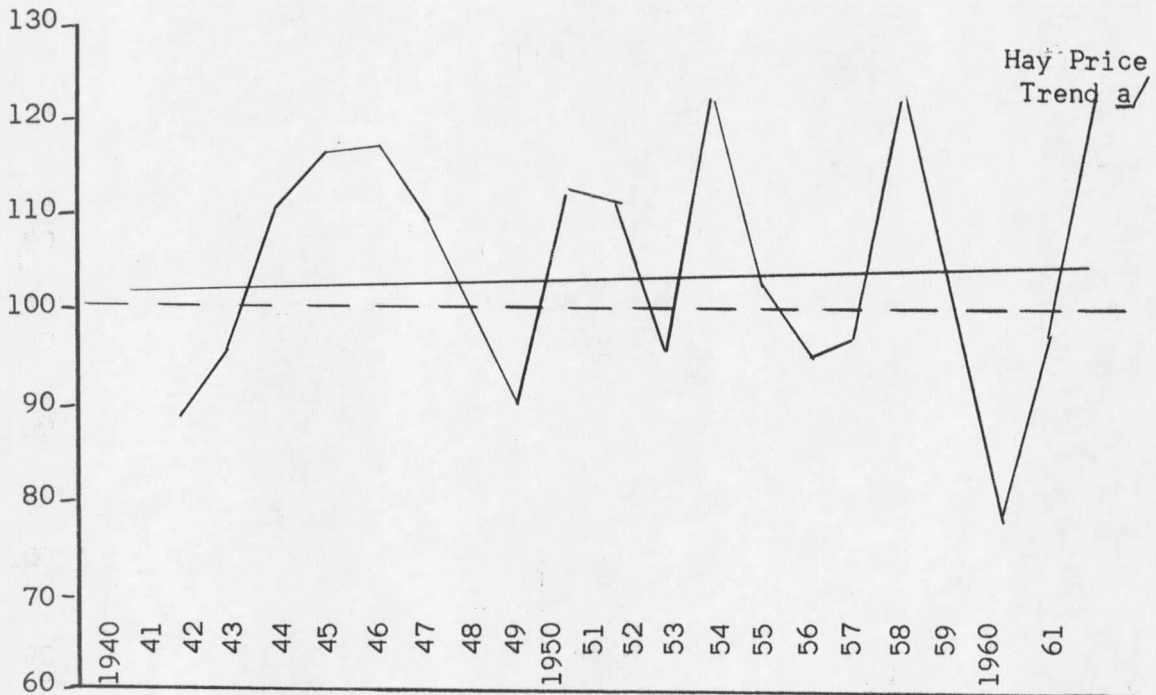
subjected to the standard straight line equation ($Y = a + bX$) only a slight upward trend is evidenced, Figure B. Solving this equation for the parameters (a) and (b), values of 103.4 and .132, respectively are obtained. The (b) parameter in this equation measures the slope of the trend line, i.e., it measures the change in (Y) corresponding to a unit change in (X).

Seasonal Price Variation

Seasonal price movements for hay tend to follow the same general pattern year after year. Prices are generally lowest in July when the new crop comes on the market, Figure 16. From July through January there is a gentle upswing in prices. In February the price trend reverses itself and continues to decline throughout the remainder of the marketing year. ^{55/} The shaded area in Figure 16 represents one standard deviation from the seasonal price line and provides a measure of the extent of variation that might be expected. ^{56/} During some months more price variations are experienced than in others. The early spring months--February through May--demonstrate more price uncertainty than any other portion of the marketing

^{55/} The procedure used to derive this seasonal price pattern is similar to that presented in F. E. Croxton and D. J. Cowden, Practical Business Statistics, (New York, Prentice Hall, Inc., 1948) Chapter 12. In this approach trend is removed by using a 12-month centered moving average. After adjustment for trend, prices are then converted to an index. An average index value for each individual month is used to establish the seasonal price pattern.

^{56/} The standard deviation is a measure of dispersion about the mean. One standard deviation includes an area in which approximately 68 percent of the observations are expected to occur.



a/ This trend line was established through the standard straight line equations $Y = a + bX$. In this analysis $(a) = 103.14$, where $a_0 = 1950$, b was equal to $.132$.

Figure 15. Index of hay prices deflated and adjusted to a 1947-49 = 100 base.

year. The harvest months--June, July and August--demonstrate the least.

It may be of interest to the buyer or seller to know whether the year to year shifts that occur in the seasonal pattern is random or whether its shape is gradually changing. If price influences are causing the shape of the seasonal price pattern to be gradually altered, it may be advantageous for buyers to adjust their marketing practices accordingly. The price pattern presented in Figure 16 would cover up any such trends. A test using methods of rank correlation, can be made to see if any changes are occurring. By computing a term referred to as "Kendall's Coefficient", the null hypothesis that all changes are random and that the observed value of S (Kendall's Coefficient) does not deviate significantly from an assumed population of zero can be tested. ^{57/} For tests in which $N \geq 10$ the population can be assumed to be distributed normally and Student's T test can be used to test the null hypothesis.

For this analysis the months of January and July were chosen to test for significant changes in the shape of the price pattern. Neither of these months showed any significant change at even the 1 percent level and, thus, it is assumed that no change is occurring, i.e., the null hypothesis that $S = 0$ is accepted. Computational work for this analysis is presented in Appendix A.

^{57/} The procedure for computing Kendall's Coefficient and making the appropriate test is presented in Frederick C. Mills, Statistical Methods, (3rd edition; New York: Henry Holt & Company, 1955) pp. 312-317 and 374-375.

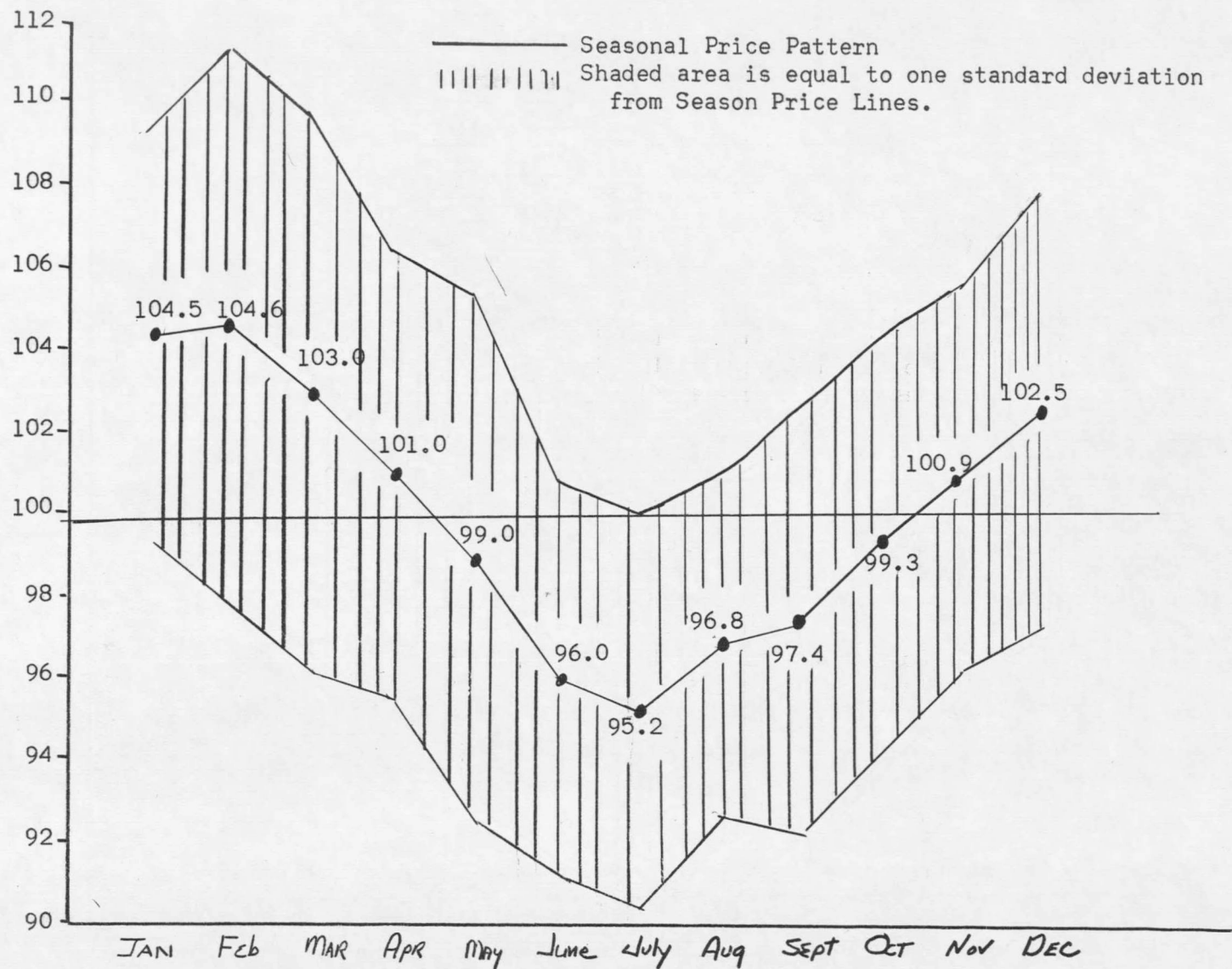


Figure 16. Seasonal price movements--all hay baled, 1940-61.

Seasonal Price Determination

Commodities that are produced seasonally for a consumption period extending over the whole year requires some unique pricing considerations. Hay, with many other agricultural products, is just such a commodity. It is produced in a three to four months period in the summer but is fed year around. In this case the market must develop a set of prices that will move a relatively fixed supply of hay (the quantity of which is generally known after harvest although it may not be offered for sale until some later date) into the hands of hay buyers whose demand for hay may be based on a 12-month use period. ^{58/} The demand curve for hay under these circumstances would not be the usual consumption-demand curve, but rather, it would reflect buyers expectations for the remainder of the hay marketing year. Since buyer expectations tend to change more often than actual needs the expectations-demand curve would be more erratic than the consumption-demand curve. It would generally be more elastic than the consumption-demand curve. Holbrook Working pointed out the difference between these two demand curves in a journal article in 1958.

^{58/} It should be kept in mind that the effective market supply of hay is not the same as the supply of hay on the farm. Raymond Stack, op. cit. found that only about 13 percent of the hay produced on Montana farms ever reached the hay market. Although this latent supply could theoretically be considered part of the market supply the immediate discussion will be concerned only with that amount normally produced for the market.

"The basic idea underlying the model is that it must make adequate place for expectations in the formation of demand. Prices of such commodities as potatoes or wheat, if found in a 'free' market, must be found under the influence of expectations.

"One may think it conceivable that prices of such commodities could be arrived at without influence from expectations, but this is a delusion. Suppose, for example, a potato market consisting only of producers on the one hand and of consumers on the other; and suppose that at harvest time producers and consumers met in a great auction, at which consumers had to bid for what potatoes they wanted during the season, knowing that they could neither buy more later nor resell a surplus if they bought too much. Such a market would not be free of influence from expectations. Consumers would be forced to anticipate their wants during all the future months of the season. . . .

"In short, this great auction would not bring consumption demand directly into the market; it would merely force consumers to become in a sense speculators, anticipating their future consumption demands. . . . prices such as we are discussing must be formed under the influence of expectations, and we therefore need a theory of market price founded on expectations. We are dealing with prices that must be anticipatory." 59/

In elementary marketing courses the static price model is often used to demonstrate that the equilibrium market price occurs at the intersection of the supply and demand schedules. This static model is, of course, too simple to explain adequately the complicated dynamics of actual price discovery. However, it can be used to gain some insight into the process of price discovery, by making some modifications and assumptions as to its applicability.

59/ Holbrook Working, "A Theory of Anticipatory Prices", The American Economic Review, May, 1958, p. 191.

The first point to be examined is the underlying principle involved in arriving at an "equilibrium price" in the market. The static model shows that the equilibrium price occurs at the intersection of supply and demand. The same principle is involved in the hay market, but with some modifications.

If buyers expectations are restricted to the marketing year, the demand schedule applicable to the last month or time unit in the marketing year will not be an expectations demand curve but a regular consumption-demand curve. Appropriate demand schedules for all preceding periods in the marketing year will be expectations-demand schedules because buyers will not only manifest their current needs but their anticipatory needs as well. It is reasonable to believe that as long as buyers anticipate a need for additional hay stocks in the near future, the demand curve will be relatively more elastic than the total market demand curve. Buyers will purchase hay for future consumption needs any time the current price is enough below their projected equilibrium market price to reimburse them for any inconveniences and added wastes that might be involved.

The overall supply curve for the market year would be rather inelastic. In any given year the amount of hay available for market will be determined by current production less the quantity of hay needed to satisfy the producer's own needs. The available market supply, therefore, is a residual sum, the amount of which will be determined shortly after harvest. Thus, the total market supply schedule will be quite inelastic. 60/ The supply schedule

60/ At the extreme ends, the supply curve would probably be relatively more elastic because at some level prices would be high enough to pay some farmers to sell off their livestock and sell their hay or enough to pay them to buy livestock and feed their hay.

for any month prior to the end of the marketing year will also be relatively less inelastic than the total supply curve because of producers expectations.

The equilibrium market price will occur at the intersection of the supply and demand schedules for the total market. This will be a price that permits a rather fixed market supply of hay to pass into the hands of buyers. In this situation the market receives signals reflecting the relative strengths of the total expected market supply and demand schedules and derives an equilibrium price therefrom. ^{61/} The equilibrium price for any month prior to the end of the marketing year will be determined by discounting the expected price for the overall market back to the particular month. By this process, the equilibrium market price in the final month will be the same as the overall market equilibrium price.

The process by which the market price of hay is determined can now be summarized. When the new hay crop comes on the market in July and August the market makes a judgment as to the relative strength of the total expected market supply and demand schedules and derives an equilibrium price. The current price of hay is determined by discounting the overall equilibrium price back to the present month. Since the total market supply and demand schedules and those for the final month both occur in the same time period their equilibrium prices will be the same.

^{61/} The degree to which the market does not estimate these schedules accurately will be the margin of error or inequity, under the assumption of the purely competitive model, that occur in the market. In reality, however, the actual demand and supply schedules are, in most cases, ex post considerations. The market then is faced with the task of making ex ante judgments (estimates) of the nature of these schedules. Under these circumstances the probability of error in any given year is likely quite high. Direction of the error, being either above or below the true equilibrium price, would appear to be a random factor and in the long run would tend to balance out.

The amount of the discount or price difference between the final month and any preceding month will, in the long run, cover the costs of storage between the two time periods. Thus over a period of several years, the theoretical seasonal price pattern will have its low point in July and August and then gentle rise to the end of the marketing year; rising sufficiently to allow for shrinkage, waste, and other costs of storage.

The appropriate question now is, how does the seasonal price pattern for Montana hay compare with the theoretical price pattern? Generally, the seasonal price pattern demonstrates the properties expected, Figure 17. However, there is one area of the price pattern that deviates from the theoretical one which is difficult to explain. This is the downward sloping portion of the curve which begins about March and continues throughout the rest of the marketing year. To explain this phenomenon a reconsideration of the underlying causative factors is needed.

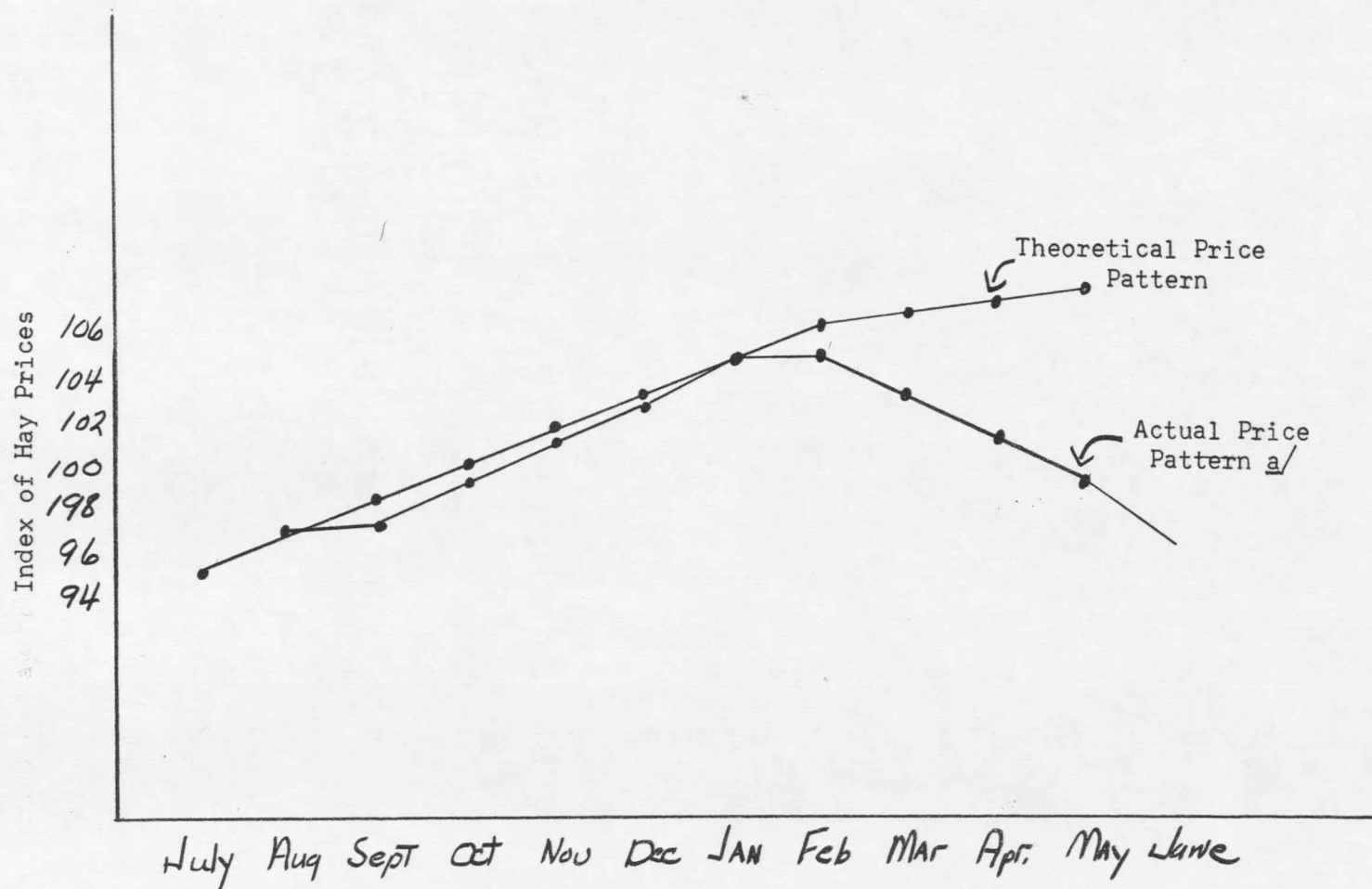
It was stated theoretically that in the long run the seasonal price pattern should rise sufficiently to cover costs of storage. What these costs are and when they occur are paramount in establishing a theoretical price pattern.

Estimates of hay shrinkage and storage wastes by hay buyers, sellers and dealers contacted during the summer of 1961 ranged from 5 to 12 percent. The Dairy Department at Montana State College uses a general rule of thumb that the loss in hay due to shrinkage and storage wastes will approximate

10 percent. H. M. Skinner found losses due to shrinkage and storage waste amounted to approximately 3 percent. ^{62/} It does not seem unreasonable to assume an average shrink and waste figure of 6 percent. Since these losses usually occur in the fall and early winter the 6 percent loss in the theoretical model is allocated over a comparable 6-month period. A charge of 5 percent per annum for interest on investment is also made. This charge is allocated only over the middle 10 months of the hay marketing year since the volume marketed during June and July is very small. The theoretical price pattern based on these assumptions is presented along with the actual one in Figure 17.

Three explanations for the divergence of the actual price pattern from a theoretical one based on the assumptions of a perfectly competitive market seem plausible. First, it is possible that there is an implicit quality differential in the actual price pattern. The price of hay tends to gravitate to the so-called "going price" regardless of quality differences. Many dairymen and other quality conscious buyers have a strong influence in setting the price at levels sufficiently high to get the quality of hay they desire. At this price, buyers who may not be as quality conscious will still search out the better quality hay because the market provides no effective method for discounting poorer qualities. Under these circumstances

^{62/} H. M. Skinner, "Comparative Costs and Losses Involved in Harvesting, Storing and Feeding Hay in Montana", Montana State College Agricultural Experiment Station, Circular 203, July, 1953.



a/ Actual price pattern was derived from hay price 1940-1961.

Figure 17. Actual and theoretical price patterns for Montana hay.

the quality level of the remaining hay will generally decrease and eventually will be reflected in the seasonal price pattern.

Secondly, the market for hay in Montana has a fairly rigid institutional structure. Farmers and ranchers, in many cases, have been buying and selling hay from the same individual and at approximately the same time for a number of years. Habit, the cost of finding new market opportunities and the cost of shifting income periods may have resulted in a situation where the relative pressures of demand and supply are not congruent and have caused the market to become somewhat out of balance. Whether economic forces dictated the prevailing institutional structure or whether these institutional arrangements are responsible for this imbalance is a matter of speculation. There is no doubt, however, that the Montana hay market is highly rigid.

The third and most satisfactory explanation, is that the price pattern reflects an attempt by farmers and ranchers to minimize risk. If they attach a higher risk to running short of hay than they do of running long, they would, in an attempt to minimize this risk, tend to buy more than they normally needed. In the beginning of the marketing year the demand for hay would be stronger than in a market where there was no apparent risk. Since a majority of hay sellers in Montana are also feeders, they will tend to insure themselves against this risk by holding a larger quantity of hay than they normally expect to feed. The result of these two separate decisions will be to shift both the supply and demand curves upward and,

consequently, to arrive at a higher equilibrium price. As the year progresses and as more accurate knowledge of future needs is obtained, this risk will be reduced and a decrease in the relative strength of demand will occur. Sellers realizing they have overestimated their needs will lower their reservation price causing the supply curve to shift to the right, and the market to establish itself at an equilibrium price lower than would prevail in a market operating under perfect knowledge. In addition, if sellers anticipate a possible carryover they may reduce their reservation price substantially in the later months of the marketing year to avoid assuming the cost of carryover stocks. Thus, as the relative strength of the supply and demand curves vary over the marketing year, being stronger in the beginning and weaker in the later part of the year, it would result in a seasonal pattern of rising prices at first which then tends to fall off.

The degree to which each of these three factors is responsible for the downturn in the seasonal price pattern is a matter of conjecture. The relevant point is, that the presence of these or other unspecified factors cause the actual price pattern to vary from a theoretical one which is based on the assumptions of a perfectly competitive model.

CHAPTER V

IMPACT OF HAY PROCESSING ON THE MARKET FOR MONTANA HAY

Growth and Importance of Processed Alfalfa

Areas of the state that tend to be general surplus areas experience depressed hay prices when good growing conditions prevail for extended periods of time. New irrigation projects coming into operation are often surplus producing areas. Alfalfa is considered a valuable crop for building and conditioning the soil. Restrictions on the acreage of some crops by government regulation have increased the importance of alfalfa as a production alternative in both new and old established irrigated areas. In an attempt to increase the income from this crop, farmers are on the lookout for alternative markets and methods of marketing.

One method is the production of alfalfa meal. Dehydrated alfalfa meal is considered a feed supplement and is relatively high in both protein and carotene (a substance primarily contained in green-leafed plants which is converted into Vitamin A in the body of animals). Dehydrated alfalfa meal is produced by running green alfalfa through a revolving drum heated to between 1500 and 2000 degrees Fahrenheit. It enters the drum containing approximately 70 to 85 percent moisture and is dehydrated to less than 10 percent moisture.

Dehydrated alfalfa meal is customarily sold on the basis of 17 percent protein and 100,000 Chick Units of Vitamin A per pound. It is used more as

a Vitamin A supplement than as a protein supplement. Almost all the dehydrated production in Montana (carried on at present by two mills) and in the rest of the United States is used in formula feeds.

During and shortly after World War II the production of sun-cured alfalfa meal flourished. Sun-cured meal however, has never been accepted as a feed supplement by the domestic feed industry. As a feed it provides all the nutritive elements of good alfalfa hay but is used primarily as a carrier in mixed feeds. With the development of the dehydrating industry, sun-cured meal has generally been replaced by dehydrated meal because of the latter's superior nutritional value. Sun-cured alfalfa meal probably accounts for less than one-third of the total alfalfa meal production in the state. However, interest in sun-cured meal has been revived, as an apparent export market for this product has opened up.

Recent developments in field operated pelleting or wafering machines are also being watched with interest. This process, is not a means of developing a new product from alfalfa, but primarily a means of changing alfalfa into a form that offers greater handling ease. The wafering machine, is still on an experimental basis in Montana. This machine produces a compact two inch square wafer from two to four inches long that can be handled mechanically. If feasible, it will offer potential savings in handling and transportation costs that could lead to expansion in the current geographic market for hay.

All three techniques potentially offer an increased market for Montana hay. The first two methods (dehydrated and sun-cured) have met with varying degrees of success and failure during past years. New technological developments in the storage of dehydrated alfalfa and new markets for sun-cured alfalfa meal have recently regenerated interest. Added interest arises because of the above normal hay production the last two or three years and the resultant low prices. The purpose of this chapter is to discuss some of the factors and problems that might determine success or failure of various techniques for "adding value" to Montana hay.

Dehydrated and Sun-Cured Alfalfa Meal

Increasing emphasis on balanced rations in animal nutrition and improved feeding programs have resulted in increased demand for processed alfalfa. Accompanying this increase has been a lowering of processing costs due to new technological developments and improved production methods.

The alfalfa meal industry got its start in 1903. In that year, a small firm in Wichita, Kansas began grinding alfalfa for commercial feeds. Later, a small firm in Omaha, Nebraska included alfalfa meal in a mixed horse feed that became famous in the South. About this same time the first complete alfalfa grinding plant was established at Hartman, Colorado. This operation turned out to be the founding of the Denver Alfalfa Milling Co.,--the first firm to label alfalfa meal with a guaranteed level of protein and fiber. As the mixed feed industry expanded, demand for a uniform, dark green meal

emanated. ^{63/} The first dehydrating plant in this country was built in Louisiana in 1910. However, dehydration did not become successful commercially until the 1930's. In 1931 the first dehydrator west of the Mississippi began to operate in Kansas and at present, the heart of the alfalfa dehydrating industry is located in Kansas and Nebraska.

Production of alfalfa meal has increased steadily since 1943 (the first year production data were gathered on both sun-cured and dehydrated meal). During the production year 1943-44 (April through March), 771,800 tons of alfalfa meal were produced. By 1960-61 production had grown to 1,486,000 tons, Figure 18. Production of dehydrated meal accounts for the gains in output with an increase from 317,300 tons in 1943 to 1,298,000 tons in 1960, an increase of 400 percent. Production of sun-cured meal, on the other hand, has trended downward. From a high of 675,200 tons in 1945 the volume of sun-cured meal fell to a low of 178,700 tons in 1957. Its production over the last five years has averaged close to 200,000 tons per year. ^{64/}

Production of alfalfa meal is highly seasonal. Dehydrated meal production, because it is produced from fresh green forage, is limited to

^{63/} W. G. Shchrenk, et. al., "Dehydrated Alfalfa" Agricultural Experiment Station, Kansas State College, Manhattan, Bulletin 409, April, 1959.

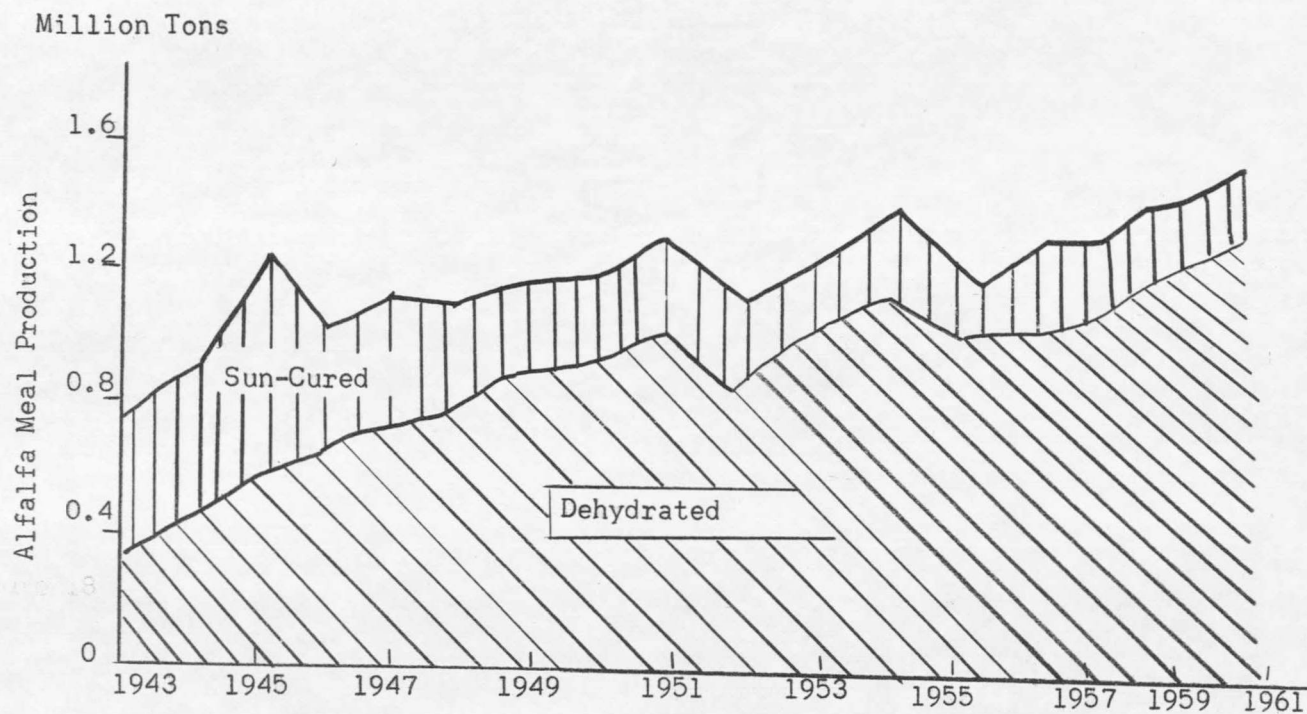
^{64/} "Grain and Feed Statistics through 1961", ERS, USDA, Washington, D. C., Statistical Bulletin No. 159, June, 1962.

the forage growing season which, with exception of some areas of the southwest, limits production to the summer months. Production of sun-cured meal exhibits almost a reverse of the dehydrated meal pattern, Figure 19. The relative importance of the two, however, will cause the combined seasonal production pattern to resemble that of the dehydrated meal, Figure 20.

Disappearance of alfalfa meal also exhibits a seasonal variation, but not to the extent of production. Seasonal variation in disappearance has tended to level out during the past five years. The increased demand for dehydrated meal as an ingredient in formula feeds and improved storage facilities for the processed meal are responsible for the more consistent consumption pattern. However, disappearance is still greatest during peak production periods when prices are relatively low.

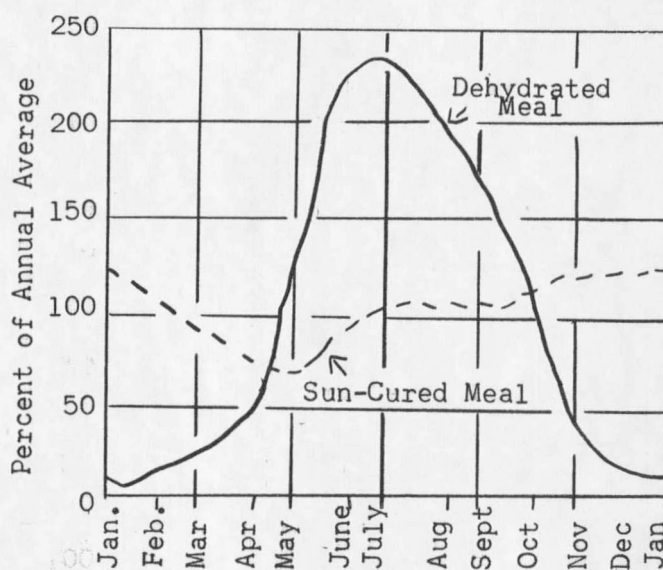
The price of alfalfa meal currently shows less seasonal price variation than either production or disappearance. This has not always been the case, however. With the expansion of storage facilities that will maintain a desired level of quality in the product, sales have stabilized and prices have also become more stable, Table X. The average price of alfalfa meal ^{65/} at Kansas City for the October-September feeding year ranged from \$38 to \$53 per ton over the past decade. In recent years, strong domestic and foreign demand has kept the average annual price around \$45 to \$50 per ton in spite of increased production.

^{65/} Prices, as quoted, are for 17 percent protein, dehydrated, wholesale, bulk meal at Kansas City. This is the major market for dehydrated meal. Prices for sun-cured meal are not reported by the USDA. Price of sun-cured meal usually follows local hay prices quite closely.



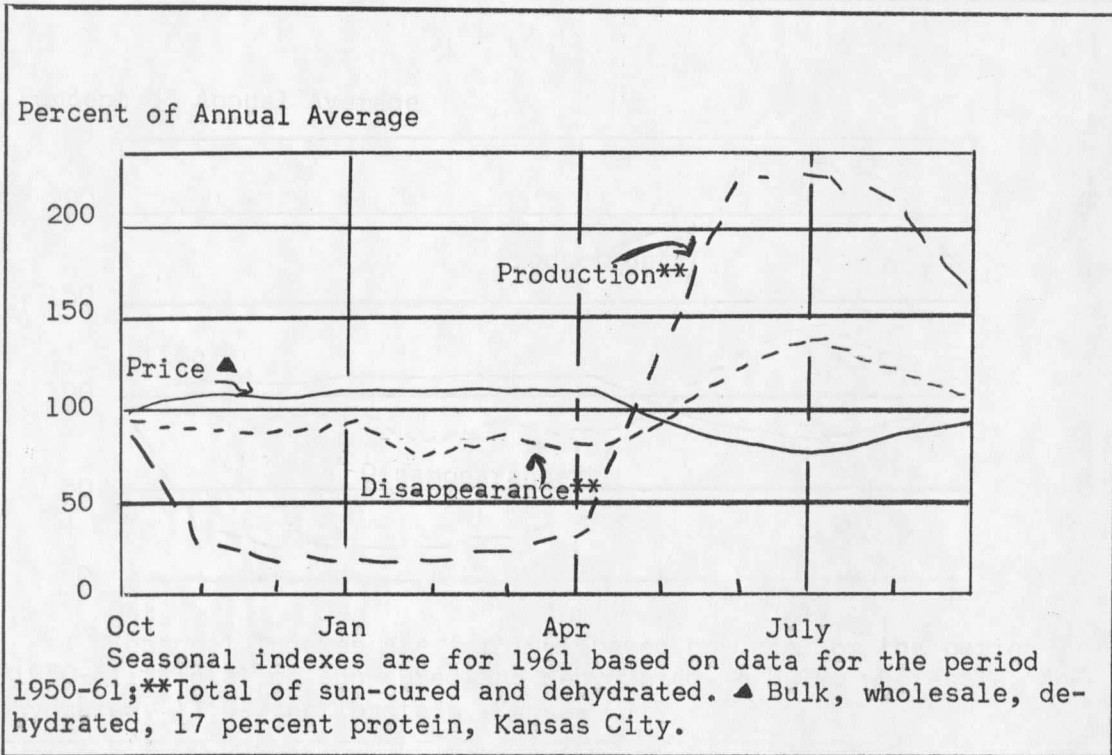
* Source: Adapted from data in "Grain and Feed Statistics," ERS, USDA, Statistical Bulletin No. 159, June, 1962.

Figure 18. Alfalfa meal production.



* Source: Marketing Dehydrated Alfalfa, (AMS, USDA in Cooperation with Kansas State Experiment Station) Marketing Research Report No. 254.

Figure 19. Seasonal variation in production of dehydrated and sun-cured alfalfa meal.



* Source: Feed Situation, ERS, USDA, August, 1963, p. 39.

Figure 20. Seasonality in alfalfa meal production, disappearance and prices.

The price of dehydrated alfalfa meal is generally lowest in the West North Central region of the United States, as represented by the Kansas City market. This is the major production area of the United States and has a relatively large number of processing plants. Prices at Buffalo, New York--a major feed mixing center--have ranged from about \$8.50 to \$14.50 per ton above those at Kansas City. This price differential generally reflects cost of transportation from the West North Central area to Buffalo. The price of alfalfa meal in California has generally been lower than at Buffalo, but have still been \$3 to \$11 per ton higher than at Kansas City. Higher prices in California are attributed to an expanding domestic and foreign market coupled with higher alfalfa production costs. ^{66/} Average annual wholesale prices for alfalfa meal for selected markets are presented in Table XI.

The production of alfalfa meal is regionally located. Major production occurs in the West North Central (Table XII) area. This area has traditionally produced over 50 percent of the total U. S. production. During the 1961-62 production year, this area accounted for approximately 52 percent of the total supply, with its leading state, Nebraska, producing over 33 percent of the nation's total supply. The second largest area is the Western region where approximately 28 percent of the total supply is produced. California, the leading state in this area and second largest in the United States, produced slightly more than 18 percent of the total supply.

^{66/} Jack S. Ross, "Recent Trends and Seasonality in Alfalfa Meal Production, Use and Price", Feed Situation, ERS, USDA, August, 1963.

TABLE X. MONTHLY INDEXES OF SEASONAL VARIATION IN DEHYDRATED ALFALFA MEAL.

Year	Average			Average			Average		
Beginning	1950-55	1956-61	1961	1950-55	1956-61	1961	1950-55	1956-61	1961
October	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
October	103	100	95	102	99	97	104	103	101
November	41	32	30	83	88	92	107	109	109
December	30	23	23	87	88	90	114	110	109
January	29	21	20	76	93	94	122	115	112
February	31	20	19	73	74	77	122	117	114
March	39	28	27	78	83	85	113	114	112
April	40	34	34	71	80	79	110	111	110
May	115	128	125	102	95	91	80	87	93
June	216	225	223	135	129	125	72	78	81
July	217	225	229	148	138	138	81	80	82
August	186	207	213	130	122	122	85	85	87
September	153	157	162	115	111	110	90	91	90
AVERAGE	100	100	100	100	100	100	100	100	100

* Source: Feed Situation, ERS, USDA, August, 1963.

a/ The indexes are computed on the basis of monthly data for the period 1950-61, with adjustments for trend, cycles and irregularities in the data so as to reflect the "normal" seasonal variation for the 5-year periods and for 1961.

b/ Total of sun-cured and dehydrated.

c/ Wholesale, sulk, 17 percent protein, dehydrated, Kansas City.

TABLE XI. ALFALFA MEAL: AVERAGE WHOLESALE PRICES AT SELECTED MARKETS,
YEAR BEGINNING OCTOBER, AVERAGE 1957-61, ANNUAL 1957-62. *

Market	Average							a/
	1957-61	1957-59	1958-59	1959-60	1960-61	1961-62	1962-63	
	Dol./ Ton	Dol./ Ton	Dol./ Ton	Dol./ Ton	Dol./ Ton	Dol./ Ton	Dol./ Ton	
Buffalo	57.50	52.95	61.80	60.40	56.25	56.20	60.80	
Chicago	50.40	44.40	54.90	52.65	48.70	51.10	52.60	
Kansas City	45.75	38.30	50.15	47.60	45.15	47.60	48.90	
Memphis	51.90	49.40	b/ 58.10	54.00	47.90	50.10	52.00	
California Mills	53.20	49.40	53.00	54.20	55.00	54.20	55.20	
Principal Markets	c/47.70	41.30	51.20	49.50	47.50	48.80	50.20	

* Source: Feed Situation, ERS, USDA, August, 1963. Simple averages of Tuesday quotations, with exception of principal markets which are weighted. Prices are a basis of bulk, 17 percent protein, dehydrated meal.

a/ October-July average.

b/ Bagged alfalfa meal.

c/ Kansas City, California mills, Minneapolis and Omaha.

TABLE XII. ALFALFA MEAL: PRODUCTION BY REGIONS AND STATES, YEAR
BEGINNING MAY, AVERAGE 1957-61, ANNUAL 1957-62. * a/

Region & State	Average						
	1957-61	1957-58	1958-59	1959-60	1960-61	1961-62	1962-63b/
	1,000 Tons	1,000 Tons	1,000 Tons	1,000 Tons	1,000 Tons	1,000 Tons	1,000 Tons
North Atlantic c/	33	24	34	36	35	35	33
East North Central							
Ohio	93	88	91	76	94	115	69
Michigan & Wisconsin	21	24	16	20	20	24	16
Illinois & Indiana	<u>19</u>	<u>22</u>	<u>19</u>	<u>19</u>	<u>20</u>	<u>16</u>	<u>16</u>
Total	133	134	126	115	134	155	101
West North Central							
Nebraska	473	436	451	493	492	490	522
Kansas	142	135	142	125	149	160	195
Missouri	46	50	46	46	46	43	39
Minnesota	24	21	19	22	22	34	39
Iowa	<u>29</u>	<u>27</u>	<u>26</u>	<u>26</u>	<u>29</u>	<u>34</u>	<u>35</u>
Total	716	685	684	712	738	761	830
South Central							
Arkansas & Tennessee	22	20	14	21	30	26	23
Oklahoma	8	10	11	7	7	6	8
Texas	<u>25</u>	<u>26</u>	<u>27</u>	<u>26</u>	<u>24</u>	<u>22</u>	<u>21</u>
Total	55	56	52	54	61	54	52
Western							
California	233	187	218	240	257	266	364
Colorado	116	123	118	108	114	118	144
Washington & Utah	<u>39</u>	<u>31</u>	<u>42</u>	<u>44</u>	<u>41</u>	<u>35</u>	<u>30</u>
Total	392	359	378	392	412	419	548
Other States	<u>55</u>	<u>30</u>	<u>54</u>	<u>76</u>	<u>67</u>	<u>49</u>	<u>34</u>
Total U. S.	1,384	1,288	1,328	1,385	1,447	1,473	1,598

* Source: Feed Situation, ERS, USDA, August, 1963.

a/ Includes total of sun-cured and dehydrated.

b/ Preliminary.

c/ Pennsylvania only.

There is no breakdown of sales and distribution of alfalfa meal made in USDA or Census Statistics and without this information it is very difficult to arrive at a supply-demand balance for each region. Statements by researchers familiar with the industry that" . . . almost all the dehydrated alfalfa produced in the United States goes into the manufacture of formula feeds. . ." 67/ is substantiated by people in the industry. According to USDA estimates, approximately 28,145,000 tons (65 percent) of the 43,464,000 tons of formula feeds manufactured were produced east of Kansas City. 68/ The market for most of the alfalfa meal produced in the West North Central region probably lies east of the Mississippi River. Over half of the total formula feeds for livestock are manufactured east of the Mississippi and just under 70 percent of the mixed poultry feeds--a large user of alfalfa meal. Additional support may be found in the findings of a study in 1954 which showed that of the total production coming from sample firms. . . only 7 percent was sold direct to livestock feeders. An additional 3 percent was used in production of a mixed feed by the firm originally producing the alfalfa meal. Thus, approximately 90 percent of the total volume was being marketed either direct to feed manufacturers (44 percent) or to brokers (36 percent) or commission men (10 percent), Table XIII, Figure 21.

67/ Charles E. Reed, et. al., Marketing Dehydrated Alfalfa, AMS, USDA and Kansas Agricultural Experiment Station, Manhattan Marketing Research Report No. 254, July, 1958.

68/ Feed Situation, ERS, USDA, May, 1963.

TABLE XIII. CHANNELS OF DISTRIBUTION USED IN SELLING DEHYDRATED ALFALFA, BY REGION AND BY TYPE OF PLANT, 1954. *

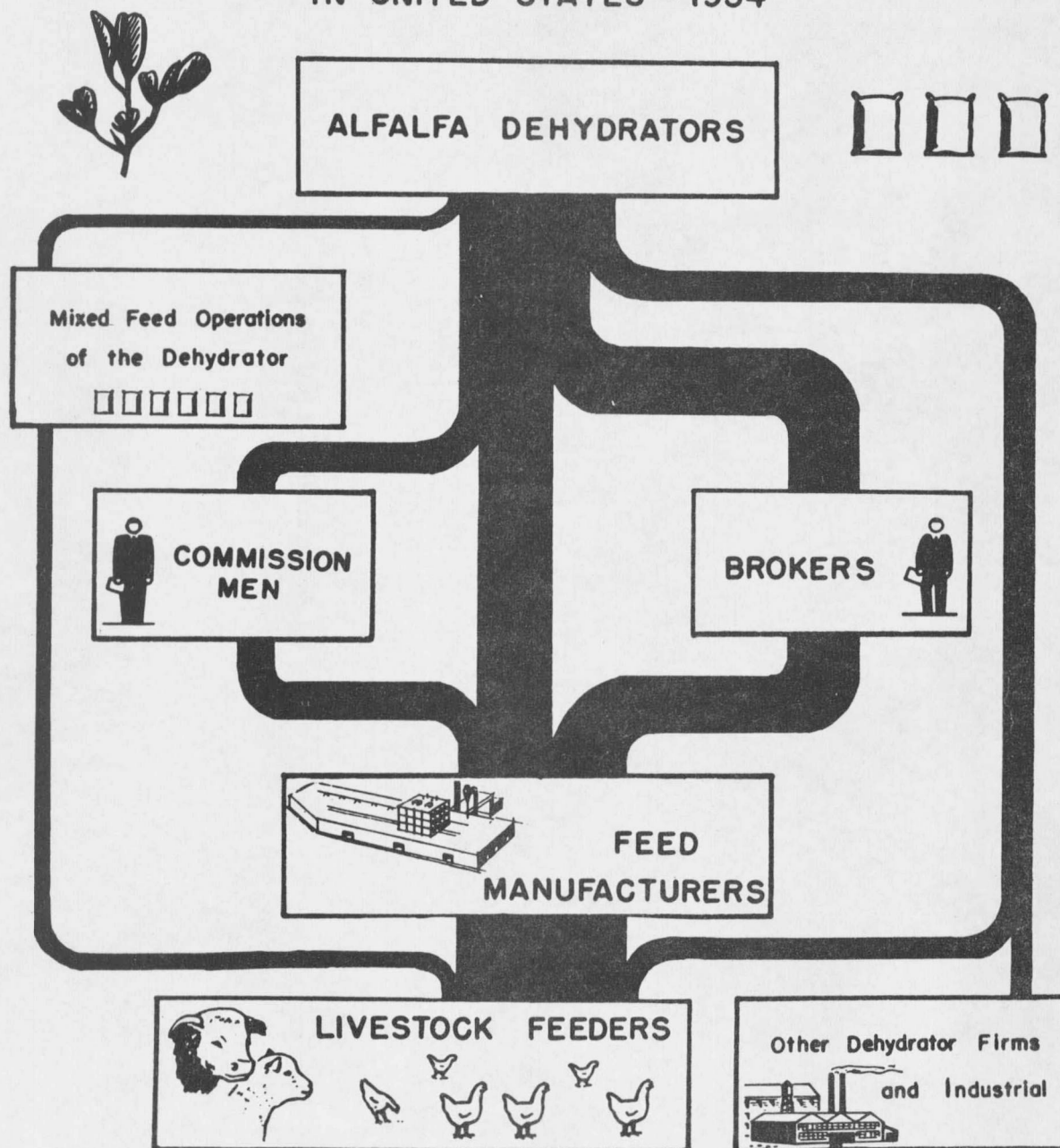
Region & Type of Plant	Total Plants in Region <u>Number</u>	Commission-		Brokers		Direct to Feed Manufacturers		Other Direct Sales a/	
		Men		Percent-		Percent-		Percent-	
		Number	Percent-	Number	Percent-	Number	Percent-	Number	Percent-
		of Plants <u>Number</u>	age of Total Sales <u>Pct.</u>	of Plants <u>Number</u>	age of Total Sales <u>Pct.</u>	of Plants <u>Number</u>	age of Total Sales <u>Pct.</u>	of Plants <u>Number</u>	age of Total Sales <u>Pct.</u>
Northeast:									
Single Drum	11	--	--	7	36	9	49	7	15
Multiple Drum	3	--	--	3	85	2	15	--	--
All Plants	14	--	--	10	54	11	36	7	10
North Central:									
Single Drum	11	5	11	9	19	10	62	9	8
Multiple Drum	10	5	24	8	31	8	40	8	5
All Plants	21	10	20	17	28	18	46	17	6
South Central:									
Single Drum	15	3	10	8	31	10	34	6	25
Multiple Drum	7	2	3	6	22	7	56	8	19
All Plants	22	5	7	14	26	17	45	14	22
Southwest:									
Single Drum	5	--	--	5	45	5	43	6	12
Multiple Drum	7	--	--	6	52	6	44	2	4
All Plants	12	--	--	11	51	11	44	8	5
United States:									
Single Drum	42	8	7	29	30	34	47	28	16
Multiple Drum	27	7	11	23	40	23	43	18	6
All Plants	69	15	10	52	36	57	44	41	10

* Source: Charles E. Reed, et. al., op. cit., p. 56.

a/ A majority of sales in this category were made direct to cattle feeders.

Figure 21 *

MARKETING OF DEHYDRATED ALFALFA IN UNITED STATES - 1954



* Source: Charles E. Reed, et. al., op. cit., page 55.

It would seem reasonable to expect that a high proportion of the meal handled by brokers and commission men to go either to feed manufacturers or to the export market. For the West North Central region, both these markets are probably to the east of Kansas City.

In other regions, most of the alfalfa meal is probably marketed within the region where it is produced. An examination of the prices in Table XI also supports this observation. The difference between the average 1957-61 prices at Kansas City and Buffalo is \$11.75 per ton. Ross claims this price differential to be generally reflective of transportation costs between the two points. ^{69/} The differential between the average prices at Kansas City and Chicago is \$4.65 per ton and \$6.15 per ton between Kansas City and Memphis. Comparing the relative distance from Kansas City to these last two points with the distance to Buffalo, it appears that these price differentials also represent a cost of transportation.

In a competitive industry, the price differential between a market in a surplus area (market A) and one in a deficit area (market B) would be equal to the cost of transportation between the two markets. A firm producing in market B area would have a price umbrella under which it could operate and would find no particular advantage to selling outside its own market. If output by firms in market B expand sufficiently to satisfy local demand and also compete for other markets, its price structure may be altered.

^{69/} Jack S. Ross, op. cit., p. 40.

If market B competes for a deficit market lying farther away from market A than itself, then the price at market B will still be equal to the price at market A plus cost of transportation between them. If, however, firms in market B choose to compete with market A for intermediate markets, then the price differential between them will not be equal to the cost of transportation. In effect, as market B extends its sales into intermediate markets, it will have to absorb the cost of transportation into this area. Theoretically, the effective price in the market B will be equal to its umbrella price less the amount of transportation costs between it and the point of penetration into the area mutual to both markets.

Since prices in Buffalo, Chicago and Memphis generally reflect the Kansas City price plus cost of transportation to each respective market, it can be assumed that each of these markets is in a deficit area. The differential between the average prices of dehydrated alfalfa meal at Kansas City and the California mills (Table XI) does not appear to be high enough to represent a transportation cost. The California mills are about one and a half times as far from Kansas City as Buffalo, but the average price spread is only \$7.45 per ton. This would appear to be insufficient to cover transportation costs when compared to the \$11.75 per ton differential between Kansas City and Buffalo. From the theoretical discussion above, it can be argued that California is a surplus area and is competing with Kansas City for available markets. The difference between California's umbrella price and its existing market price will be a measure of its penetration into the

area between it and Kansas City.

The overall market for alfalfa meal can now be brought into sharper focus. The West North Central region, with primary markets in Kansas City and Omaha, is the major production area (52 percent of the total production) in the United States. Alfalfa meal moves North, South, East and West from the Kansas City market. Since the center of the formula or mixed feed industry lies east of Kansas City together with the major export centers, a preponderance of the alfalfa meal would be expected to move East. In the West, California is a major producer of alfalfa meal. If output in this state continues to expand as it has done in the last five years, it could soon become the leading state in alfalfa meal production. A large production, however, does not mean that it is a surplus area. Indication that California is a surplus area lies in the observation that the price differential between California and Kansas City is not large enough to cover the cost of transportation between these two markets. Since there are no large producing areas between California and Kansas, which could be supplying West Coast markets, it can be assumed that California is also a surplus area.

Although prices at other Western markets are not reported, a generalization can be given of the market situation in which they may find themselves. If the effective price in a given market is Kansas City or California price plus cost of transportation, then either: (1) a deficit market exists, or (2) while firms in the area are supplying local needs, surpluses are being sold at markets in a direction away from their basing point.

If the effective price is less than a Kansas City or California price plus transportation costs, then it would indicate that the market area not only has a surplus but that the size of the surplus is such that the area is competing for sales with its major basing point market.

The appropriate question now is, how does Montana fit in this overall scheme? In the past, Montana has been a deficit area. Estimates by people in the feed industry of the total quantity of alfalfa meal used in the state range from 6,000 to 12,000 tons per year. Production within the state has ranged from 3,000 to 6,500 tons annually, leaving a possible deficit of up to 6,000 tons in some years. 70/

The price of dehydrated alfalfa meal in Montana will normally approximate the Kansas City price plus cost of transportation. 71/ Production

70/ These figures were obtained in personal interviews with managers of the two dehydrating plants within the state.

71/ In some years this may not appear to be true. It has become a common practice for firms in the West North Central region to sell f.o.b. Kansas City and, to a lesser extent, f.o.b. Omaha. Reed and associates found in their study, for instance, that approximately 70 percent of the sales with destinations outside the area were made f.o.b. basing point. This practice was more common among larger firms with 82 percent of their sales made on this basis while only 40 percent of the sales by smaller firms were f.o.b. basing point. This practice forces firms on the outer fringes of the market area to absorb the cost of transportation to Kansas City or Omaha. In order to avoid this, these firms will attempt to make sales in an area advantageous to them and without going through Kansas City or Omaha. Firms in the western portion of the West North Central market often supply the Billings area. The price differential, under this condition, may be less than Kansas City plus freight, but, nevertheless, the Montana price will still be a West North Central area price plus cost of transportation.

of dehydrated alfalfa in Montana depends on the output of two mills--one in the southwestern portion of the state and the other in the northeastern section. Sales are primarily local. During peak production periods the local markets quite often have not been able to handle the volume of output and the mills have had to seek markets outside their immediate area. In the past they have generally found it less profitable to sell on the Billings market than to ship West to Portland even though it is several hundred miles farther. 72/

Potential of Dehydrated Alfalfa Meal Processing
In Montana

Marketing Problems

Outlook for dehydrated alfalfa meal production in Montana is viewed optimistically by the industry with the reservation however, that there is a restricted market. The opinion prevailed that dehydrated meal is just coming into its own as a feed and formula-feed ingredient. It was also indicated that recent technological advances will permit the practical construction of the type of storage facilities necessary to stabilize the carotene content of dehydrated alfalfa.

With these storage facilities the Montana mills will be able to offer a year-round supply of the quality and type of product demanded by the feed industry.

72/ The reason for this practice is implied in the previous theoretical discussion. Essentially, a minor surplus market can more profitably compete in markets farther away from major surplus areas because it can add the cost of transportation to its own umbrella price. If it competes with the major surplus market for intermediate markets, it must absorb the cost of transportation. For the two Montana mills, Billings would be an intermediate market.

The carotene content in dehydrated alfalfa meal is relatively unstable. Loss occurs through oxidation and the carotene content will diminish rapidly if preventive steps are not taken. Until the recent use of gas storage, cold storage was about the only effective method known to retard the carotene loss. The cost of cold storage was high and, only a small quantity was stored each year.

Without proper storage facilities a firm is faced with two alternatives both of which place it in a disadvantageous competitive position. It can sell its output at the time of production, when it will meet quality requirements of the formula-feed industry, but at a time when the market is flooded and prices are depressed. As an alternative, it can hold its production to a later date and sell at a discount price because it cannot meet the feed industries specifications.

The development of relatively inexpensive inert gas storage facilities is solving many of the industries storage problems. This type of storage facility can be constructed at a cost of around \$25 per ton; an increase of about \$15 per ton over storage facilities that are not air tight. 73/

73/ These cost estimates were given by a manager of a dehydrating mill in Nebraska. The remainder of this section will rely heavily on the information received from interviews held with 14 dehydrating plant managers during the summer of 1963. Two interviews were held with plant managers in Colorado; the remaining 12 were made in the Platte Valley region of Nebraska.

The cost of gas is nominal. At some dehydrating mills visited in Colorado and Nebraska during the summer of 1963, carbon dioxide was taken off a burning flame and pumped into the storage tanks until almost all the oxygen was removed. Other mills were taking gas directly off their drums. Special equipment used in some cases burns the oxygen out of the air leaving a mixture of about 12 percent carbon dioxide and 88 percent nitrogen. After the air in the tanks has been displaced with gas, pressure of a few ounces is maintained so that no outside air may enter. Preservation of up to 95 percent of the carotene for a storage period of seven or eight months has been claimed for inert gas. 74/

Many of the smaller mills in the Platte Valley region have been able to circumvent the problem of making a relatively large investment in storage facilities by leasing storage space for a portion of their production. The larger mills, usually with better access to capital funds and able to take advantage of the economies achieved in building large scale storage facilities, have found it profitable to construct gas storage facilities at their millsite. Most of them offer a limited amount of storage space for rent. A more recent development, and one that seems promising, has been the joint ownership of a large storage and blending mill by several (both large and small) dehydrating mills. A limited amount of commercial storage is also available at these consolidated mills. Commercial storage charges at both the local and consolidated mills run about \$1 per ton per month.

74/ Lacey F. Rickey, Cooperative Alfalfa Dehydrators Costs and Operation, Farmer Cooperative Service, USDA, FCS Circular 12, June, 1956.

The consolidated storage and blending mills offered some definite advantages. First, if a mill has good storage facilities available, it need not place its total winter carryover under gas storage. As the meal held in open storage declines in nutritive value it can be blended with sufficient quantities of the high grade meal to bring it up to market specifications, and, reduce the overall cost of storage. The protein and carotene content of alfalfa also varies with the crop and stage of growth of a particular crop. With the necessary blending facilities available, it is possible to combine different grades of meal into a blend that will meet a given order precisely.

A third advantage of the consolidated mill lies in selling. Many of the independent mills are unable to afford a specialized sales force. They either have to wait for buyers to come to them, or wait for slack production periods when management is free to divert some of its efforts to selling. The consolidated mill employs full time salesmen. Also, with a large quantity of meal concentrated at one point through joint pooling, smaller firms can participate in some of the larger more lucrative contracts that otherwise would not have been available to them. On the other side, greater knowledge of product, better control of quality, sales force, specialization; ability to provide more services, capacity to deal in large volumes and location of facilities at terminal markets with good transportation facilities, have benefited buyers and probably resulted in reduced purchasing costs.

Production Problems

Marketing problems, such as selling and storage, are not the only difficulties with which dehydrating firms in Montana must cope. Production costs have generally been higher than in other sections of the country. The price umbrella under which Montana firms operate also acts as a cost ceiling within which they must stay if they are to operate successfully.

The higher production costs in Montana are due to environmental conditions. It is not a problem that can be overcome with new management or a modernization of existing facilities, but must be recognized as a liability on the dehydrating industry in the state. Requirements in terms of plant and equipment for dehydrating mills are actually quite standard. There is little need, or opportunity to use facilities other than a basic plant design. Because diseconomies of scale set in rapidly, many questions on plant size and plant organization are not encountered in the dehydrating industry. There are, of course, decisions to be made regarding the type or model of a particular piece of equipment that must be used but most of these are determined more on the basis of personal preference than of distinct cost advantages. Probably the most outstanding feature of the production units observed during the summer of 1963 was their similarity. Differences can best be explained in terms of the extraneous environmental conditions unique to the plant in question, rather than by an organic analysis of plant organization. The physical equipment and layout of a dehydrating plant in Montana would differ little from a dehydrating plant in Colorado or Nebraska. Therefore, a decision was made not to dwell on extensive and detailed plant

layout studies, but to orient reserach efforts to a consideration of the environmental or extraneous factors that influence cost. A summary of some recent studies concerned with the costs of production is presented in Appendix E.

Production Advantages of North West Central Region of U. S.

Initial investment in a dehydrating plant is relatively high. A typical mill will require an original investment of around \$200,000 for plant and equipment. As a result, fixed costs become an important cost item which makes it mandatory that a high volume of output be maintained if unit costs are to be low. In a study of cooperative dehydrating plants, Rickey found that depreciation alone accounted for as much as 19 percent of the total processing costs. ^{75/}

The ability to maintain a high average annual output has been one of the strong points favoring dehydrating plants in the North West Central region of the United States. Environmental conditions in this area are ideally suited to the production of alfalfa. This is especially true of the Platte Valley area which benefits from a vast underground stream that flows sufficiently near the surface to reach the area of alfalfa root penetration. Being able to draw needed moisture from this source it has eliminated the need for irrigation. The soil is a sandy loam type that provides good drainage and will remain relatively accessible to field equipment even after extended periods of rain. Thus in years of drought conditions, growth of the alfalfa will not suffer because its root system can draw needed moisture

^{75/} Lacey F. Rickey, op. cit., p. 25.

from the underground stream. In wet years or extended periods of rain the soil is such that production can continue much longer than would be possible on a heavier soil.

Length of production season is also an important factor in this area. It does not compare with the Southwestern region of the United States but it is still relatively long. Mills in this area normally plan on a six-month production period beginning around May 15th and running to November 15th. Average production per acre was reported by many plants to run from five to seven tons per acre. In drier regions it averaged three to five tons per acre.

Combined with these physical advantages is an excellent institutional setting. It is a mature industry and appears to enjoy a good relationship with related communities. One of the early problems encountered by dehydrating plants was that of acquiring sufficient working capital to cover the costs of operation until income from sales could take care of their needs. For the most part, the dehydrating firms in this area have proven to be good credit risks. Arrangements can now be made with local financial institutions for assistance over this period. The dehydrating mills have provided a major source of income to families in this area for some time now. Farm credit and other financial dealings have become adjusted to coincide with the income periods of the dehydrating industry as it has assumed a more important role in the economy of this region.

Another institutional factor that adds strength and stability to the dehydrating industry is a lack of competing uses for alfalfa. This region

does not support a livestock industry that requires large amounts of roughage. It is far enough away from large cattle producing areas that it seldom has to compete with hay buyers from outside the area. In fact, most farmers doing business with them no longer own enough haying equipment to handle their own hay crop. Price tends to respond to conditions affecting the dehydrating industry more than it does to competing uses since the industry is the major user of alfalfa in the area.

The price of dehydrated alfalfa meal is not independent of hay prices, but it is generally considered a feed supplement and has to be competitively priced with other supplements. With the dehydrating industry occupying a dominant position in the market for alfalfa, it is able to more or less control its price. Generally, the industry is not faced with a situation where it has to pay high prices to outbid other uses for available hay supplies when, at the same time it is facing adverse prices in its own product market. This is evidenced, somewhat, by a stable raw product price over the past several years. Plant managers indicated that they have been paying \$8 per ton for first and second cuttings with an increase of two dollars a ton for each crop thereafter. Due to drought conditions in 1963 that extended over most of the Great Plains states, most of the mills reported they paid \$9 per ton for the first and second crop. They were in the third cutting at the time these interviews were held, and reported they were paying \$12 per ton for it. The Colorado firms paid \$10 per ton for all three crops in 1962. In 1963, they paid \$10 per ton for first cutting and \$14 per ton for second cutting. They also reported that from 30 to 40 percent

of the farmers from whom they have regularly purchased had not taken contracts in 1963. Nebraska firms indicated that they had not had an unusually high number of cancellations during 1963.

In summary then, several factors provide the Platte Valley region of Nebraska and Kansas with a comparative advantage in the production of dehydrated alfalfa. Climatically, they are located in an almost ideal area for alfalfa growth. The vast underground stream which flows close enough to the surface to provide alfalfa with adequate moisture, in most of the area, without irrigation has provided a large supply of alfalfa at relatively low production costs. Yield per acre is relatively high but probably of more importance, their yields are consistent.

Institutionally, the dehydrating industry has reached a position of respect and trust in the affected communities and generally operates in a good business climate. It is in an enviable position of not having any major competitors for the available alfalfa. It seldom faces a trend in raw product prices that is adverse to its own position.

Combining these physical advantages and institutional achievements along with economies in marketing and distribution, it becomes apparent why this region assumes the lead in pricing and general policy maker for the industry. Other areas, of course, enjoy many or possibly all of these same advantages but they have yet to challenge seriously the Northwest Central Region as the industry's policy maker.

Production Potential for Montana

How does Montana compare with this region? A few brief comparisons will point this out fairly clearly. The following observations rest on the premise that there will be no major technological break-throughs that will change the industry from a high investment, high fixed cost industry. If major innovations are made that change this relationship, it could alter the picture considerably.

One of the most limiting factors to the dehydrating industry in Montana is the relatively short production season. Except for a select few irrigated regions, we normally only harvest two crops of alfalfa. Dehydrators cannot begin cutting until around the first of June and in many years they have been forced to halt operations in early September. As a result of the short growing season, yields per acre are relatively low also. In 1960, the state average yield on irrigated land was 2.3 tons of alfalfa per acre. ^{76/} It increased to 2.4 tons per acre in 1961. Average yields for the two counties in which dehydrating mills are currently operating were 2.2 and 2.9 tons per acre. Even if ideal conditions existed otherwise, it would be difficult to reach a volume which could lower fixed costs per unit comparable to that of regions with longer production seasons and/or greater yields.

The yield of alfalfa on irrigated land has been fairly consistent over the past decade. Potentially, it offers the dehydrating mills a continuous supply of raw material. However, in practice this is not the case. Production of alfalfa on a local level is quite vulnerable to the whims of

^{76/} Montana Agricultural Statistics, 1962, p. 63.

nature. Insects, disease, drought, rain, frost, hail and snow have all caused considerable damage, at one time or another, to the alfalfa in most local areas. When such a catastrophe occurs in the vicinity of one of the states two dehydrating plants, it can seriously reduce production and as the drought of 1960-61 demonstrated, it can even cause plants to close operation. Even with normal production locally, the dehydrating plant is liable to face adverse raw product prices. It was pointed out earlier, that the market price of hay in Montana tends to settle at price extremes. When they tend upward the mills face real difficulty. The price of dehydrated meal from Nebraska imposes a definite limit on the ability of Montana mills to pass costs forward.

One of the most frequently mentioned factors which dehydrators felt contributed to a successful operation was the distance of travel incurred in acquiring raw materials. This distance was minimized in the high production areas of Nebraska. Acreage requirements for the Nebraska plants ran from 1,000 to 1,500 acres for the single drum plants up to 6,000 or 7,000 acres for the multiple drum mills. Managers of the plants interviewed (11 multiple drum and 3 single drum) indicated that they attempted to keep a majority of their fields within a 10 mile radius. Maximum distance reported was 18 miles by one of the Colorado firms. Most of the plants, however, indicated they had some fields about 15 miles away to reduce the chance of being shut down by rain or hail. Costs increase rapidly past a 10 mile radius. Reed and associates found in their study of 69 dehydrators that, over the United States as a whole, approximately 60 percent of the acreage cut for

dehydration lies within five miles of the plant and another 30 percent within the five to ten mile distance. 77/

Securing the required acreage within a reasonable distance of the plant has been a problem for the Montana firms. Both mills are located in older irrigated regions of the state that have developed extensive livestock enterprises. At the prices dehydrators are able to pay for alfalfa they have not been able to bid a large acreage of hay near the mill away from the livestock enterprises. In one county the mill has also run into a rock problem on nearby fields and has had to travel further out for its needed acreage. One year it was reported that one of the plants had to purchase hay at a point more than 30 miles away.

There are areas in the state, however, that could furnish the required acreage within a relatively small radius of the plant. The newer irrigation projects generally are surplus hay producing regions. In the past, other crops have become more competitive with alfalfa and livestock units have become established as these projects develop. Whether a dehydrating plant could survive or not, would depend on its ability to compete with these other uses for hay and hay land.

The future of the plants now operating depends on what success they will have in overcoming some of the current obstacles. Montana will probably continue to be a higher than average production cost area. But they also have a price advantage of around five to six dollars per ton over Nebraska firms because of the freight cost differential from Nebraska to Montana.

77/ Charles E. Reed, op. cit., p. 26.

If they are able to keep this differential within its margin, then it is reasonable to believe they will continue to operate. Their ability to provide storage facilities for a portion of their output will be important to their future also.

Sun-Cured Alfalfa Meal

The outlook for sun-cured alfalfa meal 78/ in Montana is about the same as for dehydrated hay. Production of sun-cured meal has declined substantially. At present, it is used mostly as a carrier in the "economy line" mixed feeds. It is still quite popular in mixed dairy feeds where the demand for carotene (Vitamin A) has not been as great as in other mixed feeds. The current status of sun-cure as a formula feed ingredient is adequately demonstrated in Table XIV.

78/ This may be somewhat of a misnomer because a large portion of the total output is sold in a pellet rather than as a meal. It is commonly called a meal by industry, regardless of the form it is marketed in, and will be referred to as a meal in this manuscript.

In a talk before the American Dehydrators Association, Dr. William Burkitt, Head Nutritionist for Montana Flour Mills, made the following statements which represent the feed industry's attitude toward sun-cure.

"Of the 20 ruminant feeds our company produces, dehydrated alfalfa meal is used in all but two dairy feeds. This is because of the terrific opposition from dairymen in some of our areas to dehydrated alfalfa in dairy feeds. Our two best dairy feeds contain dehy." 79/

Recent development of an export market for sun-cured alfalfa meal to Japan has created new interest in and provided a stimulus for increased production. The sun-cured alfalfa pellet is being used primarily for its "roughage nutrition" in Japan's rapidly expanding dairy and cattle feeding

79/ William H. Burkitt, "Dehydrated Alfalfa in Formula Feed for Ruminants", New Feeding Frontiers, Proceeding of 1960 Convention, American Dehydrators Association, (Colorado Springs, Colorado), February 4-5, 1960.

TABLE XIV. SUMMARY OF ALFALFA USE IN RUMINANT FORMULAS BY 43 FEED COMPANIES THROUGHOUT THE UNITED STATES. *

	Number of Companies Reporting This Type of Feed	Alfalfa Use as Indicated by In- gredient List on Tags. a/					
		Dehydrated		Sun-cured		Number	
		Alfalfa		Alfalfa		Alfalfa	
		No.	%	No.	%	No.	%
BEEF CATTLE AND SHEEP							
Stilbestrol Supplements	33	22	66.7	2	6.1	18	54.5
Other Supplements	37	27	75.7	3	8.1	20	54.1
Complete Rations							
Beef	9	6	66.7	1	1.1	2	22.2
Sheep	7	6	85.7	1	1.4	1	14.3
CREEP FEEDS							
Calf	14	12	85.7	1	0.7	1	7.1
Lamb	7	4	57.1	1	1.4	2	28.6
DAIRY CATTLE							
Supplements	32	8	25.0	3	9.4	25	78.1
Complete Rations	31	12	38.7	7	22.6	23	74.2
Calf Starters	32	20	62.5	3	9.4	7	21.9
MEDICATED FEEDS	13	9	69.2	2	15.4	4	30.8

* Source: William H. Burkitt, "Dehydrated Alfalfa in Formula Feed for Ruminants", New Feeding Frontiers, American Dehydrators Association, Proceedings of 1960 Convention, (Colorado Springs, Colorado) February 4-5, 1960.

a/ In some cases the numbers of any one class of feed containing dehydrated alfalfa, sun-cured alfalfa, or no alfalfa is greater than the total number of companies reporting on that type of feed. This results from the practice of some companies offering a particular class of feed with either dehydrated, sun-cured or no alfalfa in it.

enterprises and as such, it has not been challenged by dehydrated alfalfa meal for the Japanese market. How dependable this market will be is still a matter of speculation. It has increased steadily over the past five years and shows signs of continued growth and strength.

The 1963 price for sun-cure was \$38 per ton on dock at Portland. 80/ It is difficult to reduce this figure to a net Montana price because the freight rate structure is so complex. One Western Montana firm reported a freight charge of \$10 per ton to Portland, with a \$2 per ton concession for exported hay. Another firm in South-central Montana had investigated the export market but found that freight charges from its location to Portland were \$14.50 per ton. Under this price-cost situation they were unable to operate profitably. Thus, the effective freight rate structure in a given area will be instrumental in determining the feasibility of producing sun-cure for export.

The initial investment required for a sun-cured alfalfa pelleting mill, although not as high as a dehydrating operation, is high in relation to its output capacity. Starting with new equipment, the initial investment will be from \$50,000 to \$65,000 for a small to medium sized mill. It is difficult to estimate actual investment costs for pellet mills owing to the many types of equipment and differences in building requirements and design. In many instances, all or part of the necessary equipment may be purchased, used or rebuilt at considerable savings.

Specifications and costs for a small mill (two or three ton per hour

80/ This price was quoted by one of the mills in the state which has contracted hay to the Japanese market. At present, price information on hay exports is not available in usual USDA sources.

capacity) are presented in Table XV. Equipment costs used are list prices of various equipment manufacturers. An allowance of 20 percent of the equipment costs is allowed for installation. Building costs can vary widely according to the needs of the equipment used and the storage facilities provided. If the pellets are shipped out immediately, as they might be under an export contract, building requirements can be held to a minimum. The building allowances made in this analysis is for an inexpensive building with limited storage.

Operating costs of a pellet mill will also be dependent on several other factors. Type of plant and equipment and the various capacities attained under each combination will effect the level of operating costs. In addition, such items as electricity, labor, fuel, taxes and interest will vary from area to area.

Processing Costs of Sun-Cured Alfalfa Meal

Estimates of the average operating costs that might be incurred have been synthesized from various sources and are presented in Table XVI. Where possible, these costs were taken from a cost analysis made on a Montana firm. The costs presented were compared with similar cost items for pellet mills in the State of Washington and with those reported in a study of selected cooperative pelleting mills. ^{81/} Adjustments were made where it was deemed appropriate.

Assuming an average annual production of 4,000 tons (this would require a little over seven hours operation per day for 305 days at assumed capacity)

^{81/} J. B. Wycoff and O. L. Brough, Pelleted Alfalfa, Washington Agricultural Experiment Stations, Washington State University, Pullman, Station Circular 345, December, 1958 and Lacey F. Rickey, Costs of Pelleting Feeds at Selected Cooperative Feed Mills, FCS-USDA, Washington 25, D. C., FCS Bulletin 3, April, 1954.

TABLE XV. SPECIFICATIONS AND INVESTMENT COSTS FOR A SMALL PELLETING MILL.

Item	Cost
Bale Conveyor--80' with variable speed 5 h.p. motor	\$ 300.00
Baler Breaker	1,000.00
Hammer mill with 75 h.p. motor and 20 h.p. motor on blower, magnet, starter, ammeter and large dust collector	7,750.00
Pellet Mill, Cooler and scalper with feeders, molasses conditioning tank, drive belts, dies, ammeter steam equipment, magnet, pellet cooler with vari-speed 1/2 h.p. motor, fan with 15 h.p. motor, dust collector, pellet scapler with 1/2 h.p. motor	15,000.00
Molasses equipment--100 gallon storage tank, electrical heating unit, flow pump meter, automatic molasses regulator, 10 h.p. motor with a capacity of 7 tons per hour	2,255.00
Boiler, 25 h.p. motor, with pump, valves, etc.	2,400.00
Conveyors--from Hammermill to pellet mill to cooler to storage and loading	1,500.00
Scales	3,000.00
TOTAL EQUIPMENT COSTS	<u>33,205.00</u>
Equipment installation @ 20% of equipment costs	6,641.00
Building to house equipment, 75 ton pellet storage and shed over part of conveyor	15,000.00
TOTAL EQUIPMENT, BUILDING & INSTALLATION COST	<u>\$ 54,846.00</u>

average cost of production would be approximately \$8.77 per ton, Table XVI and XVII. Because of relatively high investment costs in relation to output capacity, a lower annual output will cause costs per ton to mount rapidly. Higher volumes will cause costs to decline, but not at the same rate. Production cost may also be lowered in some cases by installing equipment with greater capacity. Investment costs of larger machines seldom increase proportionally with their increased capacity and many times will not require additional building space. A reduction in unit costs may be possible with higher capacity machines in these situations.

If a production cost of \$9 per ton is assumed, what does the Japanese export market for sun-cured alfalfa offer to Montana mills? With a Portland price on dock of \$38 per ton and assuming a freight charge of \$10 per ton and production costs of \$9 per ton, Montana firms will have a margin of \$19 per ton to purchase raw materials and pay selling costs or any other costs that might be incurred. Since 1954, the average annual price of baled alfalfa has only been below this figure one year. It has been in the \$19 to \$20 range three of these years and was over \$23 per ton the remaining three years. These price figures represent prices received by Montana farmers and a transportation charge would have to be added to arrive at a net mill price. An average annual price, of course, does not provide a picture of the seasonal price pattern when price relationships may be more favorable. However, it seems reasonable to expect that the Portland export price follows a seasonal price pattern also and therefore, price relationships would tend to remain fairly constant.

TABLE XVI. APPROXIMATE OPERATING COST PER TON FOR A SMALL PELLETING MILL.

Item	Approximate Cost/Ton a/	Percent of Total Cost
<u>Operating Costs</u>		
Labor--4 man @ \$2/hr. = \$8/hr. for 2 ton/hr.	4.00	46
Electricity--227 KWH/ton at 6 mills/KWH	1.36	16
Fuel b/	.39	4
Dies = \$400/set/1,000 tons	.40	5
Repairs b/	.30	3
<u>Fixed Costs</u>		
Equipment depreciation--10 yr. straight line \$39,846--(3,985)	1.00	11
Building depreciation--20 yr. straight line \$15,000--(750)	.19	2
Interest on Investment--6% non-compounded \$54,846--(3,290)	.82	9
Taxes and Insurance 1.0% of initial investment \$54,846 x .01 = \$548	.14	2
Administration 1.5 hrs/day @ \$2.00/hr.	<u>.19</u>	<u>2</u>
TOTAL	8.79	100

a/ Costs based on an annual output of 4,000 tons.

b/ Estimated from Washington State Study.

TABLE XVII. RELATIONSHIP BETWEEN PELLETING COSTS PER TON AND ANNUAL OUTPUT FOR SMALL PELLETING MILL.

Daily av. hrs. of operation	Total annual production	Labor a/	Elec.	Fuel a/	Dies	Repairs a/	Bldg. depr.	Equip. depr.	Int. on invest	Insurance & Taxes	Admin.	Total
4	2,000	4.00	1.46	.43	.40	.29	.38	2.00	1.64	.28	.23	11.11
8	4,000	4.00	1.36	.39	.40	.28	.19	1.00	.82	.14	.19	8.77
10	5,000	4.00	1.31	.35	.40	.27	.15	.80	.66	.11	.15	8.20
12	6,000	4.00	1.27	.33	.40	.26	.13	.66	.55	.09	.13	7.82
16	8,000	4.00	1.23	.31	.40	.25	.10	.50	.41	.07	.11	7.38

a/ Estimates taken from Washington State Study.

On the basis of the cost structure assumed here, it would be necessary for a firm to reduce costs or receive special concessions before it could profitably sell on this market. Montana firms in the best position to accomplish this are the two dehydrating mills. They already have the necessary equipment which is not in use during their off season. It is quite probable that they could more than cover their variable costs of operation and could profitably process sun-cure pellets.

Wafered Hay

Hay wafering is a new harvesting technique that is receiving considerable attention. The wafer has been described as a "bite-sized compressed package of hay." Actually, the wafer is a compressed block about two inches square and varying in length from two to six inches. It retains its shape without special ties or wrapping materials and is structurally stable enough to be hauled, unloaded, stored and fed mechanically. The bulk density of wafers runs approximately 25 pounds per cubic foot compared with 8-12 pounds for baled hay. Yet, they are soft enough to be readily eaten by livestock.

Interest in the wafering process is coming from both hay producers and feeders. Producers see in it a potential means of mechanically handling a job that heretofore has had a high labor requirement. It also offers potential savings in storage and transportation which could substantially expand the geographic market area for hay. Livestock feeders have been seeking a method of handling forages comparable to those now in use in concentrate feeding.

The hay wafer provides them with a product that can be handled by modern mechanical techniques. In addition to savings in labor, it requires less storage space and under proper storage and handling conditions reduces waste and spoilage to a minimum. 82/

The wafering process operates on the same principle as baling, except that wafer is formed under pressures that range up to 10,000 pounds per square inch. Hay is usually held in the wafering chamber slightly over five seconds when operating under normal conditions. The interlocking of the crushed hay stems provide the bonding action that holds the wafers together. Legumes, especially alfalfa, produce a much stronger bonding agent than non-legume forages. Difficulty has been experienced in wafering grasses and grass-legume mixtures because of the lack of a bonding agent. Water sprayed on the hay just as it enters the wafering machine aids considerably in the bonding action. All wafer machines are now manufactured with water tanks so that water can be added in the wafering process.

82/ Dale O. Hull, "Hay Wafers; A New Haymaking System," Iowa Farm Science, Volume 17, August, 1962.

Crop preparation is critical to the operational performance of the wafering machine. A flail chopper is recommended for use with the Lundell wafer machine and has been used with apparent success in field trails in Montana and Iowa. 83/ Researchers at California, 84/, Beltsville, 85/

83/ E. R. Holekamp, "Experiences in Hay Wafering in Montana", Proceedings of Seminar on Wafering, Massey-Ferguson Co., Chicago, Illinois, December 10-11, 1962. Also Dale O. Hull, "Systems in Handling Forage Crops", Technical Paper Reprint, 40th Annual Meeting--American Society of Agricultural Engineers, Anaheim, California, April 19 and 20, 1962.

84/ John B. Dobie, "Hay Wafering Production in California", Proceedings of Seminar on Wafering, Massey-Ferguson Company, Chicago, Illinois, December 10-11, 1962.

85/ R. D. Holdren, "Wafering Research Progress at Beltsville", Proceedings of Seminar on Wafering, Massey-Ferguson Company, Chicago, Illinois, December 10-11, 1962.

and other areas have found the windrower with crushing attachment to be superior to the flail chopper in preparation of hay for wafering. Reasons given were, greater durability of the wafer, a more uniform and cohesive windrow and a more uniform moisture content in the windrow. Regardless of the method used there are some practices that benefit the wafering operation. Care should be taken to get uniform windrows. Bunchiness in the windrow results in uneven drying which interferes in the wafering process and causes undue fines and breakup of the wafer. For satisfactory operation the moisture content of the hay should be around 15 percent. Moisture levels higher than this not only cause the machine to work harder, but difficulties in storing the wafer are encountered. With the exception of the dry southwest climates, other areas have required artificial drying or storage in specially constructed facilities that allow a maximum amount of circulation. Wafering the hay at higher moisture levels will also increase the amount of fines. These fines restrict air movement in storage and further complicate the ventilation problem. 86/ In Southern California, under an extremely dry climate, the moisture content of the windrowed hay will often go as low as 6 to 8 percent. Under these conditions it was possible to store the wafers without artificial drying.

A phenomenon that cannot be entirely explained by agricultural engineers working with the wafer machine is the need to get the moisture content quite low before wafering. To get the needed bonding properties, however, water

86/ For a good discussion of storage problems see E. R. Holekamp, Department of Agricultural Engineering, "Resumé of Experiences with Wafering Hay," Unpublished report, Montana State College, Bozeman, 1963. This problem is discussed in almost all reports available on wafering, however.

must be applied. Moisture contained inside the plant has had an undesirable effect on the wafer. This means that if the wafer can be safely stored with a 20 percent moisture content without artificial drying and if moisture is added as a bonding agent, then the windrow moisture content has to be 12 percent or below before artificial drying can be eliminated. A moisture level this low is extremely difficult to reach in most areas of the United States.

Wafering Cost

It is difficult to arrive at a reliable operating cost estimate for wafering due to a lack of operational history. The Lundell wafer machine (Massey-Ferguson now owns the patent rights) has only been on the market one year and only a few sales have been made. Nevertheless, there have been attempts to develop per-ton costs for wafering. A considerable amount of effort has been directed to the cost, as well as other aspects, of wafering in the work at Iowa State University with the Lundell wafering machine. Hull, Extension Agricultural Engineer at Iowa, included a cost schedule for wafering in a talk presented to the Pacific Coast section of the American Society of Agricultural Engineers, Table XVIII. Where possible, actual costs of operation were used. Cost items for which actual data were not available were synthesized on the basis of what experience they had gained.

The original investment cost used in their computations was an f.o.b. price Cherokee, Iowa. Freight or any price revision that might have occurred since these cost figures were reported would have to be taken into an account in an estimate of costs for Montana.

TABLE XVIII. ESTIMATED OPERATING COST FOR LUNDELL WAFERING MACHINE. *

Overhead Charges		
Original cost of the machine		\$8,000
Less 10% salvage value		800
Total 10-year cost		<u>7,200</u>
Annual depreciation on \$8,000 machine		720 <u>b/</u>
Annual interest @ 6% of average cost		
\$8,000 <u>plus</u> \$800 equals to \$8,800 divided		
by 2 equals \$4,400 times 6% interest		264 <u>b/</u>
Annual tax, insurance, and housing at 2½%		180
Total annual overhead charges		\$1,164
Operating Costs		
Fuel and Lubrication		492
Repairs at 4% or original cost		320
Tractor and trailer charge @ \$1.90 per hour		570
Labor at \$1.50 per hour for 300 hours		450
Total annual operating charges		\$1,832
Total Overhead and Operating Charges		\$2,996
Costs Per Hour		
Total operating and overhead costs per hour (\$2996 300)	10.00	
Allowance of a 20% custom markup for profit and risk	2.00	
Total costs per hour	12.00	
Costs Per Ton		
Assumed production per hour of operation	4 tons	
Total cost per ton	3.00 <u>a/</u>	

* Source: Dale O. Hull, "Systems in Handling Forage Crops", op. cit. p. 2.

a/ Operating costs are figured on the basis of an assumed annual operation of 300 hours. Varying this figure can change overhead costs significantly. Assuming different levels of production will produce the following results.

Annual Production	Overhead Cost/ton
100 tons	\$11.64
500 tons	2.33
1200 tons	.97

b/ These figures are not as they appeared in the original publication. Revisions were supplied by the author through personnel correspondence.

Hull assumed a useful life of 10 years with a salvage value of 10 percent of the initial cost. The straight-line method of depreciation, an interest on investment charge of 6 percent per year, and a charge of 2.25 percent to cover taxes, insurance and housing were used to compute overhead costs.

An operating period of 300 hours, which is relatively high, was used because he felt that most machines would be used for custom work. Fuel and lubrication, labor and an allowance for a tractor to pull the wafer machine were figured on the basis of 300 operating hours. Labor was figured at \$1.50 per hour, a charge of \$1.90 per hour was made for the towing unit and fuel and lubrication were figured on manufacturers recommendation. The Lundell machine comes with a 140 H.P. engine which the manufacturer claims will consume 7.5 gallons per hour while producing at its rated capacity of six tons per hour. Repairs were figured at 4 percent of the original cost.

Production was based on a field efficiency of approximately 60 percent. For the 140 H.P. machine with a six ton rated capacity, this amounts to about four tons per hour. At this level of production the wafering process compared quite favorably with baling. The Farm Service Department at Iowa State University estimates the cost of baling to be \$0.10 per bale. Assuming an average of 30 bales per ton (66 pounds per bale) this amounts to \$3.00 per ton; the same estimated cost of wafering. If the costs of these two operations are comparable, then wafering would seem to have an advantage because of the lower handling and storage requirements for wafered hay.

The cost of wafering was also estimated in some work at California. California has had much more experience with wafering and was able to base their cost estimates pretty well on actual operating experiences, Table XIX.

The California study is concerned with a comparison of the two wafering machines currently on the market. The Cal-Cube wafering machine is quite large, and requires a high initial investment of around \$24,000 for the pull-type and around \$27,000 for the self-propelled machine. It was designed as a high capacity machine especially adapted to the unique features of Southern California's hay producing regions. Because of its high investment and high production requirement which is not well suited to Montana, it will not receive further treatment here.

The per ton cost estimates stated in the California study included the cost of preparing the hay crop for wafering. This accounts, in part at least, for the higher costs of operation in California.

Potential for Wafering in Montana

There are at least two factors that will be instrumental in determining the feasibility of hay wafering in Montana. One will be the ability of hay and livestock producers to create handling and storage systems to accomodate the wafered hay. The hay wafer offers its greatest potential savings in this area. Without this system, which in effect requires mechanical handling from the wafer machine to the feed manger, it becomes highly questionable whether any advantage is gained.

Another critical factor in this discussion is the annual output that can be expected from a wafering machine. It was shown that approximately

TABLE XIX. COST PER TON OF WAFERING HAY WITH TWO TYPES OF MACHINES AT DIFFERENT ANNUAL OUTPUTS. *

Tons Per Year	Massey-Ferguson (Lundell Machine)			Cal-Cube Machine		
	Overhead	Cash Costs	Total	Overhead	Cash Costs	Total
100	\$25.72	\$5.21	\$30.93	\$62.07	\$3.76	\$65.83
500	5.14	5.21	10.35	12.41	3.76	16.17
1,000	2.57	5.21	7.78	6.21	3.76	9.97
2,000	1.28	5.21	6.49	3.10	3.76	6.86
3,000	.86	5.21	6.07	2.07	3.76	5.83

* Source: John B. Dobie, op. cit., p. 3.

300 hours of operation or 1200 tons of production is needed to bring the costs of wafering down to a competitive range with baling. The normal haying season in Montana is from 90 to 100 days. In some of the lower irrigated valleys, three crops of alfalfa are harvested. This means that approximately 400 tons of hay will have to be wafered from each crop to reach 1200 tons. Assuming a rate of output of four tons per hour, it would require 100 hours of operating time or 10 to 12 days for each crop. 87/ Even though this appears to be within the reach of a custom operator there are still problems. In areas of the state where three crops are harvested farmers will not delay cutting their first or second crop after it reaches maturity or they will not get sufficient growth in the third crop to justify harvesting. Thus, the actual time of harvest is probably not much longer than 10 or 12 days. The custom operator would definitely be limited time wise unless he were able to move from area to area as later maturing areas begin to harvest.

Another problem that may be encountered deals with moisture. With present technology it is recommended that wafering not be done until the windrowed hay reaches a moisture content of around 15 percent. This

87/ An assumed output of four tons may be too high for Montana. In what limited amount of work has been done with wafering at Montana State College they have only been able to reach about 50 percent field efficiency. This would be three tons per hour. Montana will generally have smaller fields than the Midwest due to the presence of irrigation ditches. In smaller fields a greater portion of the operating time is spent in turning and getting back on the windrow causing field efficiency to be lowered.

obviously will be a problem in areas of the state with late spring rains. However, hay can be baled at around 20 to 22 percent moisture without danger of spoilage. It will be difficult to get farmers to wait for the hay to lose that extra 5 percent moisture required for wafering. In areas where heavy dews are common, the wafering process may have to be delayed three to four hours over the baling process. Delays such as these could become critical to the successful operation of the wafer machine, especially when they occur during peak production seasons.

Scheduling of work could likely become a problem to the custom operator also. Since most farmers like to harvest their alfalfa when it reaches a certain stage of growth, the custom operator may find it difficult to schedule a continuous supply of hay throughout the crop harvest period. He will have to convince some to harvest earlier than the average and others to delay their cuttings. For farmers who are concerned about a fine quality-quantity balance in their hay crop, this arrangement may be unacceptable.

Although the discussion so far appears to paint a discouraging picture for hay wafering in Montana, it is not necessarily intended as such. The potential savings wafering offers to hay and livestock producers is of significant economic importance. In general, it offers an expanded market to hay producers. Feeders in local areas should be willing to feed more hay as prices fall, due to savings in handling and storage. In a geographic sense, it will be economically feasible to ship hay over greater distances and increase their range of competition. It offers livestock feeders a chance to feed their roughages mechanically, an activity that has not adapted itself

well to mechanical feeding. By being able to transport the wafered hay from greater distances it should also provide the livestock feeder with more consistent supplies at more stable prices.

The hay wafering machine is still considered to be in the development stage. There are still technical problems of the machine that need to be worked out. Questions raised about physical and chemical characteristics of hay await answers. Agricultural engineers are, for the most part, very optimistic about the wafering process itself and feel that answers will soon be forthcoming. When these are obtained and a possible lowering of initial investment cost is realized through mass production, "hay-making" could well be revolutionized.

CHAPTER VI

SUMMARY AND CONCLUSIONS

General Market Considerations

Use and importance of hay in Montana has grown in almost direct correlation with the cattle industry. The first cattle operations were located in the western mountainous region of the state where feeding hay during the winter was mandatory. Ranching in the eastern and central regions of the state got its start as an open range type of operation. It relied entirely on the range for both summer and winter feed supplies. The need for winter supplies of hay was brought forcefully to their attention by the catastrophic cattle losses of the 1886-87 winter. Since that disaster cattlemen have generally stocked sufficient hay to carry their cattle through winter periods when range feed is not available.

Hay acreage in Montana has averaged better than two million acres over the past decade from which an annual harvest of almost three million tons is taken. Value of the hay crop varies between 60 and 70 million dollars annually and in terms of total value from a crop, it is surpassed only by wheat. The hay crop, and its vast rangelands provide the basis for a livestock industry which has grossed better than 200 million dollars annually since 1958.

Since its introduction into the state around 1880, alfalfa has become the leading hay producing forage. In 1961, alfalfa accounted for approximately 64 percent of the total hay crop. Wild hay production amounted to 14 percent followed by clover-timothy hay at 13 percent, grain hay at 6 percent and the remaining 3 percent was from the other same forage crops.

Montana has generally been 10 to 15 percent short of its total hay requirements for the past 10 years. The major deficit areas are usually in the central and eastern regions of the state.

Theoretical Aspects of Pricing Hay

Hay markets in Montana are small and usually limited to local trade. Hay prices are generally determined within the confines of the local market. Due to the high bulk, low value nature of hay the area of price influence is rather narrow. The number of transactions made in a local market is low and the price influence of any given sale is significant. Since individual action is of such importance to the pricing of hay, it is essential that relevant price relationships be understood.

Theoretically, there are three salient values that should determine what action an individual operator should take in regards to buying, selling, and feeding hay. These are the marginal value product, (MVP) the salvage value and the acquisition value of hay. If the MVP of hay lies between its acquisition and salvage value, it becomes a fixed resource. If it is above the acquisition value, more hay should be purchased. If the MVP is below the salvage value, a reduction in hay stocks sufficient to bring it up to or above the salvage value should be made.

When hay is used in combination with other variable inputs decision-making becomes more complex. The optimum input combination in the production of a particular product would be obtained when the ratio of the MPP of hay over its price is equal to the same ratio for the other variable inputs. The output of hay as one of a combination of enterprises is also a complex.

decision. In this case, the optimum output level of hay would be obtained when the ratio of the MVP of the inputs used in hay production over their MFC is equal to the same ratio for all other competing enterprises.

In the long run, the price producers receive for hay must cover their costs of production if they are to remain in operation. Estimates of these costs run between \$15 and \$16 per ton. This is the cost at harvesting time. Allowances for storage and waste have to be added to ascertain a comparable cost for periods later in the marketing year.

Hay feeders, on the other hand, cannot pay more for hay than its marginal value product. This will depend on the enterprise in which hay is employed, the level of use and the resource base with which it is combined. Because of the many variables, few studies have been made to ascertain the marginal value product of hay.

The price feeders are willing to pay for hay is influenced by the availability of substitutes. Pasture, ensilage and concentrates are all relatively good substitutes for hay. Marginal rates of substitution for hay concentrates have been estimated. Both linear and nonlinear estimates of this relationship were made. Nonlinear estimates of the marginal rate of substitution of grain for hay ranged from 18 to 3.86. The linear estimate was 2.30. If the linear estimate is accepted then whenever the price of concentrates is more than 2.30 times that of alfalfa the least cost combination of inputs would lie at the stomach capacity for forages. When the price of concentrates was less than 2.30 times that of alfalfa, the least cost combination would lie at the physiological limit line for concentrates.

The marginal value product of a given input is a product of two components--the marginal physical product of the input and the price of the product. A rise in either of these components will cause the marginal value product to rise also. If physical production relationships are assumed constant then a rise in the price of the product would indicate the marginal value product has increased also. An increase in the marginal value product of a factor would lead to increased utilization of the input. With this in mind, the price of milk and beef were tested for trend. Both showed an upward trend over the 21-year period 1940 to 1960. However, neither trend was significant from zero. Thus, no conclusion on the future demand for hay could be drawn from this analysis.

If the relative price of close substitutes for hay changes, it will also affect the utilization of hay. In this respect, barley was tested for trend over this same period. It demonstrated a downward trend that was highly significant. It can thus be concluded that barley has displaced some hay in the feed ration and will continue to do so as long as this relationship holds.

Montana Hay Market Characteristics

Approximately 50 percent of the total hay transactions are made in the period from June through September. The period from October through January accounted for 25 to 30 percent of sales with the remainder occurring in the late winter, early spring period. Ranchers concentrated their hay transactions in the hay harvest period when prices were low and their ranches accessible to heavy trucks. Although most dairymen followed this same procedure, there was a tendency for many of them to purchase hay as it was needed.

Dealer activity reflected the buying pattern predominant in his area.

A majority of both buyers and sellers felt there were not special practices they could use to assure themselves of a desired price. Eight of thirty-one buyers felt, that buying in the harvest season tended to give them a price advantage. Three buyers and seven of the twenty-three sellers were of the opinion that trading with the same individual year after year resulted in their gaining a price advantage.

Grass hay usually sells for a premium over alfalfa. Auction markets and ranchers prefer grass hay because it has less tendency to cause bloat or scours in their animals. There is generally less waste in feeding grass hay and since it is similar to the native range forage, it can be fed intermittently without danger of throwing the cattle off feed. Demand for grass hay has been sufficiently strong in relation to supply that its price has tended to be higher than the price of alfalfa hay. The latter is considered a more productive feed than the grass hay. It will usually have a higher protein and T.D.N. content.

There is little evidence that hay is priced according to quality. The only means of testing and grading now being used in the state is visual inspection. One reason for this situation is lack of agreement on general quality factors. Dairymen, sheepmen, and feedlot operators prefer a fine textured, high protein hay. Ranchers, in general, have not been so quality conscious. In fact, they have demonstrated a distinct preference for a ranker, lower protein hay to reduce the risk of bloat and scours. Thus, producers have been able to resist any effort to discount the poorer quality (in terms

of T.D.N. and protein) hay because they have a market for it in the rancher. Even dairymen, who have quite a bit at stake in the quality of their hay, are generally apathetic toward the quality of the hay they feed.

A majority of hay buyers and sellers are uninformed as to the market for hay outside their local areas. Because of the diffused nature of the market, it has been physically impossible to collect reliable market information. Without some means of reporting prices according to type, grade or quality, it is questionable as to what value it might have anyway.

Hay dealers tend to be well informed on conditions surrounding their immediate market. This is natural and necessary to their occupation. They are generally looking for new customers and a knowledge of potential buyers or sellers is one of the services they offer. In fact, some dealers are suspicious that more information in the hands of buyers and sellers might be harmful to their business.

Hay Prices and Pricing

Many factors influence price determination in the Montana hay market. Because of the small local nature of the hay market, the role of individual influence can be significant. There are three major obstacles to efficient pricing. These are (1) general apathy of Montana feeders to quality and other productive characteristics of hay, (2) the high bulk, low value nature of hay which has limited the geographic market to a rather small area and to relatively few buyers and sellers, and (3) the lack of current and reliable hay market information on which buyers and sellers can base their decisions.

The weighted average annual price of hay has varied considerably over the past 20 years. Average year to year variation amounted to 16 percent. However, when adjusting for changes in the price level, this average year to year variation amounts to only 14 percent. There is no trend evident in the adjusted hay prices over the period 1940 through 1960.

Hay prices adhere to a definite seasonal price pattern. Prices are lowest during the harvest months of June and July. There is a gradual rise from August through February, then prices start downward. Theoretically, the price pattern would be expected to start with low prices during the harvest months and then rise throughout the marketing year. The extent of this rise, in the long, would cover normal storage costs. Why the actual price pattern does not follow the theoretical price pattern is difficult to explain. Three explanations are plausible. First, there may be a quality differential implicit in the price pattern. Under present market conditions there may be a tendency to move higher quality hay in the forepart of the marketing year and poorer qualities in the latter part. Secondly, the market for hay in Montana has a fairly rigid institutional structure. If buying and selling habits are quite inflexible, it is possible that the relative strengths of supply and demand are not congruent in the market and are causing price disparities to occur. The third and most satisfactory explanation is that the price pattern reflects an attempt on the part of farmers and ranchers to minimize risk. If they attach a greater risk to running short of hay than they do to running long, then they would tend to buy more hay than normally needed. This practice would cause supply and demand to shift upward from the

theoretical or expected price pattern during the forepart of the marketing year and in a reverse direction during the latter part.

Impact of Hay Processing on the Market for Montana Hay

The production of alfalfa meal has experienced a rapid rise since the early 1940's. Dehydrated alfalfa meal has accounted for most of the gains with an increase of approximately 400 percent over this period. Sun-cured alfalfa meal has shown a decrease since 1946. Dehydrated alfalfa has captured most of the sun-cure market because of its superior nutritive value.

Montana is generally considered a high cost production area for dehydrated alfalfa meal. It is bordered on the east by the major producing area in the United States. This West North Central region, including the high producing states of Nebraska and Kansas, account for over 50 percent of the total United States production. On the west and south, it must compete with the rapidly expanding production of California and Washington.

The ability of Montana to produce dehydrated alfalfa will depend on what success it has in overcoming unfavorable environmental conditions. The short growing season in Montana is a difficult obstacle to overcome. Dehydrators are faced with a high fixed cost structure that requires a high volume of output in order to bring unit costs down to a level competitive with substitute feeds.

The potential for sun-cure alfalfa meal in Montana hinges on the development of a market. The formula-feeds industry in Montana, like the rest of the United States, has displaced sun-cured meal almost entirely with dehydrated alfalfa meal. Development of an export market has created new interest in

sun-cured alfalfa. At present, only those Montana firms having favorable freight rates to western ports are able to take advantage of this market. How dependable this market will be is an important question in the future expansion of sun-cured facilities within the state.

The hay wafering process has received considerable attention by both hay producer and feeder. It offers both a means of mechanically handling a job that heretofore has had a high labor requirement. However, the wafer machine is still considered to be in the development stage and awaits further testing and improvement before it will become feasible. Like in other types of hay processing, initial investment costs are high and a large volume of output is needed to reduce unit costs.

Studies at Iowa State University have estimated that it will require at least 1200 tons of production annually before costs will become competitive with other methods of hay handling. California studies indicate this requirement will be nearer 2500 tons annually.

Moisture control has been one of the major problems encountered by the wafering machine. Optimum wafering conditions call for a moisture content from 12 to 15 percent in the windrowed hay. In western Montana where late spring rains are common and in areas where heavy dews are encountered the wafering machine will probably not prove feasible.

Areas for Further Research

The most opportune area for further research that became apparent in this study was in the field of production. Farmers and ranchers are in need of more information on both physical and economic production relationships. In

many instances, this would require only bringing to their attention information already available. In others, it would require new research studies.

In general, hay feeders lack information on all production aspects of hay feeding. They need information on the nutritive value of hay and its relationship to other feeds as a productive feed input. Feeders need to be cognizant of the quality variation that can exist between two lots of hay that appear to be of equal grade when inspected visually. Finally, they need to (1) be aware of the economic implications of these physical relationships and, (2) have access to a framework within which they can make economic interpretations of changing physical and price relationships relevant to their own enterprise.

Hay producers are likewise in need of information on production relationships relevant to their operations. It is generally recognized that hay reaches a peak in quality sometime before maximum yield per acre is attained. It is not known, however, how much quantity is sacrificed if a hay stand is cut for high quality hay. Without this information the market cannot arrive at an equitable price differential for quality hay. Farmers and ranchers need to know the cost of special management and cropping techniques used to produce quality hay. They also need to know the total costs associated with producing different kinds of hay.

Both producers and feeders of hay need information on hay shrinkage and the waste involved in storing and handling hay. Discriminate pricing of hay, both as an output and an input, demands a knowledge of the wastes involved in handling, storing and feeding hay. Another question to be answered is that

posed by the deviation of the actual price pattern from a theoretical one based on the assumption of a perfectly competitive market.

When hay feeders and hay producers have knowledge of these relationships and are aware of their significance, then not only will it be possible to improve the market system for Montana hay but impetus to make improvements will be present also.

- 181 -

APPENDICES

APPENDIX A

TABLE I. COMPUTATIONS FOR "KENDALL'S COEFFICIENT" AND TESTING THE NULL HYPOTHESIS THAT VARIATION IN THE JANUARY PRICE INDEX IS RANDOM.

Year	Month January	Rank	Natural Integers	P	Q
1940					
1941	96.3	2	1	19	-1
1942	109.1	19	2	2	-17
1943	98.9	3	3	17	-1
1944	103.7	10	4	10	-7
1945	105.3	13	5	7	-9
1946	103.7	11	6	8	-7
1947	112.4	20	7	1	-13
1948	107.9	16	8	3	-10
1949	95.4	1	9	12	0
1950	102.1	7	10	8	-3
1951	100.6	5	11	9	-1
1952	116.0	21	12	0	-9
1953	104.2	12	13	4	-4
1954	106.8	15	14	2	-5
1955	102.8	8	15	4	-2
1956	105.8	14	16	2	-3
1957	108.3	18	17	0	-4
1958	102.0	6	18	2	-1
1959	99.7	4	19	2	0
1960	108.2	17	20	0	-1
1961	103.1	9	21	0	0
				112	-98

$$S = P + Q$$

$$S = 112 + (-98)$$

$$S = 14$$

$$S^2_{sc} = 1/18 N(N - 1) \cdot (2N + 5)$$

$$= 1/18 \cdot 21(21 - 1) \cdot (42 + 5)$$

$$= 1/18 \cdot 420 \cdot 47$$

$$= 1/18 \cdot 19740$$

$$= 1096.67$$

$$S_{sc} = \sqrt{S^2_{sc}}$$

$$= \sqrt{1096.67}$$

$$= 33.11$$

$$= \frac{(14 - 1) - 0}{33.11}$$

$$= \frac{13}{33.11}$$

$$\text{hyp- } S = 0$$

$$T = .39$$

$$T = \frac{S(\text{corrected}) - 0}{S_{sc}}$$

$$T_{21, .01} = 2.83$$

• We accept hypothesis $S = 0$ where S is expressed as a deviate from the null value zero.

TABLE II. COMPUTATIONS FOR "KENDALL'S COEFFICIENT" AND TESTING THE NULL HYPOTHESIS THAT VARIATION IN THE JULY PRICE INDEX IS RANDOM.

Year	Month July	Rank	Natural Integers	P	Q
1940	98.6	15	1	7	-14
1941	97.9	14	2	7	-13
1942	94.0	11	3	9	-10
1943	99.8	20	4	2	-16
1944	101.5	21	5	1	-16
1945	99.3	18	6	2	-14
1946	93.4	9	7	7	-8
1947	99.0	16	8	3	-11
1948	95.8	12	9	4	-9
1949	91.7	7	10	6	-6
1950	93.4	10	11	4	-7
1951	89.2	3	12	8	-2
1952	91.7	6	13	5	-4
1953	85.0	1	14	8	0
1954	90.3	4	15	6	-1
1955	96.4	13	16	3	-3
1956	99.7	19	17	1	-4
1957	91.4	5	18	3	-1
1958	104.0	22	19	0	-3
1959	87.8	2	20	2	0
1960	92.9	8	21	1	0
1961	99.1	17	22	0	0
				89	-142

$$S = P + Q$$

$$S = 89 + (-142)$$

$$S = -53$$

$$S_{sc}^2 = \frac{1}{18} N (N-1) (2N + 5)$$

$$= \frac{1}{18} 22 (22-1) (2 \cdot 22 + 5) \text{ hyp- } S = 0$$

$$= \frac{1}{18} (462) \cdot (49)$$

$$S_{sc}^2 = 1,257.67$$

$$S_{sc} = \sqrt{\frac{S^2}{S_{sc}}} = \frac{-54 - 0}{35.46}$$

$$= \sqrt{1257.67} = \frac{-54}{35.46}$$

$$S_{sc} = 35.46$$

$$T = -1.52$$

$$T = \frac{S (\text{corrected}) - 0}{S_{sc}}$$

$$T_{22, .01} = 2.82$$

• We accept hypothesis that $S = 0$ where S is expressed as the deviate from the null value zero.

TABLE I. GRAIN FORAGE COMBINATIONS AND MARGINAL RATES OF SUBSTITUTION OF GRAIN AND FORAGE FOR VARIOUS OUTPUTS OF MILK BY GOOD COWS ^{a/}

Pounds of Hay ^{b/} (1)	7,000-lb. Milk			8,000-lb. Milk			9,000-lb. Milk			10,000-lb. Milk			11,000-lb. Milk		
	Pounds of Grain (2)	MRS H/Gc/ (3)	MRS G/Hd/ (4)	Pounds of Grain (2)	MRS H/Gc/ (3)	MRS G/Hd/ (4)	Pounds of Grain (2)	MRS H/Gc/ (3)	MRS G/Hd/ (4)	Pounds of Grain (2)	MRS H/Gc/ (3)	MRS G/Hd/ (4)	Pounds of Grain (2)	MRS H/Gc/ (3)	MRS G/Hd/ (4)
	(2)	(3)	(4)	(2)	(3)	(4)	(2)	(3)	(4)	(2)	(3)	(4)	(2)	(3)	(4)
3,000	4,675														
3,500	4,025			5,050											
4,000	3,500	1.30	0.5	4,400	1.30	0.8	5,600								
4,500	3,050	.90	1.1	3,875	1.05	1.0	5,000	1.20	0.8						
5,000	2,650	.80	1.2	3,450	.85	1.2	4,500	1.00	1.0	6,125					
5,500	2,300	.70	1.4	3,050	.80	1.2	4,050	.90	1.1	5,450	1.35	0.7			
6,000	1,975	.65	1.5	2,700	.70	1.4	3,625	.85	1.2	4,925	1.05	1.0	7,200		
6,500	1,675	.60	1.7	2,385	.67	1.5	3,275	.70	1.4	4,450	.95	1.1	6,550	1.30	0.8
7,000	1,400	.55	1.0	2,675	.58	1.7	2,950	.65	1.5	4,050	.80	1.2	6,000	1.10	0.9
7,500	1,160	.48	2.1	1,820	.51	2.0	2,650	.60	1.7	3,700	.70	1.4	5,575	.85	1.2
8,000	930	.46	2.2	1,585	.51	2.0	2,375	.55	1.8	3,410	.58	1.7	5,180	.79	1.3
8,500	705	.45	2.2	1,380	.47	2.1	2,125	.50	2.0	3,160	.50	2.0	4,900	.56	1.8
9,000	490	.43	2.3	1,115	.43	2.3	1,890	.47	2.1	2,925	.47	2.1	4,680	.44	2.3
9,500	290	.40	2.5	900	.43	2.3	1,690	.40	2.5	2,700	.45	2.2	4,500	.36	2.8
10,000	100	.38	2.6	730	.34	2.9	1,500	.38	2.6	2,540	.32	3.1			
10,500				580	.28	3.6	1,360	.28	3.6	2,400	.28	3.6			
11,000				475	.23	4.3	1,250	.22	4.5						
11,500				330	.19	5.3									

^{a/} A 1200-pound cow capable of giving 10,000 pounds of 3.5% FCM when fed a grain-milk ratio of 1:4.

^{b/} Includes silage and pasture converted to hay equivalent consumed. This does not include the portion of hay fed but not consumed, which is normally about 8 percent.

^{c/} This is the average marginal rate of substitution of hay for grain, pounds of grain required to substitute for 1 pound of hay within a short range and is the reciprocal of column 4.

^{d/} This is the average marginal rate of substitution of grain for hay, pounds of hay required to substitute for 1 pound of grain within a short range and is the reciprocal of column 3.

Source: Synthesized data based upon feeding experiments and estimates from dairy scientists and agricultural economists.

APPENDIX B

TABLE II. FEED COMBINATIONS IN PRODUCING SPECIFIED MILK LEVELS AND MARGINAL RATES OF SUBSTITUTION OF GRAIN FOR HAY PREDICTED FROM MODIFIED QUADRATIC EQUATION. ABILITY FIXED AT MEAN OF 36 COWS FOR 26-WEEK BASIC EXPERIMENT. *

Feed to Produce 5,300			Feed to Produce 6,300			Feed to Produce 7,300		
Lbs. Milk			Lbs. Milk			Lbs. Milk		
MRS of			MRS of			MRS of		
Grain for			Grain for			Grain for		
Lbs.	Lbs.	Hay a/ $\Delta H / \Delta G$	Lbs.	Lbs.	Hay a/ $\Delta H / \Delta G$	Lbs.	Lbs.	Hay a/ $\Delta H / \Delta G$
Grain	Hay		Grain	Hay		Grain	Hay	
1,000	5,560	3.37	1,000	8,256 ^b	3.59	1,000	11,138 ^b	3.86
1,500	3,969	2.99	1,500	6,566	3.17	1,500	9,328 ^b	3.39
2,000	2,558	2.65	2,000	5,074	2.79	2,000	7,738 ^b	2.97
2,500	1,313	2.33	2,500	3,761	2.45	2,500	6,345	2.60
3,000	221 ^b	2.03	3,000	2,612	2.13	3,000	5,130	2.25
- - -	- - -	- - -	3,500	1,616	1.84	3,500	4,080	1.94
- - -	- - -	- - -	4,000	763 ^b	1.56	4,000	3,182	1.64
- - -	- - -	- - -	- - -	- - -	- - -	4,500	2,428	1.36
- - -	- - -	- - -	- - -	- - -	- - -	5,000	1,813	1.09

* Source: Earl O. Heady, et. al., Milk Production Functions, Hay/Grain Substitution Rates and Economic Optima in Dairy Cow Rations, Research Bulletin 444, Agricultural Experiment Station, Iowa State College, Ames, October, 1956.

a/ Marginal rate of substitution: Amount of forage replaced by 1 pound of grain for "small change" away from the combination shown. Figure is a derivative of hay with respect to grain.

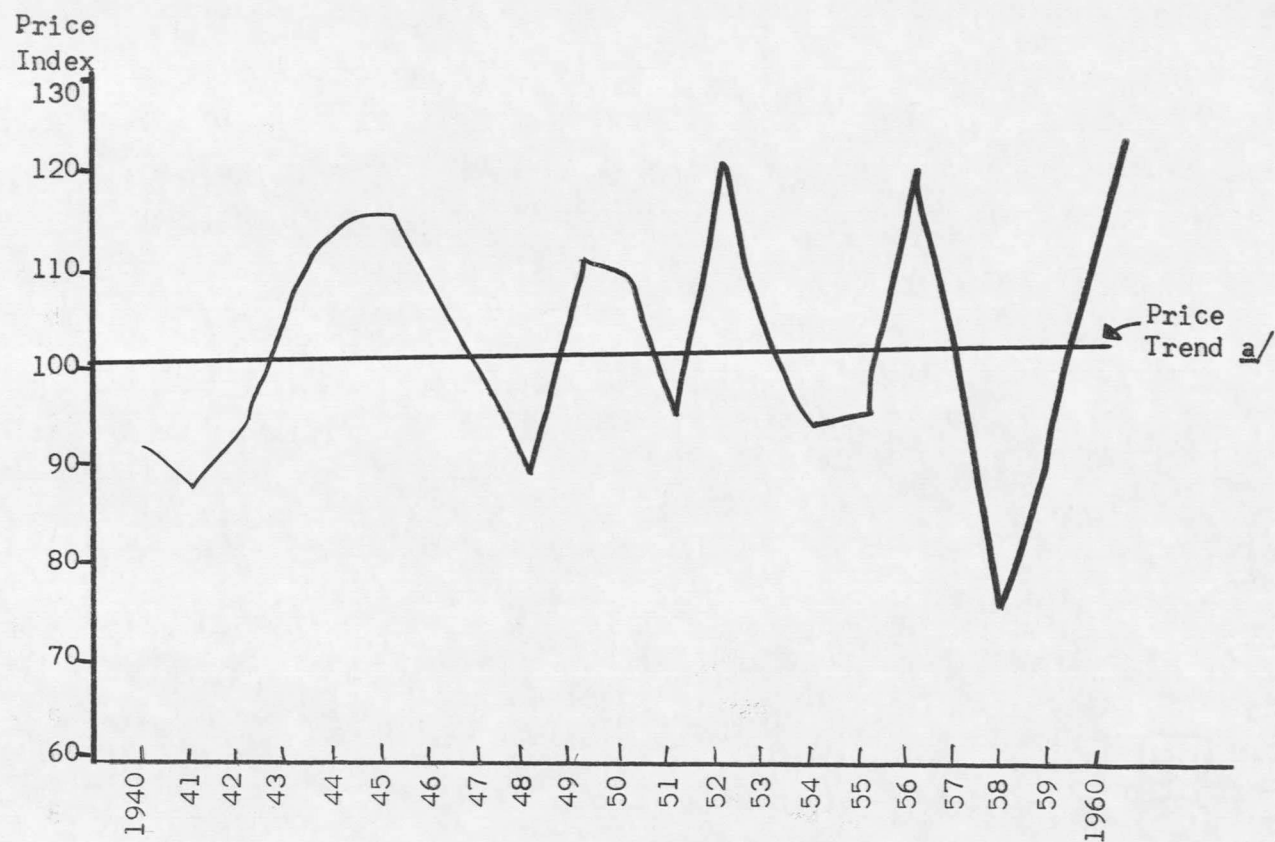
b/ Prediction is outside range of observations.

TABLE III. FEED COMBINATION IN PRODUCING SPECIFIED MILK LEVELS AND MARGINAL RATES OF SUBSTITUTION OF GRAIN FOR HAY PREDICTED FROM LINEAR EQUATION. ABILITY FIXED AT MEAN OF 36 COWS FOR 26-WEEK BASIC EXPERIMENT. *

Feed to Produce 5,300 lbs. milk			Feed to Produce 6,300 lbs. milk			Feed to Produce 7,300 lbs. milk		
		Substi- tution			Substi- tution			Substi- tution
Lbs. Grain	Lbs. Hay	rate $\Delta H/\Delta G$	Lbs. Grain	Lbs. Hay	rate $\Delta H/\Delta G$	Lbs. Grain	Lbs. Hay	rate $\Delta H/\Delta G$
1,000	5,194	2.3017	1,000	7,602 ^a / ₂	2.3017	1,000	10,010 ^a / ₂	2.3017
1,500	4,043	2.3017	1,500	6,451	2.3017	1,500	8,859 ^a / ₂	2.3017
2,000	2,892	2.3017	2,000	5,300	2.3017	2,000	7,708 ^a / ₂	2.3017
2,500	1,741	2.3017	2,500	4,149	2.3017	2,500	6,557	2.3017
3,000	590 ^a / ₂	2.3017	3,000	2,998	2.3017	3,000	5,406	2.3017
- - -	- - -	- - -	3,500	1,847	2.3017	3,500	4,255	2.3017
- - -	- - -	- - -	4,000	697 ^a / ₂	2.3017	4,000	3,105	2.3017
- - -	- - -	- - -	- - -	- - -	- - -	4,500	1,954	2.3017
- - -	- - -	- - -	- - -	- - -	- - -	5,000	803	2.3017

* Source: Earl O. Heady, et. al., Milk Production Functions, Hay/Grain Substitution Rates and Economic Optima in Dairy Cow Rations, Research Bulletin 444, Agricultural Experiment Station, Iowa State College, Ames, October, 1956.

^a/ Outside range of observation.



a/ Price trend estimated by simple regression equation $Y = a + bX$. In this estimate $a = 101.7$, $b = .13$. b is non-significant from zero at the 10 percent level.

Figure 1. Index of hay prices; deflated and adjusted to 1947-49 base.

TABLE I. DEFLATED ALL HAY BALED PRICES USING INDEX OF PRICES RECEIVED
TO DEFLATE PRICE SERIES.

Year	Annual Average Hay Price	Index of Prices Received (Montana)	Adjusted Price	Price Index Adjusted 1947-49 Base
1940	7.39	35	21.11	.92
1941	8.25	41	20.12	.88
1942	11.08	51	21.72	.95
1943	15.37	61	25.20	1.10
1944	16.98	64	26.53	1.16
1945	18.12	68	26.65	1.17
1946	19.45	78	24.94	1.09
1947	23.10	102	22.65	.99
1948	21.26	105	20.24	.89
1949	23.86	93	25.65	1.12
1950	25.47	100	25.47	1.11
1951	25.74	118	21.81	.95
1952	32.76	118	27.76	1.22
1953	20.78	89	23.34	1.02
1954	19.35	89	21.74	.95
1955	19.32	87	22.20	.97
1956	22.58	81	27.88	1.22
1957	19.21	86	22.34	.98
1958	16.23	92	17.64	.77
1959	19.62	91	21.93	.96
1960	24.69	87	28.38	1.24
1961	23.19			

TABLE II. HAY PRICE TREND

Year	X	Y	XY	² X	Yc
1940	-10	92	-920	100	101.82
1941	- 9	88	-792	81	101.95
1942	- 8	95	-760	64	102.08
1943	- 7	110	-770	49	102.22
1944	- 6	116	-696	36	102.35
1945	- 5	117	-585	25	102.48
1946	- 4	109	-436	16	102.61
1947	- 3	99	-297	9	102.74
1948	- 2	89	-178	4	102.88
1949	- 1	112	-112	1	103.00
1950	0	111	0	0	103.14
1951	1	95	95	1	103.27
1952	2	122	244	4	103.40
1953	3	102	306	9	103.54
1954	4	95	380	16	103.67
1955	5	97	485	25	103.80
1956	6	122	732	36	103.93
1957	7	98	686	49	104.06
1958	8	77	616	64	104.20
1959	9	96	864	81	104.33
1960	<u>10</u>	<u>124</u>	<u>1240</u>	<u>100</u>	<u>104.46</u>
	0	2166	102	770	

COMPUTATIONS FOR HAY PRICE TREND AND TESTS OF SIGNIFICANCE

$$\sum Y^2 = 226,702 \quad \sum X^2 = 3311 \quad \sum XY = 23,928$$

1. $\sum Y = Na + b\sum X$

2. $\sum XY = a\sum X + b\sum X^2$

$$a = \frac{2166}{21} = 103.14$$

when $X = \text{other}$

$$a = \frac{\sum Y}{N} \quad b = \frac{\sum XY}{\sum X^2}$$

$$b = \frac{102}{770} = .132$$

$$\sum X^2 = \frac{N\sum X^2 - (\sum X)^2}{N} = \frac{(21)(3311) - (231)^2}{21} = 770$$

$$\sum Y^2 = \frac{N\sum Y^2 - (\sum Y)^2}{N} = \frac{(21)(226,702) - (2166)^2}{21} = 3,294.6$$

$$\sum XY = \frac{N\sum XY - (\sum Y)(\sum X)}{N} = \frac{(21)(23,928) - (231)(2166)}{21} = 102$$

$$b = \frac{\sum XY}{\sum X^2} = \frac{102}{770} = .13$$

$$a = \frac{\sum Y - b\sum X}{N} = \frac{2166 - (.13)(231)}{21} = 101.7$$

ANOV TABLE

Source	Sum of Squares	d.f.	Variance
Total $\sum Y^2$	3,294.6	20	164.73
Regression $b\sum XY$	13.3	1	13.3
Residual $\sum Y^2 - b\sum XY$	3,281.3	19	172.7

$$F = \frac{13.3}{172.7} = .077$$

$$F(.01, n_1 = 1, n_2 = 19) = 8.28$$

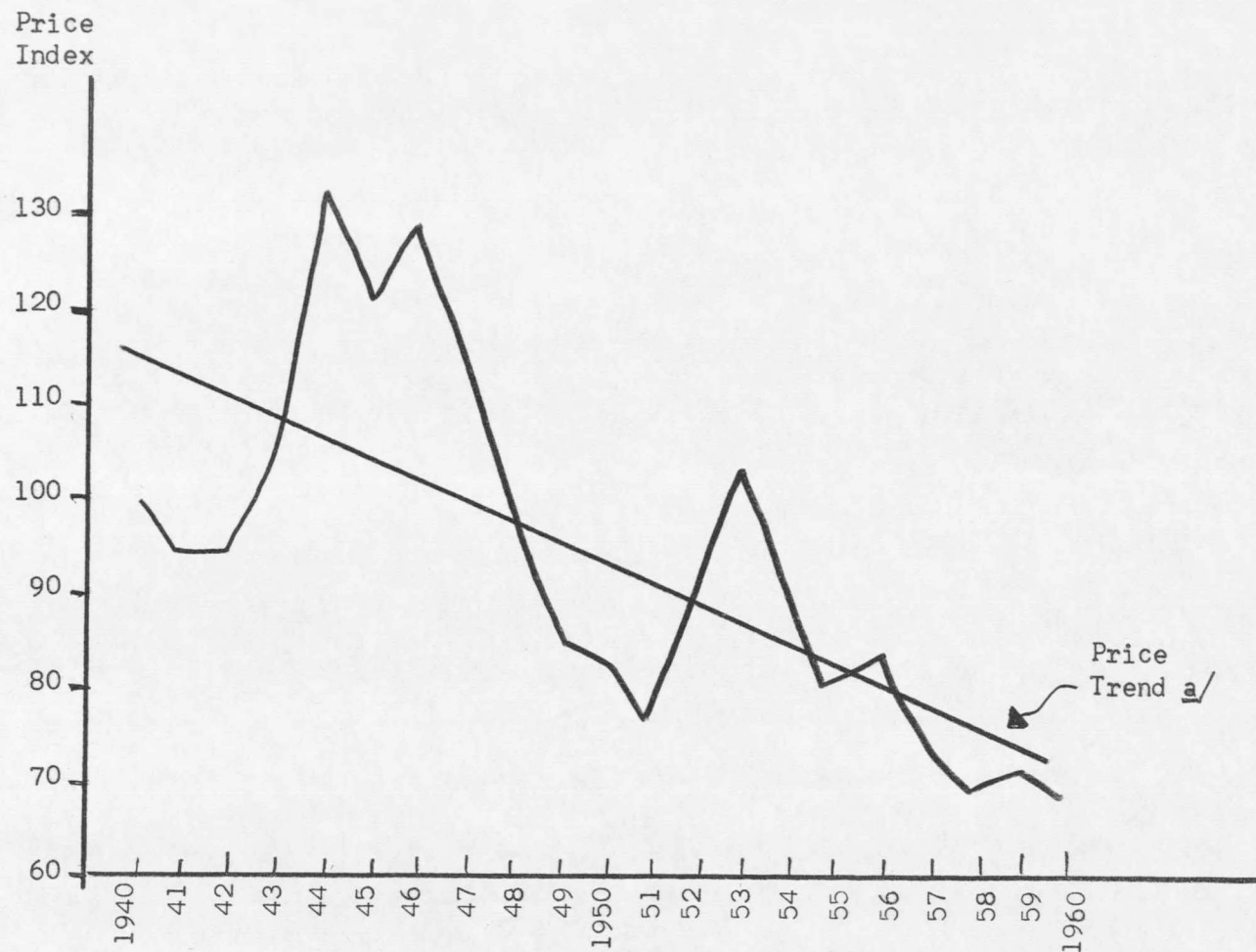
$$F(.05, n_1 = 1, n_2 = 19) = 4.38$$

$$\sigma_b^2 = \frac{\sigma_v^2}{\sum X^2} = \frac{172.7}{770} = .2242, \quad \sigma_b = \sqrt{.2242} = .473$$

$$H_0 : b = 0 \quad t = \frac{b}{\sigma_b} = \frac{.13}{.473} = .275$$

$$t_{19}, .10 = 1.73$$

∴ We accept the $H_0 : b = 0$



a/ Price trend estimated by simple regression equation $Y=a + bX$. In this estimate $a = 116.4$, $b = -2.1$. b is significant from zero at the 1 per-cent level.

Figure 2. Index of barley prices: Deflated and adjusted to 1947-49 base.

TABLE III. DEFLATED BARLEY PRICES USING INDEX OF PRICES RECEIVED BY MONTANA FARMERS AND RANCHERS TO DEFLATE PRICE SERIES.

Year	Average Annual Barley Prices	Index of Prices Received All Farm Products	Adjusted Prices	Price Index Adjusted to 1947-49 Base
1940	.39	35	1.11	.99
1941	.43	41	1.04	.93
1942	.53	51	1.04	.93
1943	.72	61	1.18	1.05
1944	.94	64	1.47	1.31
1945	.90	68	1.33	1.19
1946	1.12	78	1.44	1.29
1947	1.30	102	1.27	1.13
1948	1.21	105	1.15	1.03
1949	.88	93	.95	.85
1950	.92	100	.92	.82
1951	1.02	118	.86	.77
1952	1.23	118	1.04	.93
1953	1.03	89	1.15	1.03
1954	.89	89	1.00	.89
1955	.78	87	.90	.80
1956	.76	81	.94	.84
1957	.71	86	.83	.74
1958	.71	92	.77	.69
1959	.73	91	.80	.71
1960	.66	87	.76	.68

TABLE IV. BARLEY PRICE TREND.

Year	X	Y	XY	X ²	Yc
1940	-10	99	-990	100	114.3
1941	- 9	93	-837	81	112.2
1942	- 8	93	-744	64	110.1
1943	- 7	105	-735	49	108.0
1944	- 6	131	-786	36	105.9
1945	- 5	119	-595	25	103.8
1946	- 4	129	-512	16	101.7
1947	- 3	113	-339	9	99.6
1948	- 2	103	-206	4	97.5
1949	- 1	85	- 85	1	95.4
1950	0	82	0	0	93.3
1951	1	77	77	1	91.2
1952	2	93	186	4	89.1
1953	3	103	309	9	87.0
1954	4	89	356	16	84.9
1955	5	80	400	25	82.8
1956	6	84	504	36	80.7
1957	7	74	518	49	78.6
1958	8	69	552	64	76.5
1959	9	71	639	81	74.4
1960	<u>10</u>	<u>68</u>	<u>680</u>	<u>100</u>	<u>72.3</u>
	0	1960	-1612	770	

COMPUTATIONS FOR BARLEY PRICE TREND AND TESTS OF SIGNIFICANCE.

$$a = \frac{\sum Y}{N} = \frac{1960}{21} = 93.3$$

$$b = \frac{\sum XY}{\sum X^2} = \frac{1612}{770} = -2.1$$

$$\sum X^2 = \frac{N \sum X^2 - (\sum X)^2}{N} = \frac{(21)(3311) - (231)^2}{21} = 770$$

$$\sum Y^2 = \frac{N \sum Y^2 - (\sum Y)^2}{N} = \frac{(21)(189,880) - (1960)^2}{21} = 6,946.67$$

$$\sum XY = \frac{N \sum XY - \sum X \sum Y}{N} = \frac{(21)(19,948) - (231)(1960)}{21} = -1612$$

$$b = \frac{\sum XY}{\sum X^2} = \frac{-1612}{770} = -2.1$$

$$a = \frac{\sum Y - b \sum X}{N} = \frac{1960 + (2.1)(231)}{21} = 116.4$$

ANOV TABLE

Source	Sum of Squares	Degrees of Freedom	Variance
Total $\sum Y^2$	6,946.67	n-1	$\frac{\sum Y^2}{n-1}$ 347.33
Regression $b \sum XY$	3,385.20	1	$\frac{b \sum XY}{1}$ 3,385.20
Residual $\sum Y^2 - b \sum XY$	3,561.47	n-2	$\frac{\sum Y^2 - b \sum XY}{n-2}$ 187.44

$$F = \frac{3,385.20}{187.44} = 18.06$$

$$n_1 = 1 \quad n_2 = 19, \quad F_{.01} = 8.28$$

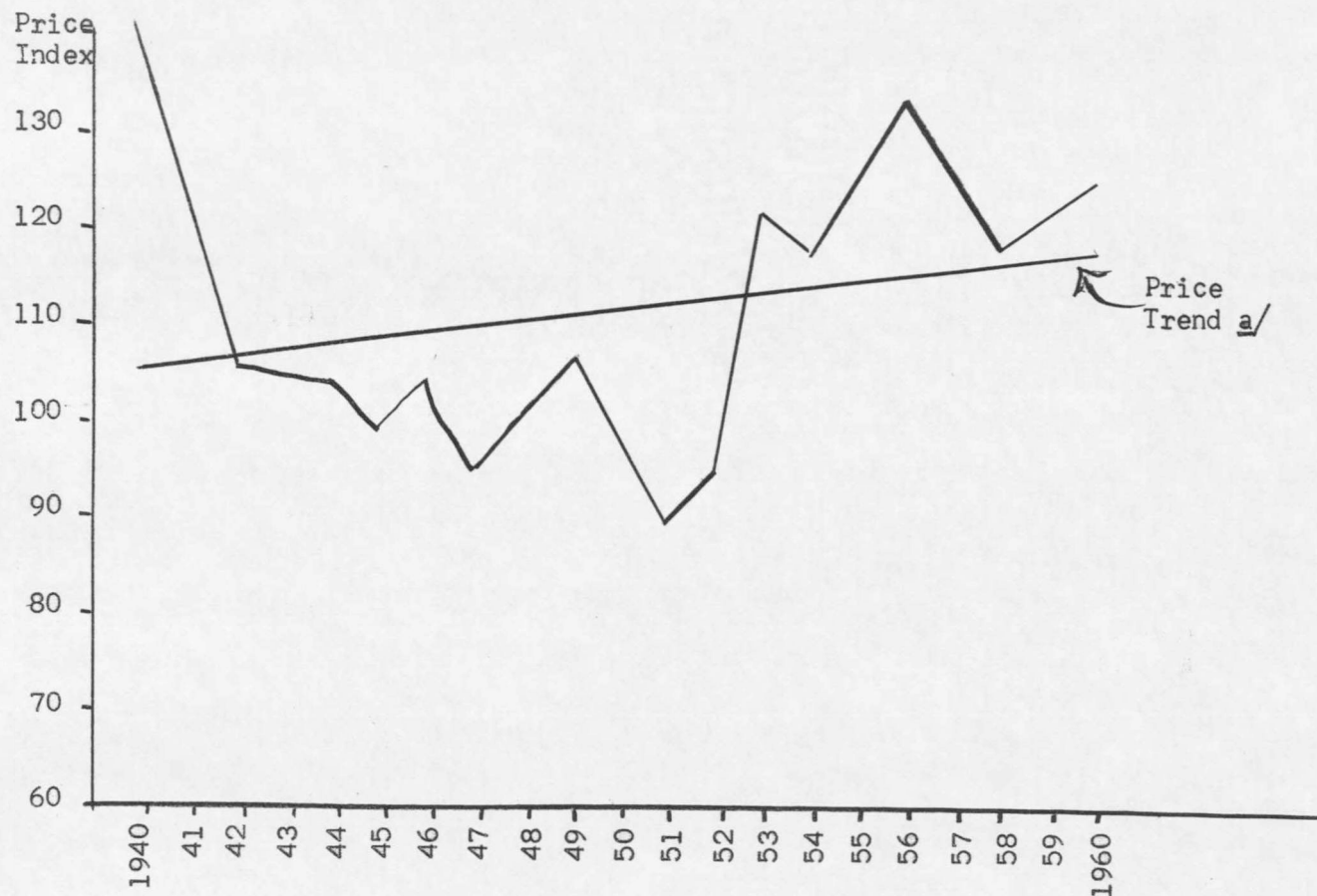
$$\sigma_b^2 = \frac{\sigma_v^2}{\sum X^2} = \frac{187.44}{770} = .2434$$

$$\sigma_b = \sqrt{.2434} = .493$$

$$H_0 : b = 0 \quad t = \frac{b}{\sigma_b} = \frac{-2.1}{.493} = -4.26$$

$$t_{19, .01} = 2.86$$

∴ We reject the $H_0 : b = 0$



a/ Price trend estimated by simple regression equation $Y = a + bX$. In this estimate $a = 104.7$, $b = .67$. b is non-significant from zero at the 10 percent level.

Figure 3. Index of milk prices: Deflated and adjusted to 1947-49 base.

TABLE V. DEFLATED MILK PRICES USING INDEX OF PRICES RECEIVED BY MONTANA FARMERS AND RANCHERS TO DEFLATE PRICE SERIES.

Year	Average Annual Milk Price	Index of Prices		Adjusted Prices	Index of Prices Adjusted to a 1947-49 Base
		Received	1947-49 Base		
1940	2.00	35		5.71	141
1941	2.02	41		4.93	122
1942	2.18	51		4.27	106
1943	2.58	61		4.23	105
1944	2.69	64		4.20	104
1945	2.72	68		4.00	99
1946	3.27	78		4.19	104
1947	3.90	102		3.82	95
1948	4.17	105		3.97	98
1949	4.02	93		4.32	107
1950	3.95	100		3.95	98
1951	4.27	118		3.62	90
1952	4.53	118		3.84	95
1953	4.40	89		4.94	122
1954	4.24	89		4.76	118
1955	4.40	87		5.05	125
1956	4.40	81		5.43	134
1957	4.43	86		5.15	127
1958	4.41	92		4.79	119
1959	4.45	91		4.89	121
1960	4.40	87		5.06	125

TABLE VI. MILK PRICE TREND

Year	X	Y	XY	X ²	Y _c
1940	-10	141	-1410	100	105.4
1941	- 9	122	-1098	91	106.1
1942	- 8	106	- 848	64	106.7
1943	- 7	105	- 735	49	107.4
1944	- 6	104	- 625	36	108.1
1945	- 5	99	- 495	25	108.8
1946	- 4	104	- 416	16	109.4
1947	- 3	95	- 285	9	110.1
1948	- 2	98	- 196	4	110.8
1949	- 1	107	- 107	1	111.4
1950	0	98	0	0	112.1
1951	1	90	90	1	112.8
1952	2	95	190	4	113.4
1953	3	122	366	9	114.1
1954	4	118	472	16	114.8
1955	5	125	625	25	115.5
1956	6	134	804	36	116.1
1957	7	127	889	49	116.8
1958	8	119	952	64	117.5
1959	9	121	1089	81	118.1
1960	<u>10</u>	<u>125</u>	<u>1250</u>	<u>100</u>	118.8
	0	2355	513	770	

COMPUTATIONS FOR MILK PRICE TREND AND TESTS OF SIGNIFICANCE.

$$\begin{aligned}\sum X_1 Y &= 26,418 & \sum X_1^2 &= 3,311 & \sum Y^2 &= 268,211 \\ a &= \frac{\sum Y}{N} = \frac{2355}{21} = 112.1 & b &= \frac{\sum XY}{\sum X^2} = \frac{513}{770} = .67 \\ \sum x^2 &= \frac{N \sum X^2 - (\sum X)^2}{N} = \frac{(21)(3,311) - (231)^2}{21} = 770 \\ \sum y^2 &= \frac{N \sum Y^2 - (\sum Y)^2}{N} = \frac{(21)(268,211) - (2355)^2}{21} = 4,114.57 \\ \sum xy &= \frac{N \sum XY - (\sum X)(\sum Y)}{N} = \frac{(21)(26,418) - (231)(2355)}{21} = 513 \\ b &= \frac{\sum xy}{\sum x^2} = \frac{513}{770} = .67 \\ a &= \frac{\sum Y - b \sum X}{N} = \frac{2355 - (.67)(231)}{21} = 104.77\end{aligned}$$

ANOV. TABLE

<u>Source</u>	<u>Sum of Squares</u>	<u>d.f.</u>	<u>Variance</u>
Total $\sum y^2$	4,114.6	20	205.7
Regression $b \sum xy$	343.7	1	343.7
Residual $\sum y^2 - b \sum xy$	3,770.9	19	198.5

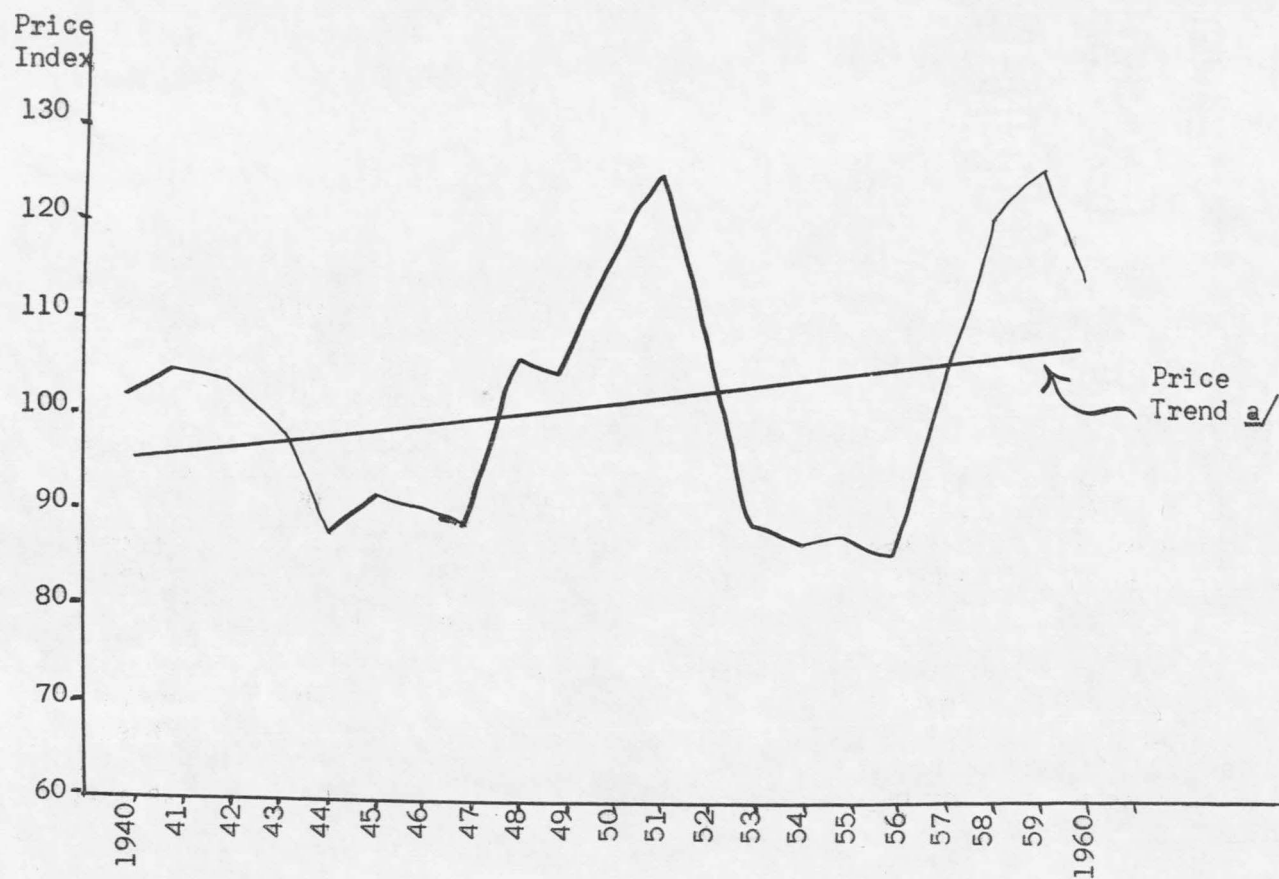
$$F = \frac{343.7}{198.5} = 1.73 \quad n_1 = 1, \quad n_2 = 19, \quad F_{.01} = 8.28 \quad .05 = 4.38$$

$$\sigma_b^2 = \frac{\sigma_v^2}{\sum x^2} = \frac{198.5}{770} = .2577 \quad \sigma_b = \sqrt{.2577} = .551$$

$$H_0 : b = 0 \quad t = \frac{b}{\sigma_b} = \frac{.67}{.551} = 1.22$$

$$t_{19} \quad .10 = 1.73$$

∴ We accept the $H_0 : b = 0$



a/ Price trend was estimated by simple regression equation $Y = a + bX$. In this estimate $a = 95.8$, $b = .54$. b is non-significant from zero at the 10 percent level.

Figure 4. Index of beef prices: Deflated and adjusted to 1947-49 base.

TABLE VII. DEFLATED BEEF CATTLE PRICES USING INDEX OF PRICES RECEIVED BY MONTANA FARMERS AND RANCHERS TO DEFLATE PRICE SERIES.

Year	Average Annual Beef Cattle Price	Index of Prices		Adjusted Prices	Index of Prices Adjusted to 1947-49 Base
		Received	1947-49 Base		
1940	7.16	35		20.46	103
1941	8.54	41		20.83	105
1942	10.52	51		20.63	104
1943	11.92	61		19.54	99
1944	11.04	64		17.25	87
1945	12.40	68		18.24	92
1946	13.89	78		17.81	90
1947	18.22	102		17.86	90
1948	22.16	105		21.10	106
1949	19.13	93		20.57	104
1950	22.76	100		22.76	115
1951	29.42	118		24.93	126
1952	24.89	118		21.09	106
1953	15.78	89		17.73	89
1954	15.33	89		17.22	87
1955	15.20	87		17.47	88
1956	13.76	81		16.99	86
1957	16.44	81		20.30	102
1958	21.65	92		23.53	119
1959	22.62	91		24.86	125
1960	19.63	87		22.56	114

TABLE VIII. BEEF PRICE TREND.

Year	X	Y	XY	X ²	Y
1940	-10	103	-1030	100	96.4
1941	- 9	105	-945	81	96.9
1942	- 8	104	-832	64	97.5
1943	- 7	99	-693	1	98.0
1944	- 6	87	-522	1	98.6
1945	- 5	92	-460	1	99.1
1946	- 4	90	-360	1	99.6
1947	- 3	90	-270	1	100.2
1948	- 2	106	-212	1	100.7
1949	- 1	104	-104	1	101.3
1950	0	115	0	1	101.8
1951	1	126	126	1	102.3
1952	2	106	212	1	102.9
1953	3	89	267	1	103.4
1954	4	87	348	1	104.0
1955	5	88	440	1	104.5
1956	6	86	516	1	105.0
1957	7	102	714	1	105.6
1958	8	119	952	64	106.1
1959	9	125	1125	81	106.7
1960	<u>10</u>	<u>114</u>	<u>1140</u>	<u>100</u>	107.2
	0	2137	412	770	

COMPUTATIONS FOR BEEF TREND AND TESTS OF SIGNIFICANCE.

$$\sum Y^2 = 220,689$$

$$a = \frac{\sum Y}{N} = \frac{2137}{21} = 101.8$$

$$b = \frac{\sum XY}{\sum X^2} = \frac{412}{770} = .54$$

$$\sum x^2 = \frac{N \sum X^2 - (\sum X)^2}{N} = \frac{21 (3311) - (231)^2}{21} = 770$$

$$\sum y^2 = \frac{N \sum Y^2 - (\sum Y)^2}{N} = \frac{(21) (220,689) - (2137)^2}{21} = 3,223.81$$

$$\sum xy = N \sum XY - (\sum X) (\sum Y) = (21) (23,919) - (231) (2137) = 412$$

$$b = \frac{412}{770} = .54$$

$$a = \frac{2137 - (.54) (231)}{21} = 95.8$$

ANOV TABLE

Source	Sum of Squares	d.f.	Variance
Total $\sum y^2$	3,223.8	20	161.2
Regression $b \sum xy$	222.5	1	222.5
Residual $\sum y^2 - b \sum xy$	3,001.3	19	158.0

$$F = \frac{222.5}{158.0} = 1.41$$

$$n_1 = 1 \quad n_2 = 19 \quad f_{.01} = 8.28$$

$$f_{.05} = 4.38$$

$$\sigma_b^2 = \frac{\sigma_v^2}{\sum x^2} = \frac{158}{770}$$

$$\sigma_b = \sqrt{.2051} = 4.53$$

$$H_0 : b = 0$$

$$t = \frac{b}{\sigma_b} = \frac{.54}{.453} = 1.19$$

Accept hyp.

$$b = 0$$

$$t_{19.10} = 1.73$$

TABLE I. ESTIMATED NET-ENERGY VALUES AND FEED EVALUATION FACTORS FOR SELECTED FEEDS.*

	Dry Matter	Digestible Protein	Est. Net Energy Per 100 Lbs.	Feed Evaluation Factors		Net Energy Factor
				Constant For Corn	Constant For Soybean Oil Meal	
	<u>Percent</u>	<u>Percent</u>	<u>Therms</u>			<u>Percent</u>
Dry Roughages:						
Alfalfa Hay, All Analyses	90.5	10.5	41.0	0.285	0.232	51.2
Alfalfa Hay, Leafy	90.5	11.7	42.2	0.265	0.267	52.7
Alfalfa Hay, Fair	90.5	9.7	38.8	0.277	0.212	48.4
Alfalfa Hay, Stemmy	90.5	8.1	34.3	0.260	0.172	42.8
Barley Hay	90.8	4.0	40.5	0.485	0.022	50.6
Barley Straw	90.0	0.7	22.4	0.316	-0.037	28.0
Clover Hay, Sweet	91.8	11.9	41.0	0.241	0.277	51.2
Clover and Mixed Grass Hay, High In Clover	89.7	5.5	41.8	0.456	0.067	52.2
Clover and Timothy Hay	88.1	4.8	41.0	0.467	0.046	51.2
Native Hay, Mt. States Good Quality	90.0	4.9	39.0	0.433	0.055	48.7
Native Hay, Mt. States Matured & Weathered	90.0	1.6	22.0	0.281	-0.007	27.5
Oat Hay	88.1	4.9	38.8	0.430	0.055	48.4
Oat Straw	89.7	0.7	23.3	0.330	-0.040	29.1
Timothy Hay, All Analyses	89.0	2.9	38.6	0.491	-0.009	48.2
Timothy Hay, Early Bloom	89.0	4.1	40.6	0.483	0.024	50.7
Timothy Hay, Full Bloom	89.0	3.3	38.5	0.477	0.004	48.1
Timothy Hay, Late Bloom to Early Seed	89.0	2.6	34.0	0.431	-0.007	42.4
Wheat Hay	90.4	3.3	35.0	0.424	0.013	43.7
Wheat Straw	92.5	0.3	10.0	0.142	-0.017	12.5

TABLE I. (Continued) ESTIMATED NET-ENERGY VALUES AND FEED EVALUATION FACTORS FOR SELECTED FEEDS.*

	Dry Matter	Digestible Protein	Est. Net Energy Per 100 Lbs.	Feed Evaluation Factors		Net Energy Factor
				Constant For Corn	Constant For Soybean Oil Meal	
	<u>Percent</u>	<u>Percent</u>	<u>Therms</u>			<u>Percent</u>
Green Roughages:						
Alfalfa, Green	25.3	3.4	12.8	0.085	0.076	16.0
Beet Tops, Green	17.8	1.7	8.8	0.079	0.032	11.0
Grasses, Mixed, Young	29.7	3.8	17.8	0.148	0.076	22.2
Grasses, Mixed at Haying Stage	30.8	1.9	17.8	0.208	0.014	22.2
Pasture Grasses and Legumes, Mixed From Well-grazed Fertile Pastures, Northern States	22.0	3.7	13.0	0.079	0.086	16.2
Silages:						
Alfalfa, Not Wilted, No Preservative	25.0	2.7	11.6	0.089	0.057	14.5
Alfalfa, Wilted Before Being Ensiled	36.0	4.1	18.1	0.431	0.085	22.6
Corn, Dent, Well- Matured, All Analyses	27.4	1.2	18.1	0.235	-0.010	22.6
Corn, Dent, Well- Matured, Well Cared for Dairy Cows	28.4	1.3	15.2	0.188	0.002	19.0
Corn, Dent, Stover Silage	23.0	0.6	9.1	0.188	-0.005	11.4

TABLE I. (Continued) ESTIMATED NET-ENERGY VALUES AND FEED EVALUATION FACTORS FOR SELECTED FEEDS.*

	Dry Matter	Digestible Protein	Est. Net Energy Per 100 Lbs.	Feed Evaluation Factors		Net Energy Factor
	Percent	Percent	Therms	Constant For Corn	Constant For Soybean Oil Meal	Percent
Concentrates:						
Barley, Common	89.4	10.0	80.1	0.892	0.110	100.0
Barley, Lightweight	89.1	9.2	60.0	0.614	0.138	74.9
Beet Pulp, Dried	90.1	4.3	76.1	1.013	-0.064	95.0
Corn, Dent Grade No. 2	85.0	6.6	80.1	1.000	0	100.0
Corn Dent Grade No. 3	83.5	6.5	78.6	0.981	0	98.1
Cottonseed Meal 43% Protein	92.1	32.4	69.1	0.012	0.869	86.3
Cottonseed Meal Below 41% Protein	92.4	30.2	67.5	0.058	0.801	84.3
Meat and Bone Scraps, 50% Protein	93.9	41.8	64.6	-0.355	1.187	80.6
Milo Grain	89.4	8.8	77.9	0.897	0.077	97.3
Molasses, Beet	80.5	4.4	71.3	1.077	-0.191	89.0
Oats, When Not Fed Over 25% of Concentrate Ration	90.2	9.4	80.1	0.911	0.091	100.0
Oats, Fed As Chief Grain	90.2	9.4	72.1	0.790	0.112	90.0
Oats, Lightweight	91.3	8.5	54.0	0.545	0.132	67.4
Soybean Oil Meal, Expeller or Hydraulic Process	90.9	37.2	78.4	0	1.000	97.9
Soybean Oil Meal, Solvent Process	90.6	42.4	78.4	-0.166	1.169	97.9
Tankage, Digester Process, 55% Protein Grade	94.1	47.6	67.9	-0.490	1.366	84.8

TABLE I. (Continued) ESTIMATED NET-ENERGY VALUES AND FEED EVALUATION FACTORS FOR SELECTED FEEDS.*

	Matter	Digestible Protein	Est. Net Energy Per 100 Lbs.	Feed Evaluation Factors		Net Energy Factor
				Constant For Corn	Constant For Soybean Oil Meal	
	<u>Percent</u>	<u>Percent</u>	<u>Therms</u>			<u>Percent</u>
Wheat, All Analyses	89.5	11.1	80.0	0.855	0.147	99.9
Wheat Bran, All Analyses	90.1	13.7	57.1	0.426	0.293	71.3
Wheat Bran & Screenings	90.0	13.6	67.0	0.576	0.263	83.6
Wheat Middlings	89.6	15.0	77.2	0.689	0.281	96.4

* Source: Frank B. Morrison, Feeds and Feeding Abridged, (8th Edition, Ithaca, New York: The Morrison Publishing Company), Appendix, Table II page 565.

APPENDIX E

Cost of Producing Dehydrated Alfalfa

A decision was made in this study not to dwell into an intensive analysis of production costs arising from different plant layouts and organization. It was felt that environmental or extraneous factors, which a plant has little control over, was more important in influencing costs of production than was the actual plant layout or operation (in an engineering sense) of it. Realizing that these costs, nevertheless, may be of interest, a summary of some of the recent studies are presented in this appendix.

In a study of eight cooperative dehydration plants during 1953 and 1954, Rickey found costs of production ranged from a low of \$17.09 per ton to a high of \$35.41 per ton.____/ The average was \$27.24 per ton. The cost figures included operating costs from the cutting of the alfalfa to sale of the product, ordinary warehouse charges and brokerage or other selling costs. They did not include the cost of the standing alfalfa, bags, oils, or antioxidants. A detailed summary of these costs are presented in Table I.

Annual volume, which is affected by length of season, size of plant and steadiness of operation, had a large effect on operating costs. Rickey divided the 16 plant-years, for which data is shown, into years

____/ Lacey F. Rickey, op. cit., p. 25.

TABLE I. OPERATING COSTS PER TON OF MEAL AND PERCENTAGE OF TOTAL PROCESSING COSTS FOR EIGHT COOPERATIVE ALFALFA DEHYDRATING PLANTS, 1953 AND 1954.

Plant Number	Year	Pro- duc- tion, tons	DIRECT LABOR								MAINTENANCE AND REPAIR								FUEL								Ad- min- is- tra- tive per ton	To- tal per ton
			Deprecia- tion		Field		Plant		Total		Field		Plant		Total		Power		Oil		Gas		Total a/ Processing Per Per- ton cent					
			Per ton	Per- cent	Per ton	Per- cent	Per ton	Per- cent	Per ton	Per- cent	Per ton	Per- cent	Per ton	Per- cent	Per ton	Per- cent	Per ton	Per- cent	Per ton	Per- cent	Per ton	Per- cent						
1	1953	1,896	\$6.16	19.2	\$4.51	14.0	\$5.54	17.2	\$10.05	31.2	\$2.98	9.3	\$1.03	3.2	\$4.01	12.5	\$1.06	3.3	-----	-----	\$3.30	10.3	\$32.13	100	\$2.15	\$34.28		
	1954	1,495	5.57	15.8	4.81	13.6	5.53	15.7	10.34	29.3	3.94	11.1	1.59	4.5	5.53	15.6	1.24	3.5	-----	-----	5.09	14.4	35.25	100	2.77	38.02		
2	1953	3,983	1.18	5.6	3.53	16.6	5.83	27.4	9.36	44.0	.63	3.0	1.47	6.9	2.10	9.9	1.85	8.7	\$5.17	24.3	-----	-----	21.25	100	-----	-----		
	1954	3,949	1.31	5.8	3.47	15.4	5.59	24.7	9.06	40.1	.70	3.1	1.81	8.0	2.51	11.1	1.99	8.8	5.49	24.3	-----	-----	22.60	100	-----	-----		
3	1953	2,218	4.17	12.1	3.67	10.7	6.62	19.2	10.29	29.9	1.47	4.3	4.36	12.7	5.83	17.0	2.34	6.8	-----	-----	4.76	13.9	34.36	100	6.36	40.72		
	1954	3,676	3.40	12.9	2.45	9.3	5.38	20.5	7.83	29.8	.73	2.8	2.22	8.4	2.95	11.2	2.77	10.5	-----	-----	4.12	15.7	26.28	100	4.39	30.67		
4	1953	11,381	1.50	8.8	4.24	24.8	3.54	20.7	7.78	45.5	.78	4.6	.81	4.7	1.59	9.3	.98	5.7	-----	-----	3.66	21.4	17.09	100	2.07	19.16		
	1954	5,879	2.50	11.2	4.89	21.9	5.23	23.4	10.12	45.3	.98	4.4	.94	4.2	1.92	8.6	1.88	8.4	-----	-----	4.01	17.9	22.34	100	2.09	24.43		
5	1953	872	5.17	14.6	5.49	15.5	8.09	22.8	13.58	38.3	1.11	3.1	.52	1.5	1.63	4.6	2.87	8.1	9.22	26.0	-----	-----	35.41	100	-----	-----		
	1954	1,021	4.56	14.1	4.73	14.6	7.25	22.5	11.98	37.1	1.65	5.1	.67	2.1	2.32	7.2	2.69	8.3	8.76	27.2	-----	-----	32.26	100	-----	-----		
6	1953	1,619	4.33	14.3	3.07	10.1	3.22	10.6	6.29	20.7	2.53	8.3	2.47	8.2	5.00	16.5	2.68	8.9	5.48	18.1	-----	-----	30.26	100	.40	30.66		
	1954	3,184	2.12	8.9	3.30	13.9	3.07	12.9	6.37	26.8	2.20	9.3	1.13	4.7	3.33	14.0	1.85	7.8	5.42	22.8	-----	-----	23.73	100	.82	24.55		
7	1953	7,090	.71	4.0	2.79	15.8	4.46	25.2	7.25	41.0	.62	3.5	.69	3.9	1.31	7.4	1.52	8.6	5.23	29.6	-----	-----	17.68	100	-----	-----		
	1954	6,984	.76	3.9	3.13	16.2	5.32	27.5	8.45	43.7	.91	4.7	.48	2.5	1.39	7.2	1.47	7.6	5.18	26.8	-----	-----	19.34	100	-----	-----		
8	1953	2,363	1.04	3.1	6.16	18.3	4.99	14.8	11.15	33.1	.86	2.5	2.32	6.9	3.18	9.4	1.50	4.5	6.34	18.8	-----	-----	33.67	100	4.20	37.87		
	1954	3,245	1.33	4.1	4.23	13.1	5.91	18.4	10.14	31.5	.53	1.7	2.36	7.3	2.89	9.0	1.60	5.0	6.73	20.9	-----	-----	32.19	100	3.80	35.99		
Average	----	3,804	2.86	----	4.03	----	5.35	----	9.38	----	1.41	----	1.56	----	2.97	----	1.89	----	6.30	----	4.16	----	27.24					
																			Omitting plants 2, 5, and 7.....					2.91	31.64			
																			Omitting plants 2, 5, 6, and 7.....					3.48	32.64			
Average of 7 plant-years under 3,000 tons.....			1,640	4.43		4.63		5.89		10.53		2.08		1.85		3.93		2.05		7.45		4.38		33.33				
Average of 9 plant-years over 3,000 tons.....			5,486	1.65		3.56		4.93		8.48		.90		1.32		2.22		1.77		5.54		3.93		22.50				

* Source: Lacey F. Rickey, Cooperative Alfalfa Dehydrators: Costs and Operations, FCS, USDA, FCS Circular No. 12, June 1956.

a/ Lines do not add to "total processing costs" as many items of general expense are not included under the headings used.

TABLE II. AVERAGE COST TO PRODUCE A TON OF DEHYDRATED ALFALFA. *

Item	Small Plants	Medium Sized Plants	Large Plants
Average Annual Tonnage	2,010	4,635	10,191
Fixed Costs			
Salaries	2.78	1.54	1.65
Rent and Depreciation	3.16	2.42	2.07
Insurance	.62	.72	.30
Taxes	.41	.58	.34
Interest & Other			
Fixed Costs	.66	.58	1.12
Total Fixed Costs	7.63	5.84	5.48
Variable Costs			
Material	8.87	9.74	9.19
Labor	6.67	6.48	4.26
Maintenance &			
Repairs	3.58	1.90	1.78
Gas	2.60	3.12	3.19
Electricity	1.97	1.78	1.56
Gas and Oil	1.27	1.85	.95
Labor, Taxes & Other			
Variable Costs	2.82	1.67	.83
Total Variable Costs	27.78	26.54	21.76
Total Costs	35.41	32.58	27.24

* Source: Charles E. Reed, "Low Cost, Full Production, Full Returns", Talk Delivered Before the Kansas Dehydrators Association's Annual Meeting, Manhattan, Kansas, May 3, 1960.

when production was over or under 3,000 tons and found that processing costs differed almost \$11 per ton.

If an allowance of \$9.00 per ton is made for cost of the raw material, the average cost of production for these mills will be \$36.24 per ton.

Reed made a study of the financial records of operating units in Kansas and surrounding states and ascertained the cost figures presented in Table II.

It is interesting to note that the difference in fixed costs is small between the medium and large sized firm while a difference of approximately \$2.00 exists between these and the smaller sized plants. In the variable cost category, there is little difference between the small and medium sized firms while the larger firms enjoy a cost advantage of almost \$5.00 per ton. The larger firms are apparently making much better use of their labor as their labor costs are more than \$2.00 per ton lower than the other two sizes. The larger firms also find savings in the use of gas and oil and in the labor taxes and other variable costs category.

In the fixed cost category, the smaller firms are experiencing higher unit costs in salaries and in rent and depreciation. Part of this may be explained in lower volumes, but Reed found evidence that management in the smaller firms was not as efficient as in the other two sizes. This is found in the percentage of time plant personnel were idle, Table III.

TABLE III. PERCENT OF TIME PLANT PERSONNEL WERE WORKING AND IDLE. *

Type of Plant	Work	Idle
One Drum	78	22
Two Drum	81	19
Three Drum	85	15

Results from a second series of visits were:

One Drum	64	36
Two Drum	88	12
Three Drum	80	20

* Source: Charles E. Reed, "Low Cost, Full Production, Full Returns",
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