ECONOMICS OF MECHANIZATION

IN FEEDING BEEF CATTLE

By

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TABLE OF CONTENTS

Chapter Pa

I. INTRODUCTION . . . .

The Problem . . . .
Importance of the Problem . . . .
Objectives of Study . . . .
Procedure for Analyzing the Problem . . . .

II. ANALYTICAL PROCEDURES. . . . .

Equipment Alternatives. . . . .

Grain Processing . . . .
Silage Removal . . . .
Feed Distribution. . . . .

The Feeding System. . . . .
Planning Horizons and Interest Rates. . . . .
Equipment Costs . . . .

Fixed Costs. . . . .
Variable Costs . . . .

Sources of Data . . . .

III. GRAIN PROCESSING ALTERNATIVES. . . . .

Roller Mill and Mixer . . . .
Grinder-Blender . . . .
Custom Processing . . . .
Comparison of Grain Processing Methods. . . . .

IV. SILAGE REMOVAL ALTERNATIVES. . . . .

Horizontal Silo . . . .

Front-End Tractor Loader . . . .
Horizontal Silo Unloader . . . .

Comparison of Removal Methods for Horizontal Silos. . . .
Upright Silo. . . . .

Hand Unloading . . . .
Surface Silo Unloader. . . . .

Comparison of Removal Methods for Upright Silos . . . .
Break-Even Price of Labor . . . .
Comparison of Horizontal and Upright Silo Costs . . . .

TABLE OF CONTENTS (continued)

Pa

Chapter

V. FEED DISTRIBUTION ALTERNATIVES 4

Wagon with Hand Unloading 4
Self-Unloading Wagon. 4
Mechanical Feeder 5
Comparison of Feed Distribution Methods 5

VI. SUMMARY AND CONCLUSIONS. 5

Summary 5
Conclusions 5

SELECTED BIBLIOGRAPHY. 6

APPENDIX 6

LIST OF TABLES

Table		Page
I.	Cost of Alternative Grain Processing Methods.	13
II.	Cost of Alternative Silage Removal Methods.	28
III.	Annual Cost Per Ton of Storing Silage	39
IV.	Cost of Alternative Feed Distribution Methods	43
V.	Cost Per Head for Feed Processing, Storage, and Handling Operations.	5

LIST OF FIGURES

Figure		Page
1.	Theoretical Average Cost Curves	5
2.	Cost of Processing Grain By Three Alternative Methods Assuming as Infinite Planning Horizon with Labor at $1.00 Per Hour	15
3.	Cost of Processing Grain by Three Alternative Methods Assuming An Infinite Planning Horizon With Labor at $2.00 Per Hour	16
4.	Cost of Processing Grain by Three Alternative Methods Assuming a Short Planning Horizon with Labor at $1.00 Per Hour	17
5.	Cost of Processing Grain by Three Alternative Methods Assuming a Short Planning Horizon With Labor at $2.00 Per Hour	18
6.	Cost of Removing Silage from Horizontal Silo by Two Alternative Methods Assuming an Infinite Planning Horizon.	29
7.	Cost of Removing Silage from Horizontal Silo by Two Alternative Methods Assuming a Short Planning Horizon.	30
8.	Cost of Removing Silage from Upright Silo by Two Alternative Methods Assuming an Infinite Planning Horizon.	33
9.	Cost of Removing Silage from Upright Silo by Two Alternative Methods Assuming a Short Planning Horizon.	34
10.	Cost of Distributing Feed by Three Alternative Methods Assuming an Infinite Planning Horizon with Labor at $1.00 Per Hour	46
11.	Cost of Distributing Feed by Three Alternative Methods Assuming an Infinite Planning Horizon with Labor at $2.00 Per Hour	47
12.	Cost of Distributing Feed by Three Alternative Methods Assuming a Short Planning Horizon with Labor at $1.00 Per Hour	48

LIST OF FIGURES (continued)

Figure Pag

13. Cost of Distributing Feed by Three Alternative Methods Assuming a Short Planning Horizon with Labor at $2.00 Per Hour 49

14. Combined Costs of Grain Processing, Processed Feed Storage, Silage Removal, and Feed Distribution (Infinite Planning Horizon with Labor at $1.00 Per Hour). 59

15. Combined Costs of Grain Processing, Processed Feed Storage, Silage Storage, Silage Removal, and Feed Distribution (Short Planning Horizon with Labor at $1.00 Per Hour). 60

CHAPTER I

INTRODUCTION

The Problem

Equipment for feed processing and handling is available in many typ and sizes. This variety of equipment allows farmers to choose mechanization levels suited to their labor-capital situation, size of business, planning horizon, and individual preferences. However, most farmers do not have the information needed to analyze their equipment needs and alternatives. Performance rates, capacities, and ownership and operatin costs are needed for each component of cattle feeding equipment. This information would provide a basis for determining least-cost methods of feed processing and handling for different sizes of cattle feeding operations.

Importance of the Problem

The productivity of labor used in agriculture has increased at a rapid rate during the past few years. However, crop production per man-hour has increased at a much faster rate than meat animal production per man-hour. During the 30 year period, 1927-57, production per man-hour of crops increased 202% while meat animal production per man-hour increased only 15%.[1] One reason for this slower increase is that the

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[1]U.S. Agricultural Research Service, <u>Changes in Farm Production and Efficiency</u>, Statistical Bulletin 233, Washington D.C., August 1958, pp.

feeding of meat animals has not been mechanized to the same extent as t:
production of crops. With recent advances in technology, it is now
possible to almost completely mechanize the feeding of livestock.

Labor is an important item of expense in beef cattle feeding, espe
ally in operations where silage is fed. During the past 20 years, pric
of farm equipment have doubled, but farm wage rates have increased 400%
With this increasing cost of labor and the decreasing availability of
farm labor, many feed lot operators are using mechanical feed handling
equipment to replace labor. In other instances, mechanical equipment i
used to increase the volume of output. Sometimes farmers justify mecha
cal equipment on the grounds of relieving human drudgery and eliminatin
disagreeable jobs such as unloading silage by hand. In this case, the
farmer will have a high reservation price for his labor.

Objectives of Study

The general purpose of this study is to obtain information on the
cost of alternative methods of processing and handling feed and to det
mine the least-cost method for different sizes of feeding operations.
The study is specifically designed to: (1) specify the equipment alter
tives which can be used in feeding beef cattle, (2) compile informatio
on equipment and labor cost needed to determine the least-cost methods

[2] Roy N. Van Arsdall, Economic Aspects of Mechanization of Feeding
Dairy Farms, paper presented at the annual meeting of the American Da
Science Association, June, 1959.

of feed processing and handling, and (3) determine break-even[3] points between alternative methods for two different labor prices and two planning horizons.

In order to analyze alternative methods of processing and handlin feed, some assumption must be made concerning the feeding system and ration. A number of feeding systems are used in Oklahoma, however, th analysis is limited to a silage system. The ration assumed in this sy is in the range of the typical high silage rations used in Oklahoma.

Procedure For Analyzing The Problem

For this study, cattle feeding is divided into three operations: (1) grain processing, (2) silage removal, and (3) feed distribution. separate chapter is devoted to each operation. Grain processing is analyzed in Chapter III, silage removal in Chapter IV, and feed distri tion in Chapter V.

Alternative methods for performing each of the three operations a specified. Average cost curves for each alternative method are then determined. As a final step in analyzing each operation, break-even points between methods for different labor prices and planning horizo are specified. In the final chapter, the costs of the three operatio are combined to get an estimate of the total annual cost involved in processing and handling.

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[3]Break-even point refers to the point where the cost of one meth equals the cost of another method.

CHAPTER II

ANALYTICAL PROCEDURES

Each alternative feed handling and processing method represents a different level of mechanization. Generally the level of mechanizatio is increased by substituting capital for labor. Thus, determining the least-cost method for a given size of operation is a problem of select the optimum combination of labor and capital.

Average total cost curves are used to determine the least-cost combination of labor and capital, i.e., method of production. For a given size operation, the method with the lowest average total cost is the least-cost method. The short run average cost curves are computed estimating the cost functions from algebraic equations such as equatic (2) below.[1]

$$TC = K + VQ + LQ \qquad (1)$$

$$AC = \frac{K}{Q} + V + L \qquad (2)$$

In the above equations TC refers to total cost; AC refers to average K represents annual fixed cost; V represents the variable non labor c per ton; L represents the labor cost per ton; and Q refers to the ton feed per year. The domain of Q is determined by the capacity of the ment having a fixed cost of K. A number of discrete points on the av

[1]Earl O. Heady, Glenn L. Johnson, and Lowell S. Hardin, Resource ductivity, Returns to Scale, and Farm Size, Iowa State College Press, Iowa, 1956, pp. 77-79.

cost curves are estimated by using different values of Q in the avera
cost equation.

For some components of equipment, only one size or scale of plan used for the entire range of operations. In these cases the short ru average cost curve is plotted over the entire range of sizes consider For several components of equipment, more than one scale of plant is In these cases, a short-run average cost curve is plotted for each sc of plant as shown in Figure 1. The portions of these short run avera cost curves representing least-cost for given levels of output form t long run average cost curve or planning curve.

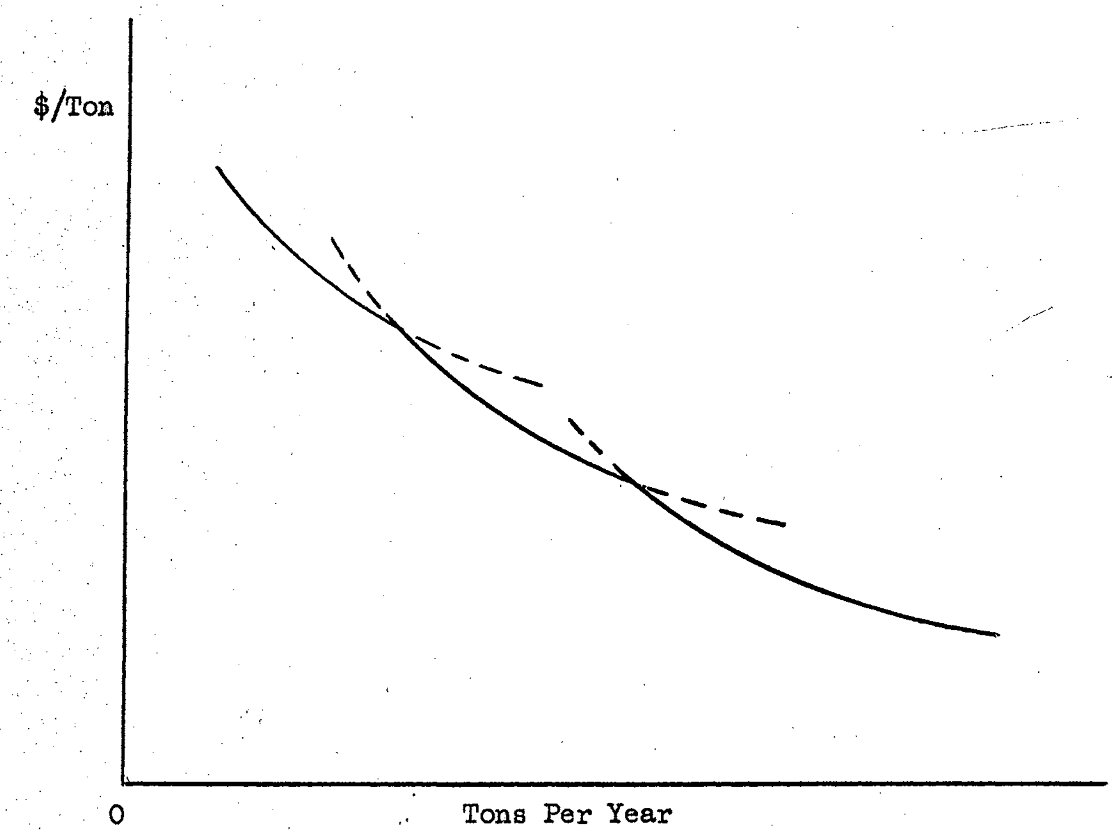

Figure 1. Theoretical Average Cost Curves

Equipment Alternatives

There are a number of alternative methods for processing grain, removing silage, and distributing feed to beef cattle. It would be impossible to study all possible methods. The purpose of this study i to compare some of the common methods used by Oklahoma cattle feeders, as well as some of the newer methods using highly mechanized equipment For each of the three operations, the alternative methods represent different levels of mechanization, (i.e., different combinations of labor and capital).

Grain Processing

Three grain processing alternatives are considered. The first method is custom processing. The second method uses a combination of equipment including a roller mill, vertical mixer and augers. The th method represents a higher level of mechanization and includes a grin blender, elevator leg, overhead bins, and auger.

Silage Removal

Four silage removal alternatives are considered, two for horizor silos and two for upright silos. The methods for removing silage frc horizontal silos are: (1) front-end tractor loader, and (2) horizont silo unloader. The two methods for removing silage from upright silc are: (1) hand unloading, and (2) surface silo unloader.

Feed Distribution

Feed distribution involves moving silage and concentrates from area of storage to the feeding area and distributing the feed into tl bunks. The three methods of feed distribution are: (1) tractor dra wagon with hand unloading, (2) tractor drawn self-unloading wagon, an

(3) mechanical auger tube feeder.

The Feeding System

Before analyzing the feed handling alternatives, some assumption must be made concerning the daily silage and grain requirements per h This will in turn give the total amount of silage and grain to be handled each day for any given size feed lot. It will then be possib to determine the size of equipment needed and the length of time each component of equipment is used each day.

Many different cattle feeding systems are used in Oklahoma. In study special emphasis is placed on silage equipment. Thus, a high s ration is used for the analysis. The ration contains 40 pounds of si per head per day and 10 pounds of concentrates per head per day. Hay might also be used in the ration, however the feeding of hay is not c sidered in this analysis. The feeding period is 140 days, and it is assumed that two lots of cattle are fed each year.

This ration is representative of typical high silage rations use Oklahoma for the first 100 to 150 days of the feeding period. The ra is not designed to fatten out cattle to the high good or choice grade

Feed lots ranging in size from 50 to 1000 head capacity are cons Since two lots are fed each year, the results of this study are appro for feed lots following essentially the system outlined and feeding 1 to 2000 head per year.

Planning Horizons and Interest Rates

Two planning horizons and two interest rates are used. The firs a long term or infinite planning horizon, and the second is a seven ; planning horizon. For the infinite planning horizon, depreciation i calculated by using the useful life of the machine and a salvage val of 5% of new cost. An interest rate of 8% is used.

Because of constantly changing economic conditions and technolo in agriculture, the organization of some cattle feeding operations a not optimum for the entire life of the equipment. A seven year plan horizon is used to demonstrate the effects on costs of withdrawing f the cattle business or changing the organization after a shorter per of time. The short planning horizon will spread fixed investment ov a shorter period of time and increase annual fixed cost. Because of faster rate of recovering fixed investment, less risk is involved wi the short planning horizon. Thus, a lower interest rate of 6% is us The machines will not wear out completely during this seven year per therefore higher salvage values are used. The salvage values for ea component are listed in Appendix Table IV.

Equipment Costs

Average cost curve analysis is used to determine the least-cost methods and break-even points. In order to plot the cost curve, it necessary to first estimate the components that make up fixed and va cost. Fixed cost is constant for a given machine and must be paid regardless of the level of use. The items making up fixed cost incl depreciation, interest, taxes, and insurance. Variable cost include items of cost that vary with level of use. In this study, repairs, and labor make up variable cost.

Fixed Costs

Depreciation--Annual depreciation is the loss in value resulting from the wearing out or obsolescence of the machine. It is the diffe between new cost and salvage value divided by the number of years the machine is used.

Interest--Annual interest is charged as a percentage of average investment. The average investment is computed by adding new cost an salvage value and dividing by two. The annual interest is then obtai by multiplying the average investment by the interest rate.

Taxes--Taxes are charged at $50.00 per $1,000 of assessed value. The assessed value is estimated to be 20% of new cost.

Insurance--Most farmers do not carry insurance on this type of equipment. However the cost of the risk involved in ownership must t carried by the farmer even though he does not have insurance. For tl reason, insurance cost is included in this study. An insurance rate $5.00 per $1,000 of new cost is used.

Variable Costs

Repair Cost--Many factors affect the repair cost of equipment, the level of use is probably the most important factor. Repair cost hour is charged as a percentage of new cost.[2]

Power Cost--Two types of power cost are used: (1) tractor opera cost, and (2) electricity. For components of equipment mounted on c pulled by a tractor, the power cost includes the total operating cos a three plow-tractor. This total operating cost is $1.90 per hour.[3]

[2]See Appendix Tables I, II, and III for the percentages corres to each component.

[3]Unpublished data, Panhandle Farm Machinery Study, Agricultura Economics Department, Oklahoma State University.

For components of equipment using electric motors, a charge of 3 cents per kilowatt hour is used. It is assumed that a one horsepower motor operating for one hour will use one kilowatt hour of electricity.

Labor Cost--Two wage rates are used in this study. A $1.00 per h wage rate is used to represent the normal farm wage rate. A second wa rate of $2.00 per hour is used to represent a higher reservation price for labor. The reservation price is the price the farmer is willing t pay to get a certain job done rather than use his own labor. The $2.0 rate is also used to show the effect of an increase in labor cost on break-even points between different levels of mechanization.

Sources of Data

Visits were made to a number of feed lots representing different levels of mechanization. Information was obtained from these operato on performance rates and labor requirements. Also data on performanc rates, labor requirements, and expected life of equipment were compil from several publications on feed handling mechanization research. Oklahoma State University Agricultural Engineers supplied some of the data and technical information used in the study. The prices used in analysis are 1961 retail prices and came from a number of equipment manufacturers and dealers.

CHAPTER III

GRAIN PROCESSING ALTERNATIVES

Three alternative methods of processing grain are considered: (1 roller mill and vertical mixer, (2) grinder-blender, and (3) custom processing. Each method represents a different level of mechanizatic Custom processing involves only a variable cost and, depending on the arrangement, a variable amount of the farmer's labor. The roller mil vertical mixer requires more capital than custom processing and in sc cases more labor. Finally, the grinder-blender requires the greatest amount of capital and much less labor than the other two alternative These three alternatives provide farmers with a wide choice of capit labor combinations.

Roller Mill and Mixer

Both roller mills and hammer mills are used by Oklahoma cattle feeders. Interviews with a number of feeders indicate there is a tr toward roller mills. It was found that most of the newer mills used process cattle feed are the roller type. Roller mills are operated either tractor power or electricity. In this study the electric pow roller mill is used. In order to mix the grain and supplement, an e trically powered vertical mixer is used in combination with the roll mill. Augers are included for conveying grain and supplement to the mill and for conveying processed feed from the mixer to the storage

The same type and size of storage bins are required for each processi method; therefore the cost of storage bins is not included.

Two sizes of mills and mixers are used. The first combination includes a 10" x 10" roller mill, a one ton vertical mixer, and two a This combination is used for the range of feed lot sizes from 50 to 6 head. The second combination includes a 10" x 18" roller mill, a $1\frac{1}{2}$ vertical mixer and two augers. This combination is used for the rang of feed lot sizes from 600 to 1000 head.

For the infinite planning horizon, a useful life of 12 years and salvage value of 5% is assumed for the mill, mixer, and augers. For seven year planning horizon, a 30% salvage value is used.

The fixed and variable costs for the roller mill and mixer are] in Table I. The coefficients used in computing these items of cost ε listed in Appendix Table I. The letters K, D, V, and L in Table I aı used to represent various components of cost. Annual fixed cost is represented by K_1 for the infinite planning horizon and by K_2 for the short planning horizon. In some cases part of the depreciation is cc puted on a per ton basis. When this is done, depreciation per ton iε resented by D_1 for the infinite planning horizon and by D_2 for the sł planning horizon. The letter V represents variable cost per ton (exc labor cost). Labor cost is represented by L when labor is $1.00 per and by L' when labor is $2.00 per hour.

Points on the average cost curves are determined by using the vε of K, D, V, and L from Table I in the equation $AC = \frac{K}{Q} + V + L$. The average cost curve for the mill and mixer assuming an infinite plann: horizon with labor at $1.00 per hour is represented by line B in Figı Line B in Figure 3 represents the average cost curve with labor at $‍:

TABLE I

COST OF ALTERNATIVE GRAIN PROCESSING METHODS

Method	Range Of Use	Initial Invest-ment	Annual Fixed Cost: Infinite Planning Horizon K_1	Annual Fixed Cost: Short Planning Horizon K_2	Depreciation Per Ton: Infinite Planning Horizon D_1	Depreciation Per Ton: Short Planning Horizon D_2	Vari-able Cost Per Ton V	Labor Cost Per Ton: \$1.00 Labor L	Labor Cost Per Ton: \$2.00 Labor L'
	(Tons/Year)				- Dollars -				
Roller Mill (10" X 10"), Vertical Mixer (1 ton)	70-840	1,862[1]	249.24	282.11	--	--	.194	.576	1.152
Roller Mill (10" X 18"), Vertical Mixer (1 1/2 ton)	840-1400	2,727[2]	365.07	413.16	--	--	.212	.417	.834
Grinder-Blender, Elevator and Storage Bins	70-312	2,794[3]	373.45	--	--	--	.228	.150	.300
	312-1400		309.57	--	.204[4]	--	.228	.150	.300
	70-536		--	452.12	--	--	.228	.150	.300
	536-1400		--	342.60	--	D_2[5]	.228	.150	.300

[1]Includes roller mill (10" X 10") costing \$715, vertical mixer (1 ton) costing \$825, and augers (6" X 12' and 6" X 21') costing \$322.

[2]Includes roller mill (10" X 18") costing \$1,282, vertical mixer (1 1/2 ton) costing \$1,071, and augers (6" X 12' and 6" X 27') costing \$374.

[3]Includes grinder-blender costing \$807, four storage bins (5 ton) costing \$1,212, and elevator (50') costing \$775.

TABLE I (Footnotes - Continued)

[4]With the infinite planning horizon, the grinder-blender will wear out before it becomes obsolete if the tons processed per year exceeds 312. For the range of use from 312 to 1400 tons per year the grinder-blender must be replaced before the end of 12 years, and depreciation is on a per ton basis (.204 per ton). All other items of fixed cost including interest, taxes, and insurance for all components and depreciation for the elevator and storage bins are included in annual fixed cost.

[5]With the short planning horizon, the grinder-blender will wear out before the end of the seven year planning period if the tons processed per year exceeds 536. For the range of use from 536 to 1400 tons per year, depreciation (D) is computed for different levels of use by using the following formula.

$$D = \frac{\left[\frac{NH}{L}\right]\frac{Ac-Sv_1}{L} + \frac{Ac-Sv_{\left[\frac{NH}{L} - \left(\frac{NH}{L}\right) \cdot L\right]}}{L}}{\frac{NH}{L}}$$

where: N = number of years in planning horizon

H = hours used per year

L = hours of useful life

Ac = acquisition cost

Sv_1 = salvage value when used to maximum hours of usefulness

$Sv_{\left[\frac{NH}{L} - \left(\frac{NH}{L}\right) \cdot L\right]}$ = salvage value of the machine which is only partially used

The symbol $\left[\frac{NH}{L}\right]$ denotes the greatest integer that does not exceed $\frac{NH}{L}$

Residual $\left[\frac{NH}{L}\right] = \frac{NH}{L} - \left[\frac{NH}{L}\right]$

For four levels of use the value of D_2 is as follows:

Tons Per Year	D_2
536	.204
824	.225

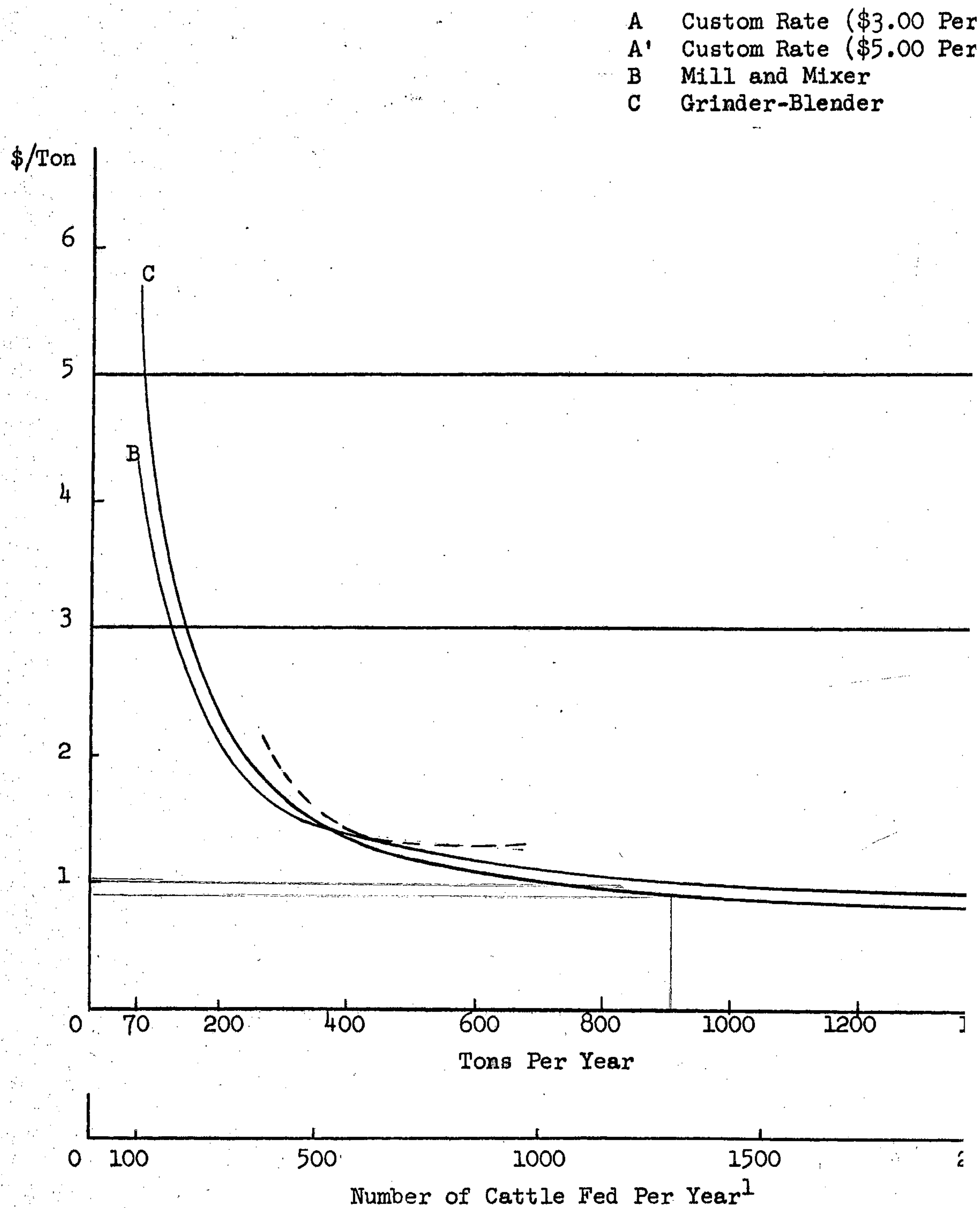

Figure 2. Cost of Processing Grain By Three Alternative Methods Assuming an Infinite Planning Horizon with Labor at $1. Per Hour.

[1]The number of cattle fed per year is equal to two times the lot capacity, because the assumption is made that two lots are fed year.

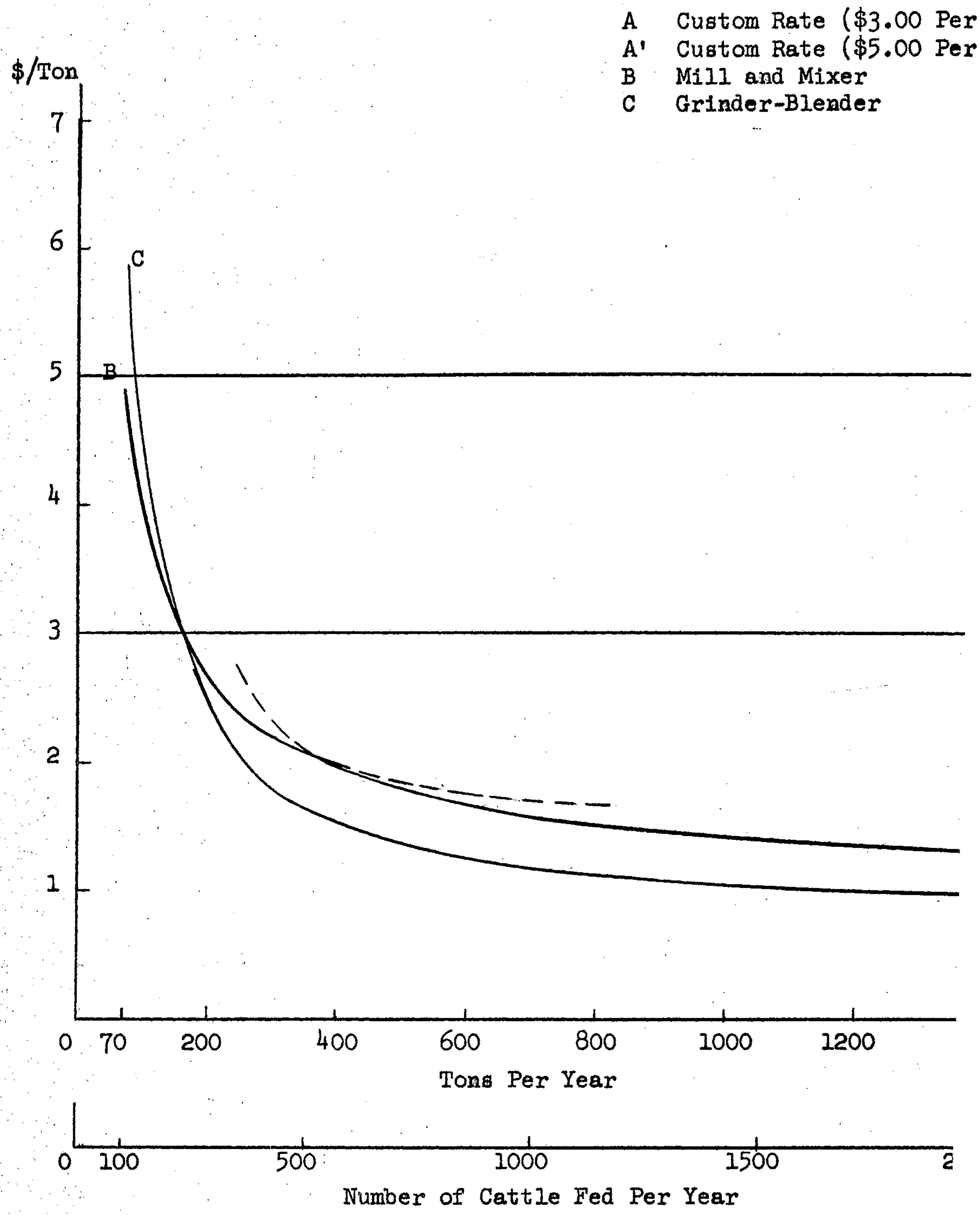

Figure 3. Cost of Processing Grain by Three Alternative Methods Assuming An Infinite Planning Horizon with Labor at $2.00 Per Hour.

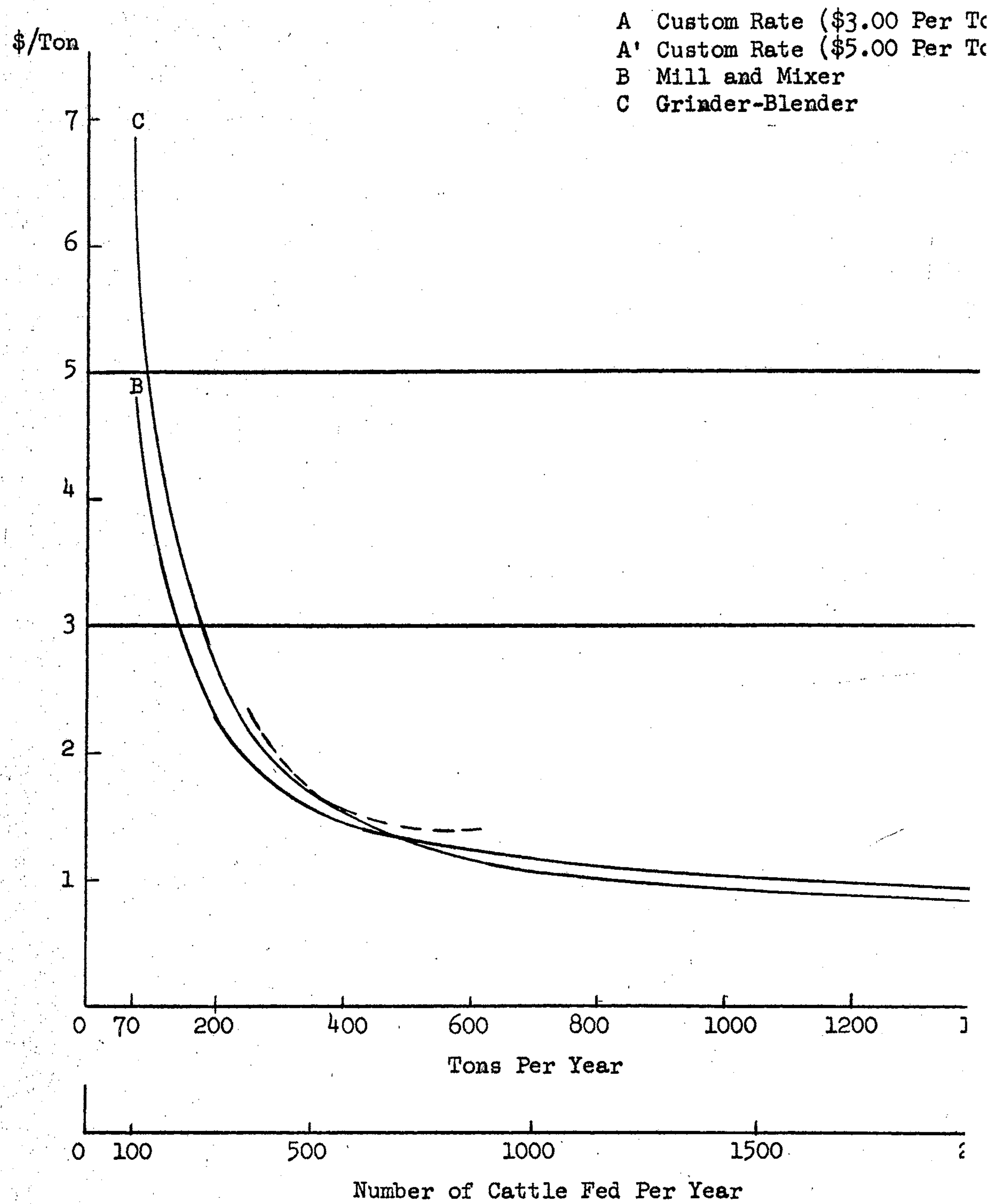

Figure 4. Cost of Processing Grain by Three Alternative Methods Assuming a Short Planning Horizon with Labor at $1.00 Per Hour

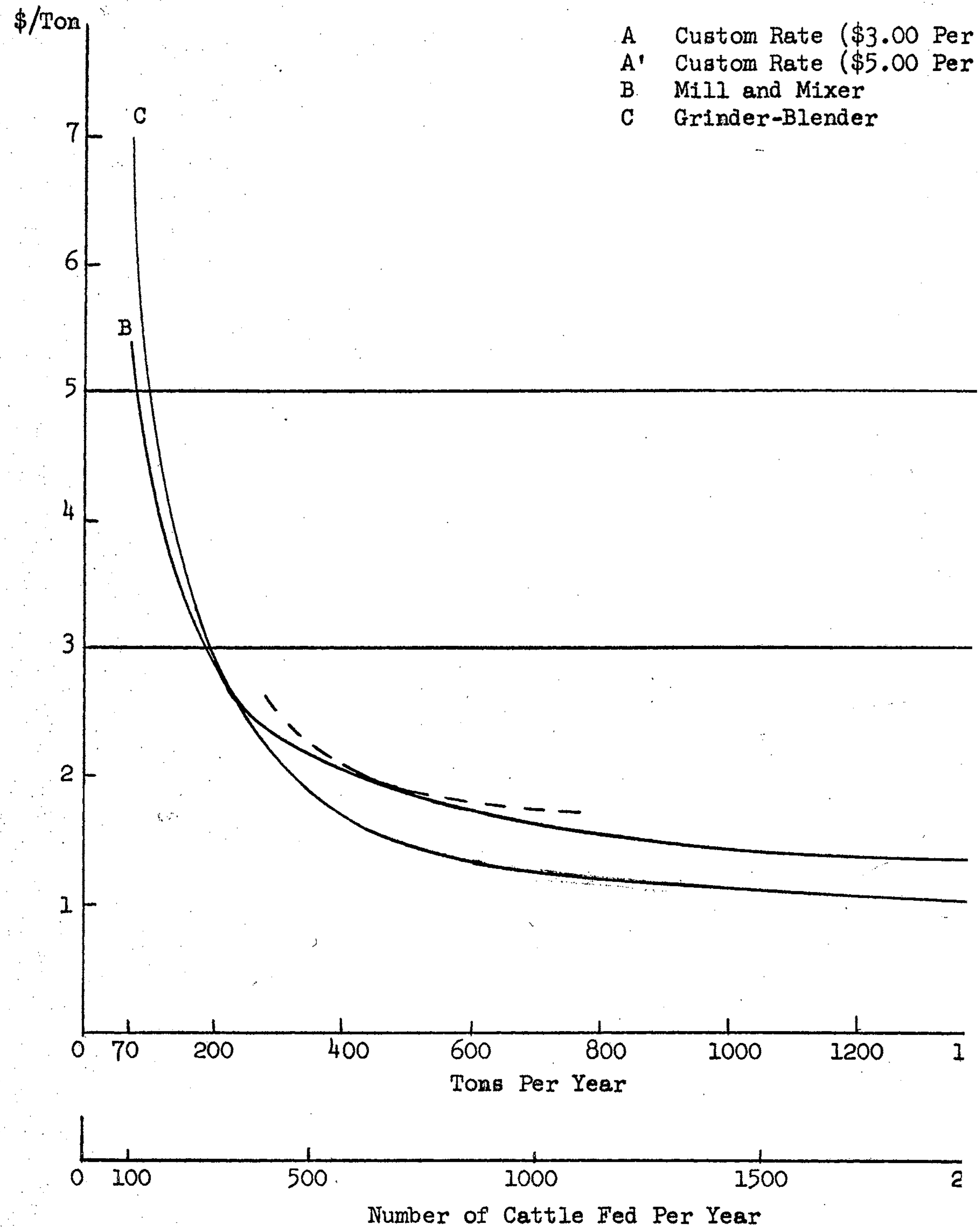

Figure 5. Cost of Processing Grain by Three Alternative Methods Assuming a Short Planning Horizon with Labor at $2.00 Per Hour.

per hour. For the short planning horizon, the average cost curve for mill and mixer is represented by line B in Figure 4 ($1.00 labor) and line B in Figure 5 ($2.00 labor).

Grinder-Blender

The grinder-blender is an automatic feed grinding and mixing uni It measures, mixes, and grinds up to four ingredients simultaneously. The unit runs without the attention of an operator and it can be equi to shut off automatically. Only a small amount of labor is required process feed with this unit. However, extra investment is required f overhead bins and an elevator leg or augers. The overhead bins are u to hold the different ingredients and to supply them by gravity flow the grinder-blender. In addition, storage bins are needed for both g and processed feed. However, since a partial budgeting comparison is made and since the cost of storage bins was not included for the mill mixer, the cost of additional bins is not included for the grinder-bl It is assumed the same type and size of storage bins are used with bo methods.

In this study a two horsepower grinder-blender is used along wit four overhead storage bins and a 30 ft. elevator leg. It would be possible to use augers instead of the elevator leg, however, this wou require more labor to fill the overhead bins. The labor requirement in this study includes time required to keep the bins filled and star check the grinder.

The grinder-blender is assumed to become obsolete after 12 years to wear out after 5000 hours of use, which ever occurs first. For lo levels of use with the infinite planning horizon, depreciation for th grinder-blender is calculated on an annual basis. For levels of use over 312 tons per year the grinder-blender will wear out before the e of the 12 year period. For all levels of use over 312 tons per year, depreciation is computed on a per ton basis. Interest, taxes and insu are computed on an annual basis for all levels of use.

For the short planning horizon, depreciation on the grinder-ble is calculated on an annual basis for all levels of use up to 536 ton year. For all levels of use beyond 536 tons per year the grinder-bl will wear out and must be replaced before the end of the seven year For all levels of use over 536 tons per year, the formula explained footnote 5 of Table I is used to calculate depreciation on a per ton The use of this formula is necessary because the remaining salvage v of the last machine is different for each level of use. In order tc a more accurate estimate, a similar formula could be used to compute interest, taxes, and insurance. In this study, interest, taxes, and insurance are based on average investment and computed on an annual

For all other components of equipment used in this study, the l of use is not great enough to wear out the machine before it become lete. For this reason depreciation for all other components is calc on an annual basis.

The fixed and variable costs for the grinder-blender are listed Table I. The coefficients used in computing cost are listed in App Table I. The values for K, D, V, and L in Table I are used in the equation and the average cost curves are plotted. The average cost for the specified planning horizons and labor costs are represented line C in Figures 2, 3, 4, and 5.

Custom Processing

There are several alternative types of custom feed processing services available. One method is to haul the grain to the mill and only for custom processing. A second method is to hire custom haulin and processing. Another method is to hire a portable mill to process grain on the farm.

Two custom rates will be used in this study. The first rate of per ton is an estimate of custom processing and variable hauling cost The second rate of $5.00 per ton includes processing cost and custom hauling at 5 cents per bushel.[1] These rates are represented by lines and A' in Figures 2, 3, 4, and 5.

Comparison of Grain Processing Methods

Average total cost curves (Figures 2, 3, 4, and 5) are used in comparing the alternative grain processing methods. For a given size operation, the method with the lowest average total cost curve is the least-cost method. The point of intersection of two average cost cur is referred to as the "break-even point." The break-even point is significant in that it represents the size of operation at which the of one method equals the cost of the other method.

The break-even point is computed by setting the average cost equ of two methods equal to each other and solving for Q (the number of t per year).

$$\frac{K_1}{Q} + V_1 + L_1 = \frac{K_2}{Q} + V_2 + L_2 \qquad (1)$$

[1] D. B. Jeffrey, Cecil D. Maynard, and Odell L. Walker, Oklahoma Custom Rates, Oklahoma Agricultural Extension Service Leaflet L-50, 1

The left side of the equation (1) represents the cost equation of or method and the right side represents the cost equation of the other and Q represents the number of tons per year at the break-even point

For low levels of use, the $3.00 custom rate is the least-cost method of processing feed. With an infinite planning horizon the bı even point between the $3.00 custom rate and the mill and mixer occı at 112 tons per year with $1.00 labor and at 151 tons per year with labor (Figures 2 and 3).[2] In order to justify the mill and mixer, ε of 160 steers[3] must be fed per year when labor is charged at $1.00 ı hour. With labor at $2.00 per hour, 216 steers must be fed per yeaı order to justify the mill and mixer.

When the short planning horizon is used with $1.00 labor a totε 181 steers must be fed per year to justify purchasing the mill and m (Figure 4). When labor is charged at $2.00 per hour, a total of 244 steers must be fed each year in order to justify the mill and mixer (Figure 5).

The $5.00 custom rate gives a break-even point at 77 tons per ȝ when the short planning horizon is used with labor at $2.00 per houı the other planning horizon and labor cost situations, the $5.00 cust rate is above the cost of owning and operating the mill and mixer at minimum level of use (70 tons per year).

With labor at $1.00 per hour there is little difference betweer average cost curves of the mill and mixer and the grinder-blender.

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[2]The custom rate of $3.00 per ton is constant and is not affec by the change in labor cost.

[3]This analysis applies to both steers and heifers, however, on word steers is used to refer to the number of cattle fed per year.

labor is charged at $2.00 per hour, the difference between the costs o the two methods becomes greater, especially at higher levels of use. ' occurs because there is a greater difference between the labor require ments of the two methods than there is between the fixed cost of the t methods.

Using the infinite planning horizon with $1.00 labor, the grinder blender will become the least-cost method at 317 tons per year (Figure For the range of operations feeding 160 to 453 steers per year, the mi and mixer is the least-cost method. For operations feeding less than steers per year the $3.00 custom rate is the least-cost method. Farme feeding over 453 steers per year can justify purchasing the grinder-bl If labor is charged at $2.00 per hour, only 217 steers must be fed per to justify the grinder-blender.

Using the short planning horizon with labor at $1.00 per hour, th mill and mixer is the least-cost method for operations feeding 181 to 731 head per. For operations feeding less than 181 steers per year th $3.00 custom rate is least-cost. The grinder-blender becomes least-co if 731 steers are fed each year. When labor is charged at $2.00 per h the grinder-blender becomes the least-cost method when only 279 steers fed per year.

The shorter planning period results in higher cost per ton and therefore causes the break-even points between methods to occur at hig levels of use. By increasing the labor cost from $1.00 to $2.00 per t the break-even point between custom processing and the mill and mixer occurs at higher levels of use. This occurs because the increased lab cost does not effect the custom rate. Increasing the labor cost, cause the break-even point between the mill and mixer and the grinder-blende occur at lower levels of use. This occurs because the labor requireme

is much greater for the mill and mixer.

CHAPTER IV

SILAGE REMOVAL ALTERNATIVES

The horizontal silo is the predominate type of silage storage use in Oklahoma. The latest available statistics show that in 1955 approx mately 90% of the sorghum silage produced in Oklahoma was stored in horizontal silos.[1] The unlined trench is the most common type of horizontal silo, however, concrete lined trench silos and bunker silos are also used. The concrete stave is the most common type of upright silo used in Oklahoma.

The partial budgeting approach is used in analyzing silage remova alternatives. Only the cost of the equipment used to remove silage fr storage is included. Other cost such as silo cost and filling cost ar not included. First, alternative methods of removing silage from horizontal silos are compared. Then, a comparison of alternative meth of removing silage from upright silos is presented.

Horizontal Silo

Two alternative methods of removing silage from horizontal silos are considered in this study. The first method is the front-end trac loader and the second is the horizontal silo unloader mounted on a us

[1] Albert P. Brodell and Harold C. Phillips, Silage From 1955 Cro Harvesting-Storing-Preserving, Statistical Bulletin No. 217, U.S. Dep ment of Agriculture, September 1957.

tractor. There are other methods including hand removal and self-fee(The latter two methods, however, are relatively unimportant in beef c(feeding and will not be considered in this study.

Front-End Tractor Loader

A front-end tractor loader is found on a large percentage of the livestock farms in Oklahoma. By using a loader of this type, silage can be loaded into a wagon or truck for a relatively small cost per t(Different size loaders are available depending on the size of tractor be used. For this study, a medium size loader with a 41 inch scoop is mounted on a three-plow tractor. On most farms the loader would have uses such as loading manure. For this reason, only 75% of the fixed cost of the loader is assigned to silage removal. This is only an estimate. In some cases the loader would have several other uses and a small percentage charged to silage removal, while in other cases th unloader would be used only for loading silage and all of the fixed co would be charged to silage removal.

The fixed and variable costs are included in Table II and the coefficients used in computing cost are listed in Appendix Table II. variable cost of 21.4 cents per ton includes the total operating cost the tractor at $1.90 per hour.[2] The average cost curves for the corre ponding planning horizons and labor costs are represented by lines A a A' in Figures 6 and 7.

[2]The tractor cost includes all fixed and variable non-labor cost is based on 500 hours of use per year.

TABLE II

COST OF ALTERNATIVE SILAGE REMOVAL METHODS

Method	Range Of Use	Initial Invest-ment	Annual Fixed Cost: Infinite Planning Horizon K_1	Annual Fixed Cost: Short Planning Horizon K_2	Variable Cost Per Ton V	Labor Cost Per Ton: \$1.00 Labor L	Labor Cost Per Ton: \$2.00 Labor L'
	(Tons/Year)		- Dollars -				
Front End Loader[1]	280-5600	477	53.47	58.23	.214[2]	.113	.226
Horizontal Silo Unloader and Used Tractor	280-5600	2,923	436.99	488.64	.057	.067	.134
Hand Removal From Upright Silo	280-5600	--	--	--	--	.333	.666
Surface Unloader (16')	280-750	1,329	198.69	216.97	.092	.054	.108
Surface Unloader (20')	750-1180	1,549	231.72	252.31	.083	.027	.054
Surface Unloader (24')	1180-1700	1,725	257.89	280.80	.078	.023	.046
Surface Unloader (30')	1700-3180	2,164	323.52	352.24	.073	.018	.036
Two 30' Surface Unloaders	3180-5600	4,328	647.04	704.54	.073	.018	.036

[1]An assumption is made that the front end tractor loader is used for other farm enterprises; therefore only 75 per cent of the fixed cost is assigned to silage removal.

[2]Total tractor operating cost (both fixed and variable) @\$1.90 per hour is included.

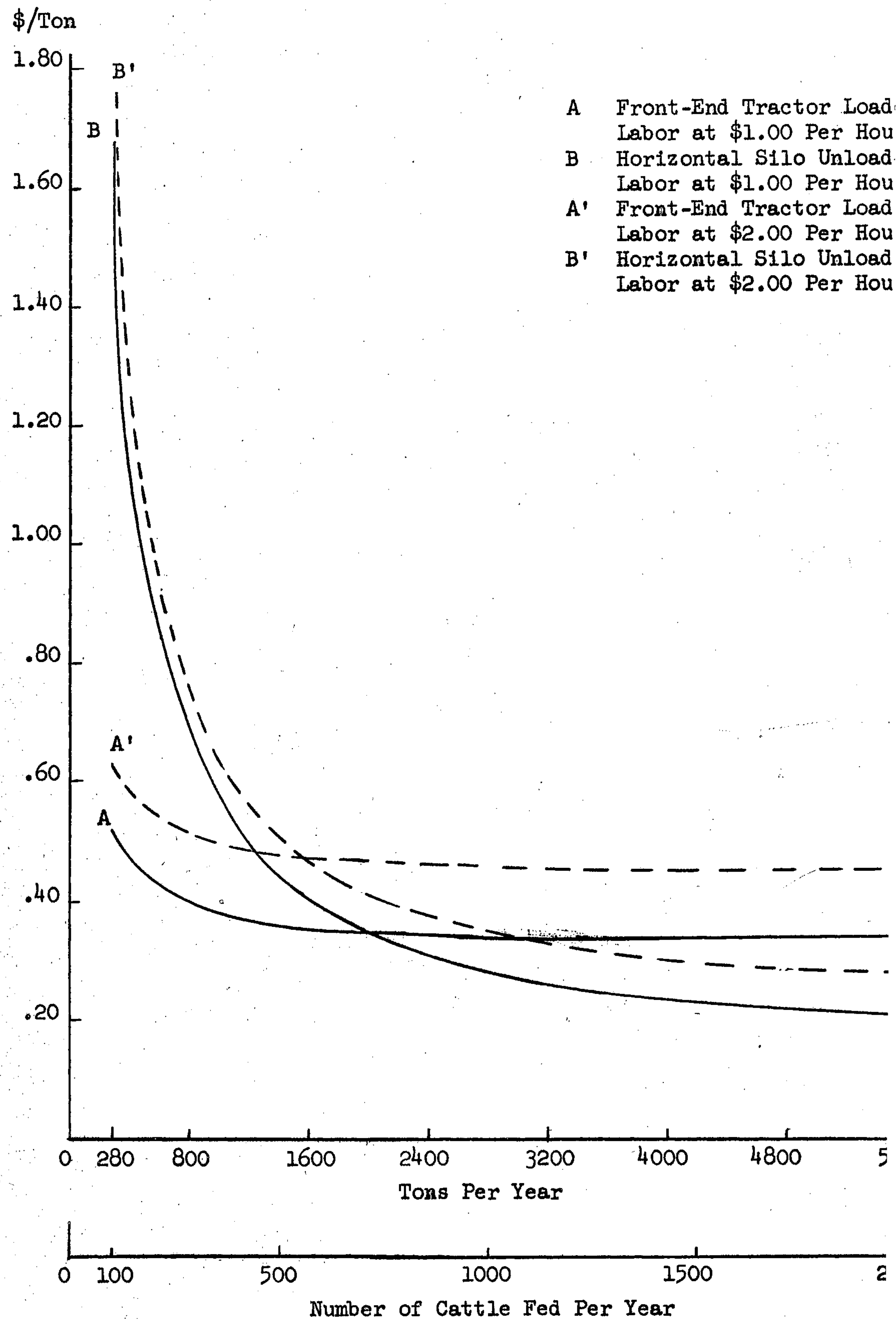

Figure 6. Cost of Removing Silage from Horizontal Silo by Two Alternative Methods Assuming An Infinite Planning Horiz

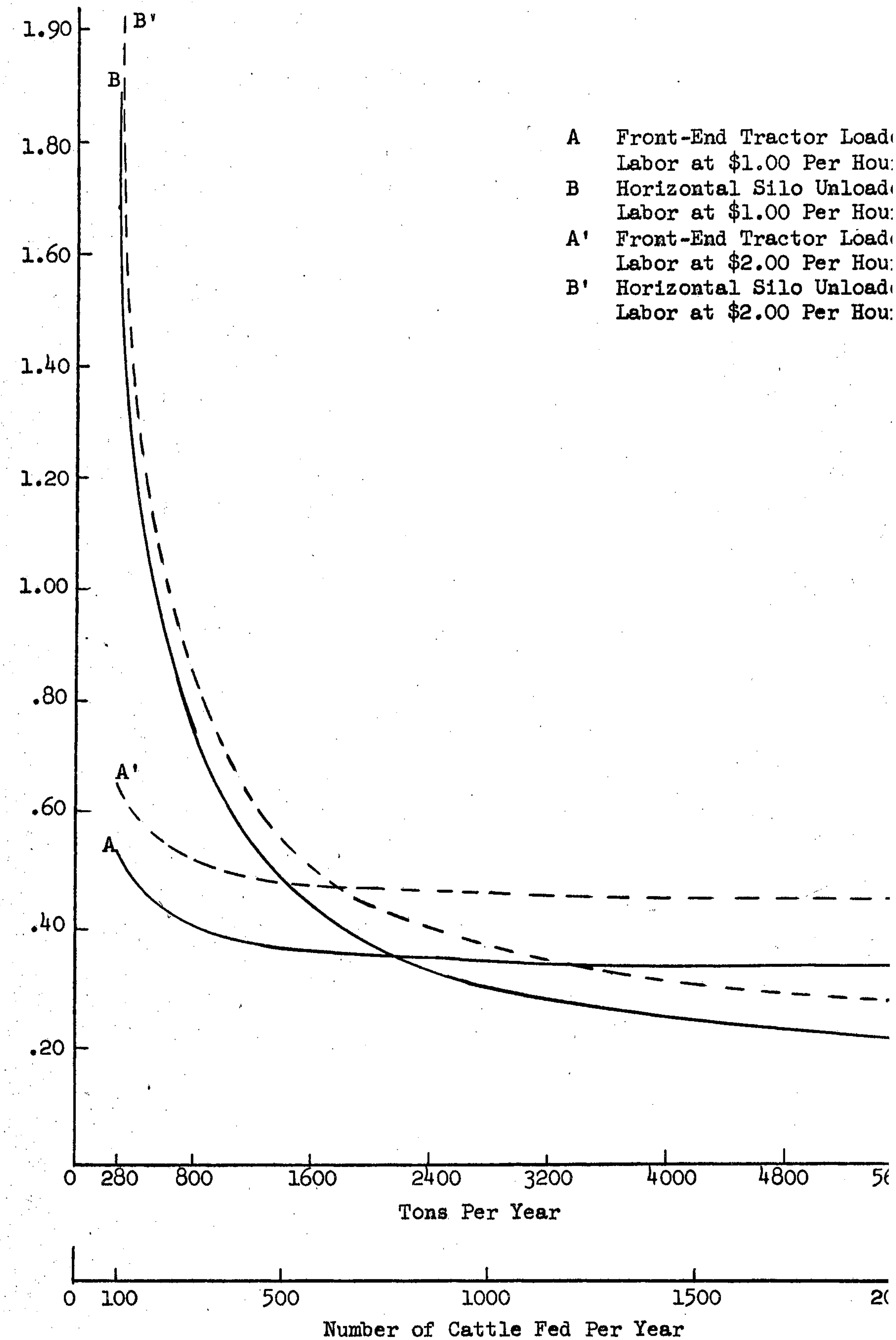

Figure 7. Cost of Removing Silage from Horizontal Silo by Two Alternative Methods Assuming a Short Planning Horizon.

Horizontal Silo Unloader

The horizontal silo unloader represents a higher level of mechani-zation. It is a more specialized machine than the front-end tractor loader. The horizontal unloader cuts the silage loose by a revolving cutter head on a boom and elevates the loose silage into a wagon or tr by a drag elevator or blower. The unit is mounted on a low profile tractor and is powered by the tractor P.T.O. Since it completely ties up the tractor, most owners mount the unloader on a used tractor. In this study a used three-plow tractor is assumed.

The cost components for the horizontal silo unloader are listed in Table II. Depreciation, interest, taxes, and insurance for both th unloader and used tractor are included in annual fixed cost. Fuel cos for the tractor and repair cost for both the unloader and tractor are included in variable cost. The average cost curves for the specified planning horizons and labor costs are represented by lines B and B' in Figures 6 and 7.

Comparison of Removal Methods For Horizontal Silo

The initial investment for the front-end tractor loader is $477, while an investment of $2,923 is associated with the horizontal silo unloader and used tractor. Because of this higher initial investment, the annual fixed cost of the silo unloader is considerably more than t annual fixed cost of the front-end loader. At low levels of use one w expect the front-end loader to be least-cost and at some higher level use the horizontal silo unloader would be expected to become the least cost method.

Average cost curve analysis as explained in the previous chapter used to determine least-cost methods and break-even points. Using th infinite planning horizon and $1.00 labor, the break-even point betwe the front-end loader and the silo unloader occurs at 1,889 tons or 67 steers per year (Figure 6). For operations feeding less that 674 ste per year, the front-end tractor loader is the least-cost method. The horizontal silo unloader can be justified when 674 steers are fed per year, since beyond this point it is the least-cost of the two methods When a $2.00 labor cost is used, only 550 steers per year are needed justify the horizontal silo unloader (Figure 6).

Using the short planning horizon and $1.00 labor, the front-end is the least-cost method for operations feeding up to 757 steers per (Figure 7). At this point the silo unloader can be justified and bey this point the unloader is the least-cost method. If labor is charge at $2.00 per hour, the silo unloader can be justified for operations feeding 617 steers per year (Figure 7).

Upright Silo

The two methods considered for removing silage from upright silo are: (1) hand unloading and (2) the surface silo unloader. Other ty of mechanical silo unloaders are available, although these are usuall for special types of silos.

Hand Unloading

There is essentially no investment in unloading equipment when h unloading is used. However, a high labor requirement is involved. T rate of unloading might be expected to decrease as the amount of sila handled at one time increases, because the worker becomes fatigued. I this analysis, however, the assumption is made that additional worke: are added as the amount of silage handled increases. For this reasoı constant unloading rate of 100 pounds per minute[3] is used. At this ı three tons can be unloaded per hour, or alternatively, .333 hour of l per ton is required. Using $1.00 labor, the labor cost is 33.3 cent: ton. When $2.00 labor is used, the labor cost would be 66.6 cents pe ton (Table II). The average cost of hand unloading is represented iı Figures 8 and 9 by lines A with labor at $1.00 per hour and by lines with labor at $2.00 per hour.

Surface Silo Unloader

Surface silo unloaders are available in sizes to fit 10 to 30 fo diameter silos. These machines loosen the silage on the surface and it to a blower or conveyor in the center of the silo. The blower or conveyor moves the silage to the silo chute and it then drops into a wagon, truck, or mechanical feeding system located under the silo chu at the base of the silo.

As the diameter of the upright silo increases, the cost per ton capacity decreases. As the size of the cattle feeding operation incr it is therefore desirable to use larger diameter silos. The selectio the size silo to use depends upon the amount of silage to be fed dail During warm weather, it is necessary to remove from 2 to 4 inches per in order to prevent spoilage.[4]

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[3]E. T. Shandys and J. H. Sitterley, Labor and Equipment for Feed Silage, Ohio Agricultural Experiment Station, Research Bulletin No. 8 November, 1958.

[4]Virginia Agricultural Extension Service, Silos and Silage, Bull 232, Blacksburg, Virginia, September, 1955.

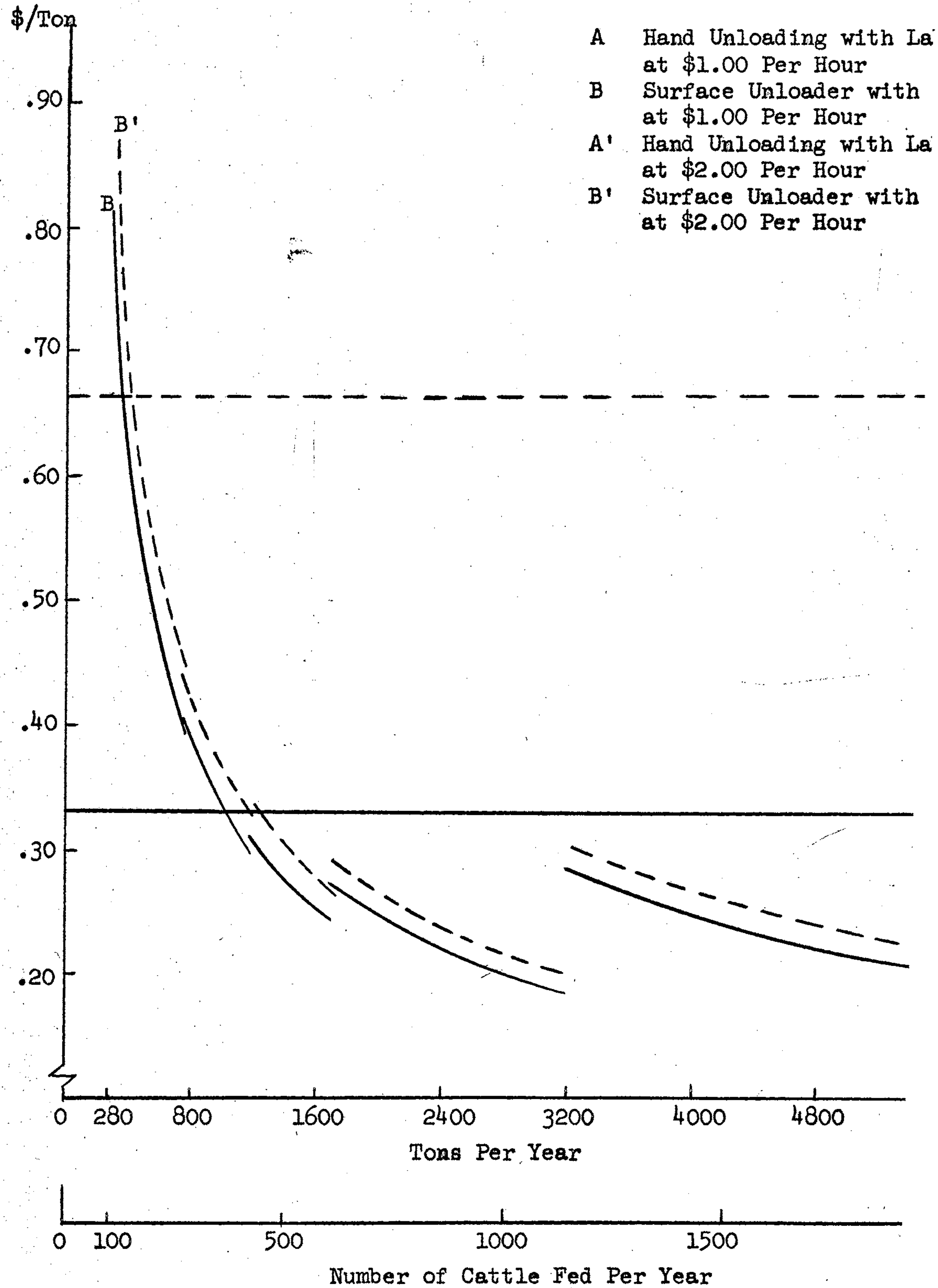

Figure 8. Cost of Removing Silage from Upright Silo by Two Alternative Methods Assuming an Infinite Planning Horizon.

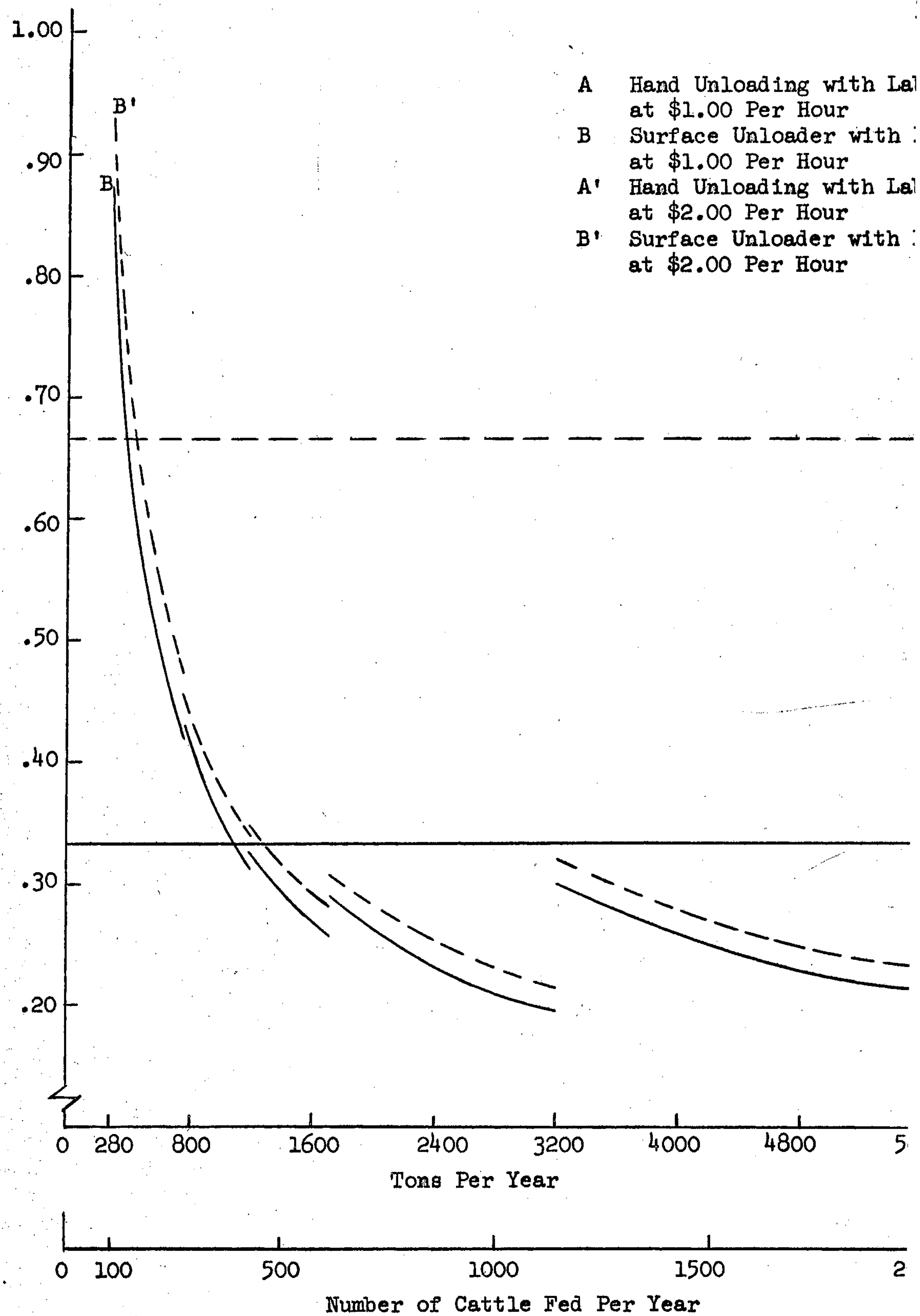

Figure 9. Cost of Removing Silage from Upright Silo by Two Alternative Methods Assuming A Short Planning Horizon.

One silo unloader can be moved from one silo to another and in t analysis one unloader is used in as many as three silos. For operati requiring more than three silos, a second unloader is added. For ope tions feeding 100 to 268 head per year the 16 ft. unloader is used. 20 ft. unloader is used for operations falling in the range of 269 to 422 steers per year. The 24 ft. unloader is used for sizes ranging f 423 to 608 head per year. For operations feeding 609 to 1136 steers year, the 30 ft. unloader is used. For operations feeding more than head per year, two unloaders will be required.

The average cost curves for the surface unloader are shown in Fi 8 for the infinite planning horizon and in Figure 9 for the short pla horizon. The solid lines labeled B represent the cost curves with $1. labor and the broken lines labeled B' represent the average cost curv with $2.00 labor.

As explained earlier, four different sizes of unloaders are used. The average cost curves in Figures 8 and 9 therefore appear as discont ous segments rather than one continuous curve. The first segment represents average cost of the 16 ft. unloader, the second segment is the 20 ft. unloader, the third segment represents the 24 ft. unloader, and the fourth segment represents the 30 ft. unloader. The fifth segm represents two 30 ft. unloaders.

Comparison of Removal Methods For Upright Silos

At low levels of use, hand unloading is the least-cost method of removing silage from upright silos. As the size of the feeding operat increases, we would expect the surface unloader to become the least-co method.

Using the infinite planning horizon with labor at \$1.00 per hour, hand unloading is the least-cost method for operations feeding less tha 371 steers per year. For operations feeding more than 371 steers per y the surface unloader is justified. If labor is charged at \$2.00 per ho the surface unloader will become the least-cost method at a lower level of use. With \$2.00 labor the surface unloader is justified for feeding 157 head per year.

For the short planning horizon with \$1.00 labor, the hand method i the least-cost method for operations feeding up to 404 head per year. When labor is charged at \$2.00 per hour, the surface unloader becomes t least-cost method at 170 steers per year.

Break-Even Price of Labor

Feed lot operators are also interested in determining the break-e price of labor at a given level of use, i.e., size of operation. In o to determine the break-even price of labor between the hand method and mechanical unloader, the following equation is used:

$$\frac{K}{Q} + V + H_1X = H_2X$$

The left side of the above equation is the average cost equation for t surface unloader. In this equation K represents annual fixed cost, Q is tons per year, V is variable cost per ton, H_1 is hours of labor required per ton and X is the break-even price of labor. The right si of the above equation is the average cost equation for the hand unload- ing method. In this equation H_2 is the hours of labor required per to for hand unloading and X is the break-even price of labor. This break- even can be computed for any Q. For an example, 2800 tons of silage p year or 1000 head of cattle is used. By solving for X in the above equation, the break-even price of labor between the mechanical unload and hand unloading at 2800 tons per year is 60¢ when the infinite pla horizon is used, and 63¢ when the short planning horizon is used.

This means the farmer who feeds 1000 head of cattle per year and places a value on his own labor above 63¢ per hour should use the mechanical surface unloader. When hired labor is used for unloading silage, the surface unloader should be used if the cost of labor is n than 63¢ per hour.

Comparison of Horizontal and Upright Silo Costs

The purpose of this section is to determine the annual silage storage cost for unlined trench silos and concrete stave silos. The cost developed here includes only annual silage storage cost. This does not give a complete comparison of horizontal and upright silos, because the cost of silo filling is not included.

In the final chapter the annual silage storage cost will be add to the cost of feed processing and handling. This will make it poss to estimate average total cost for the three feeding operations cons in this study.

Unlined trench silos with paved floors have a low initial inves when compared to the investment for a concrete stave silo. The tren silo can be built in any size ranging from less than 100 tons to ove tons of capacity. The construction cost per ton of capacity for the silo is almost constant (i.e., the cost per ton does not change as t size of the silo increases). A construction cost of $1.25 per ton o capacity is assumed.

The amount of spoilage in a trench silo varies considerably from farm to farm and from year to year. The percentage of spoilage loss i greater in the trench silo than in the upright silo because the trencl has a larger surface area exposed. Plastic covers can be used to hel reduce the spoilage loss. In this study a spoilage loss of 7% is ass

The annual cost of storing silage in a trench silo assuming a 7% spoilage loss is listed in Table III. Since the life of the trench s is assumed to be ten years, there is very little difference between c for the infinite planning horizon and the seven year planning horizon.

The concrete stave silo requires a high initial investment, howe it has a longer life than the unlined trench. The cost per ton of capacity of the concrete stave silo decreases as the diameter of the increases. Initial cost per ton of capacity for the 16 foot diameter is $10.06, for the 20 foot silo, $7.68, for the 24 foot silo, $7.32, for the 30 foot silo, $6.24.

The normal spoilage loss is less in the upright silo than in the trench. A spoilage loss of 3% is used in computing the annual cost p ton of storing silage in a concrete stave silo (Table III).

When the infinite planning horizon is used, the annual cost per for the trench silo is 90¢. This is less than the annual cost per to for the 16 and 20 foot upright silos, and about equal to the cost per for the 24 foot upright silo. However, the cost per ton for the 30 f diameter upright silo is less than the cost per ton for the trench si

When the short planning horizon is used, both types of silos are depreciated over a seven year period. This results in only a 4¢ incr in the annual cost per ton for the trench silo. However, it almost d the annual per ton costs of the concrete stave silos. All four sizes

TABLE III

ANNUAL COST PER TON OF STORING SILAGE

Planning Horizon	Range Of Use (Tons/Year)	Unlined Trench Silo: Annual Cost[1] (With 7% Spoilage) ($/Ton)	Concrete Stave Silo: Diameter Of Silo (Ft.)	Concrete Stave Silo: Annual Cost[2] (With 3% Spoilage) ($/Ton)	% Spoilage Loss That Must be Assigned to Horizontal Silo Cost if Upright Silo Cost is to Equal Horizontal Silo Cost
Infinite	280-750	.90	16	1.19	11
"	751-1180	.90	20	.96	8
"	1181-1700	.90	24	.90	7
"	1701-5000	.90	30	.82	6
Short	280-750	.94	16	2.12	23
"	751-1180	.94	20	1.67	17
"	1181-1700	.94	24	1.61	16
"	1701-5000	.94	30	1.40	13

[1]Includes depreciation 10 years, interest, taxes, insurance, repairs at 10 per cent of new cost, cost of plastic cover (assumed to last two years), the value of 7 per cent silage loss (silage valued at $7.50 per ton).

[2]Includes depreciation 5 years, interest, taxes, insurance, repairs at .03 per cent of new cost, and the value of 3 per cent silage loss (silage valued at $7.50 per ton).

the upright silo are now more expensive than the trench silo. Howeve
as pointed out earlier, the choice between upright and horizontal sil
cannot be made on the basis of the data in this chapter.

Since spoilage is the major item of cost for the trench silo, th
percentage assigned for spoilage loss might be the deciding factor in
choosing between the trench and the concrete stave silo. The last co
in Table III shows the percentages that must be assigned to trench si
spoilage loss if trench silo storage cost per ton is to equal concret
stave silo storage cost per ton.

CHAPTER V

FEED DISTRIBUTION ALTERNATIVES

The final step in feed handling is feed distribution. Three alternative methods are considered for moving concentrates and silage from the storage area to the feed bunks. These methods are: (1) wago with hand unloading, (2) self-unloading wagon, and (3) mechanical aug tube feeder.

Since the different methods require different types of bunks, th costs of bunks are included for each method. A fence-line bunk is us with the wagon and the self-unloading wagon. A special type of bunk an auger tube running down the middle is used with the mechanical fee

Since each level of operation requires a different initial inves and involves a different performance rate and labor requirement, a slightly different type of analysis is used in this chapter. However cost equations are still used to estimate points on the average cost curve. The difference comes in the coefficients used in the cost equations. For the first two operations (i.e., feed processing and silage removal), one set of coefficients was used over the entire ran of operations. For feed distribution, however, a different set of cc efficients is used for each level of use. These coefficients are lis in Appendix Table III.

Wagon With Hand Unloading

A tractor-drawn wagon requires little investment in special equipment. However, this method involves a considerable amount of labor. Since the wagon can be used for other farm work, only 75% of : fixed cost is assigned to feed distribution. The fixed cost of the w is included in annual fixed cost (K in Table IV).

The amount of bunk space required depends upon the number of cat to be fed at one time. One and one half feet of bunk space was allow per animal.[1] Fixed cost of the bunk was computed on a per linear foo basis and converted to dollars per ton of feed capacity for use in th cost equation. The fixed cost per ton is constant for all levels of and is listed under F in Table IV.

Variable cost per ton includes repair cost for the wagon and tra operating cost at $1.90 per hour. Variable costs per ton for each of levels of output are listed under V in Table IV.

Labor involved in this method includes loading concentrates,[2] driving wagon along fence-line bunk, and scooping the feed into the b Loading silage was done simultaneously with silage removal; therefore silage loading is not included in feed distribution. Labor costs per are listed under L in Table IV.

Average cost curves for distributing feed with a wagon and hand unloading are represented by lines A in Figures 10, 11, 12, and 13 f

[1]M. E. Ensminger, The Stockman's Handbook, The Interstate Print and Publishers, Inc., Danville, Illinois, 1959, p. 347.

[2]Concentrates are stored in an overhead bin, and a loading rate 500 pounds per minute is assumed.

TABLE IV

COST OF ALTERNATIVE FEED DISTRIBUTION METHODS[1]

Method	Level Of Use	Initial Investment[2]	Annual Fixed Cost[3] Infinite Planning Horizon K_1	Annual Fixed Cost[3] Short Planning Horizon K_2	Selected Fixed Cost On a Per Ton Basis[4] Infinite Planning Horizon F_1	Selected Fixed Cost On a Per Ton Basis[4] Short Planning Horizon F_2	Variable Cost Per Ton V	Labor Cost Per Ton $1.00 Labor L	Labor Cost Per Ton $2.00 Labor L'
	(Tons/Year)				-Dollars-				
Wagon & Fence-line Bunk	350	569	28.73	36.96	.082	.129	.874	.457	.914
	700	813	28.73	36.96	.082	.129	.685	.358	.716
	1400	1300	28.73	36.96	.082	.129	.621	.325	.650
	4200	3250	28.73	36.96	.082	.129	.551	.288	.576
	7000	5200	28.73	36.96	.082	.129	.551	.288	.576
Self-Unloading Wagon & Fence-line bunk	350	2304	231.01	251.50	.082	.129	.411	.200	.400
	700	2548	231.01	251.50	.082	.129	.206	.100	.200
	1400	3035	231.01	251.50	.082	.129	.137	.067	.134
	2800	4010	231.01	251.50	.082	.129	.103	.050	.100
	4200	4985	231.01	251.50	.082	.129	.084	.040	.080
	5600	5960	231.01	251.50	.082	.129	.084	.040	.080
	7000	6935	231.01	251.50	.082	.129	.084	.040	.080
Mechanical Feeder(25')	350	1096	103.16	122.33	.176	.200	.025	.080	.160
(50')	700	1503	103.16	122.33	.176	.200	.029	.040	.080
(100')	1400	2315	103.16	122.33	.176	.200	.043	.020	.040
(200')	2800	3940	103.16	122.33	.176	.200	.065	.010	.020
(300')	4200	6155	191.36	208.37	.176	.200	.051	.010	.020
(400')	5600	7780	191.36	208.37	.176	.200	.065	.010	.020
		[illegible]	[illegible]	[illegible]	.176	.200	.064	.010	.020

TABLE IV (Continued - Footnotes)

[1]It is assumed that the wagon and self-unloading wagons are also used for filling silos; therefore only 75% of the fixed cost is assigned to feed distribution.

[2]For the first two methods, initial investment includes cost of wagon and fence-line bunk. Cost of fence-line bunk is .89 per ton (based on a cost of $4.15 per foot with 4 2/3 tons of feed fed per foot of bunk space per year). The initial investment for the mechanical feeders includes drive unit(s), auger tube, bunk, and conveyor(s).

[3]Annual fixed cost (K) for the wagon and bunk includes only the fixed cost of the wagon. Annual fixed cost (K) for the self-unloading wagon and bunk includes only the fixed cost of the self-unloading wagon. Annual fixed cost (K) for the mechanical feeder includes only the fixed cost of the drive unit(s) and conveyor(s).

[4]Fixed cost per ton (F) for the wagon and fence-line bunk and self-unloading wagon and fence-line bunk includes only fixed cost for the fence-line bunk (based on an initial investment of $4.15 per foot for the bunk). Fixed cost per ton (F) for the mechanical feeder includes fixed cost for the auger and bunk (based on an initial investment of $10.00 per foot for the auger and $6.25 per foot for the bunk).

specified planning horizons and labor costs.

Self-Unloading Wagon

Several types of unloading wagons are available. The types used in this study consists of a self-unloading box with a floor conveyor, beaters at one end for mixing the ration, and a cross conveyor for unloading the feed into the bunk. The unloading wagon is powered by the tractor P.T.O.

Although this analysis is limited to self-unloading wagons, the self-unloading boxes can also be mounted on trucks. However, this add to the overall investment. For large operations and for operations involving long hauls, the truck might be the most economical type of running gear for the self-unloading box.

Since most self-unloading wagons are also used to haul green sil from the field to the silo, only 75% of the fixed cost is assigned to feed distribution. This is used only as an example. In some cases, of the use might be assigned to filling silos, leaving only 50% for f distribution. In other cases the self-unloading wagon might be used only for feed distribution.

The components of cost for the self-unloading wagon (Table IV) a computed by using the procedure outlined in the previous section. Th average cost curves for the self-unloading wagon are represented by l B in Figures 10, 11, 12, and 13 for the specified planning horizons a labor costs.

The amount of time required for distributing feed with wagons an self-unloading wagons depends upon the distance traveled. In this st a well designed arrangement of feed lots and bunks is assumed. This

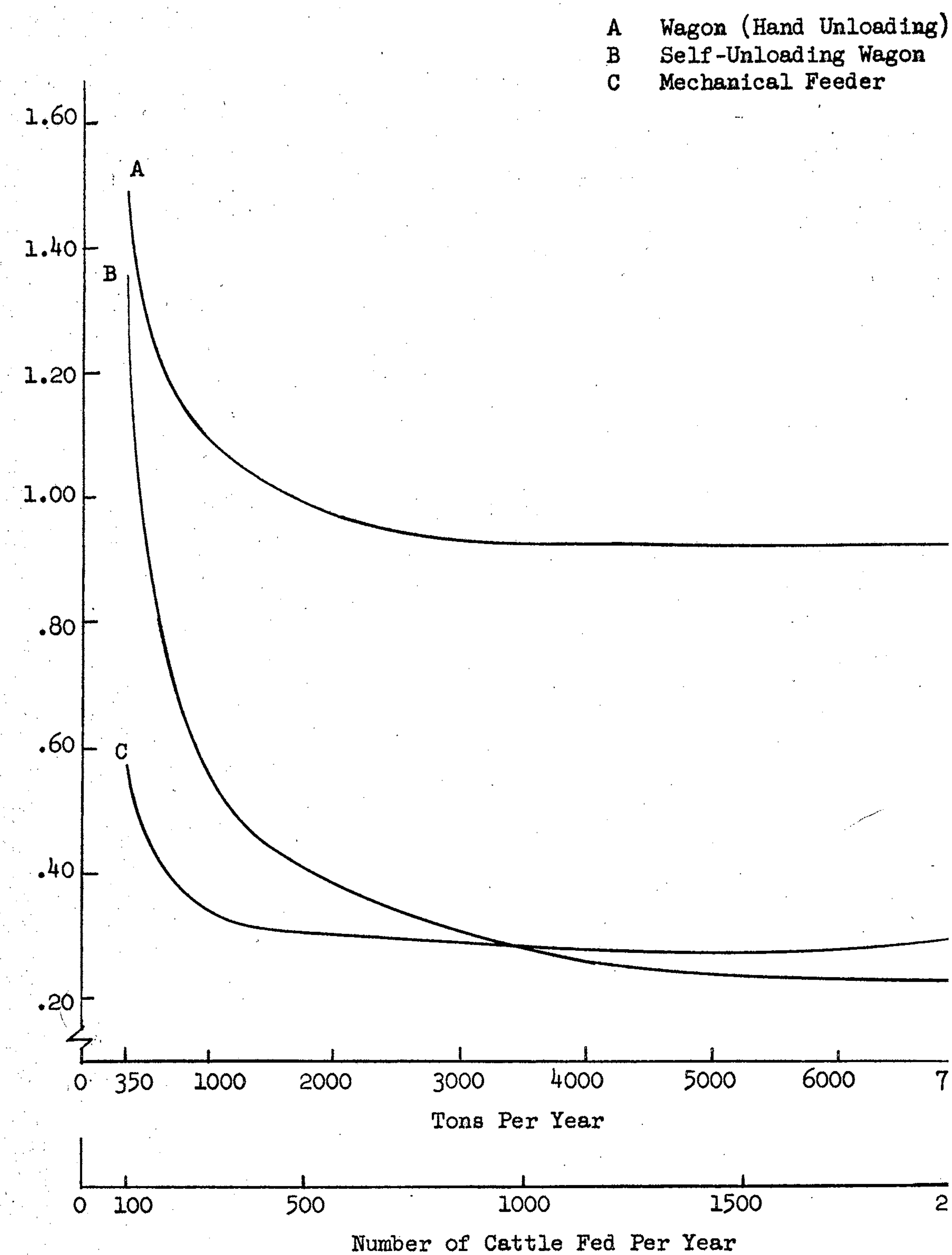

Figure 10. Cost of Distributing Feed by Three Alternative Methods Assuming An Infinite Planning Horizon with Labor at $1.00 Per Hour

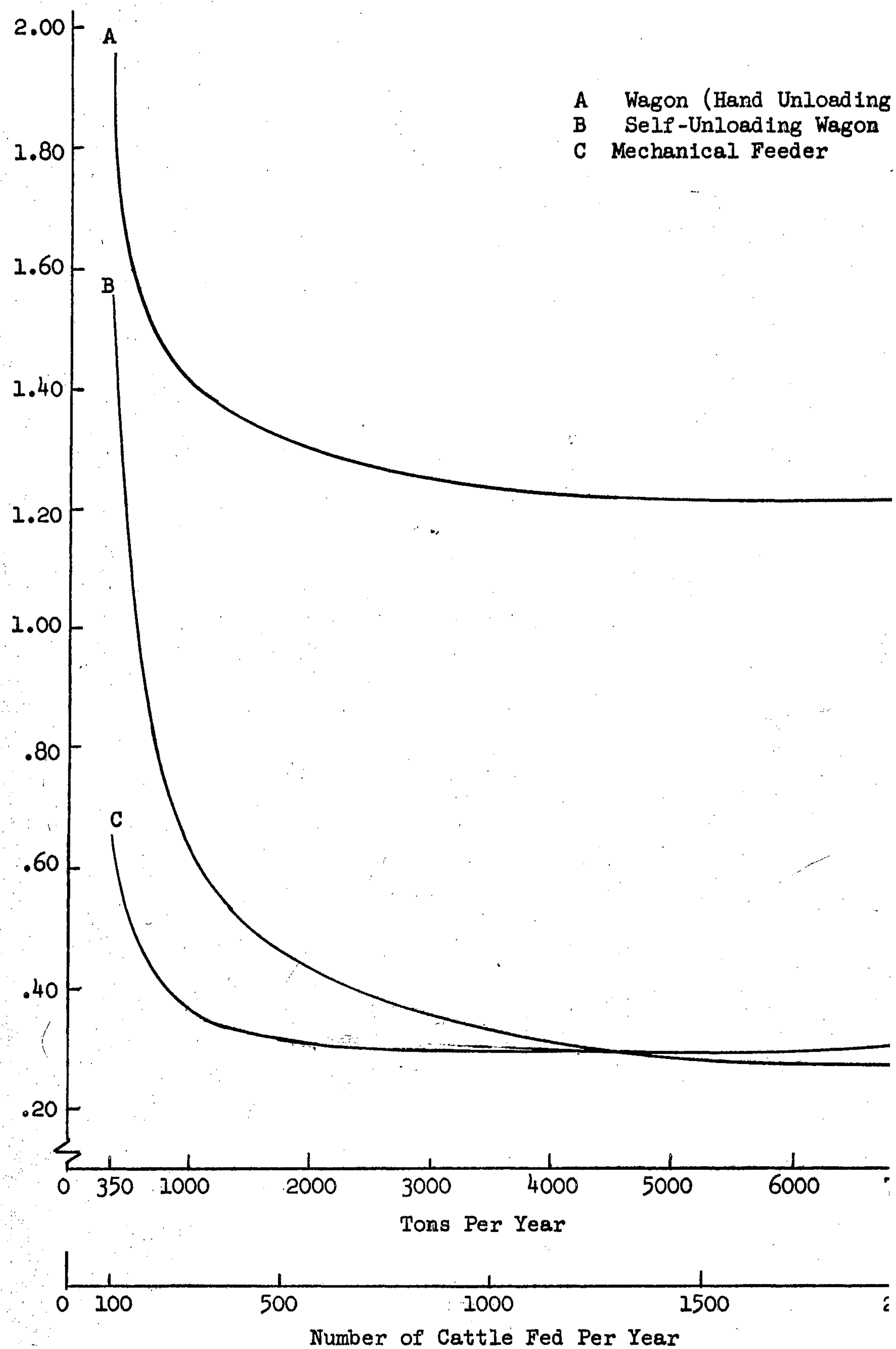

Figure 11. Cost of Distributing Feed by Three Alternative Methods Assuming An Infinite Planning Horizon with Labor at $2.00 Per Hour

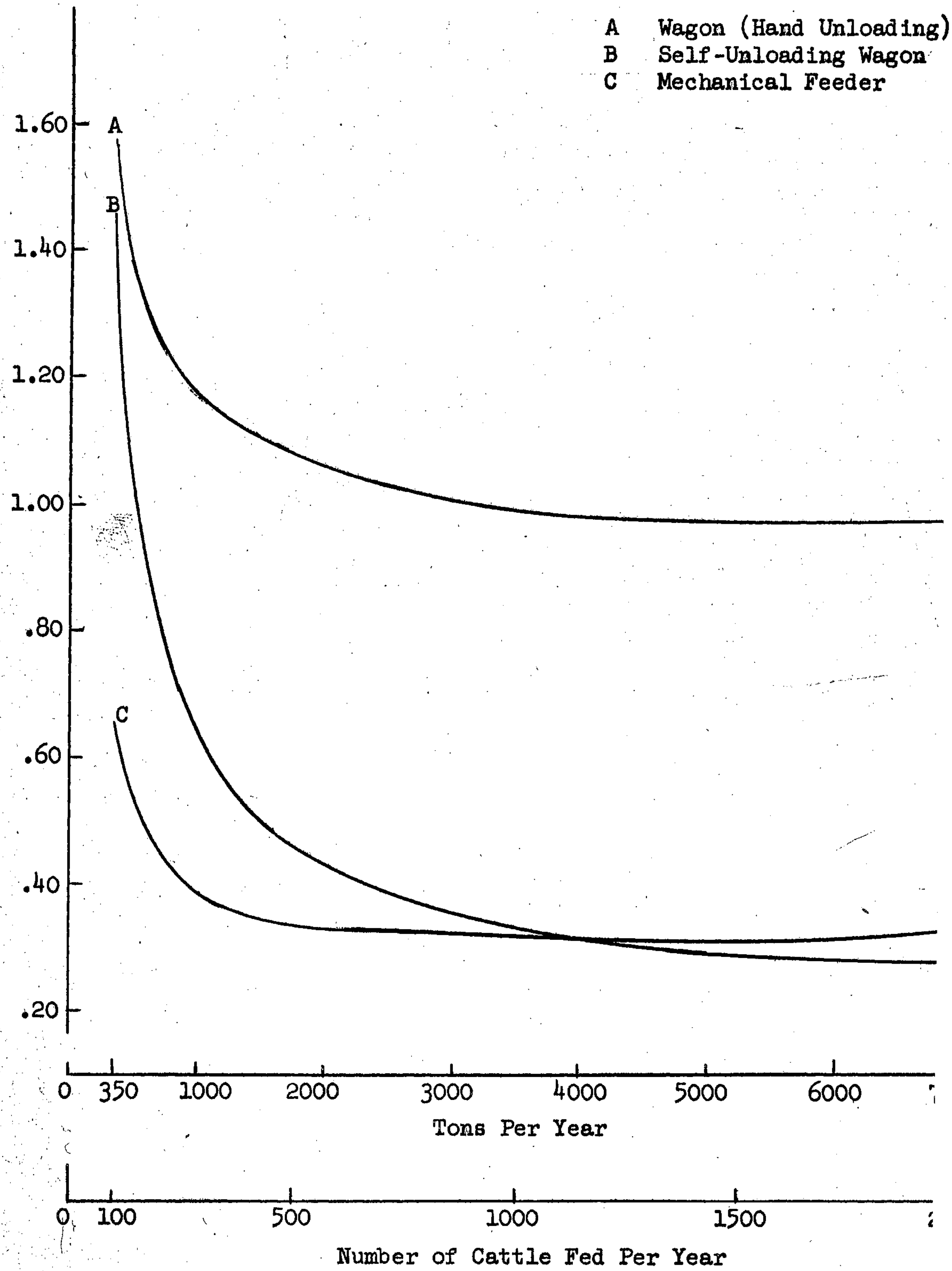

Figure 12. Cost of Distributing Feed by Three Alternative Method[s] Assuming A Short Planning Horizon with Labor at $1.00 Per Hour.

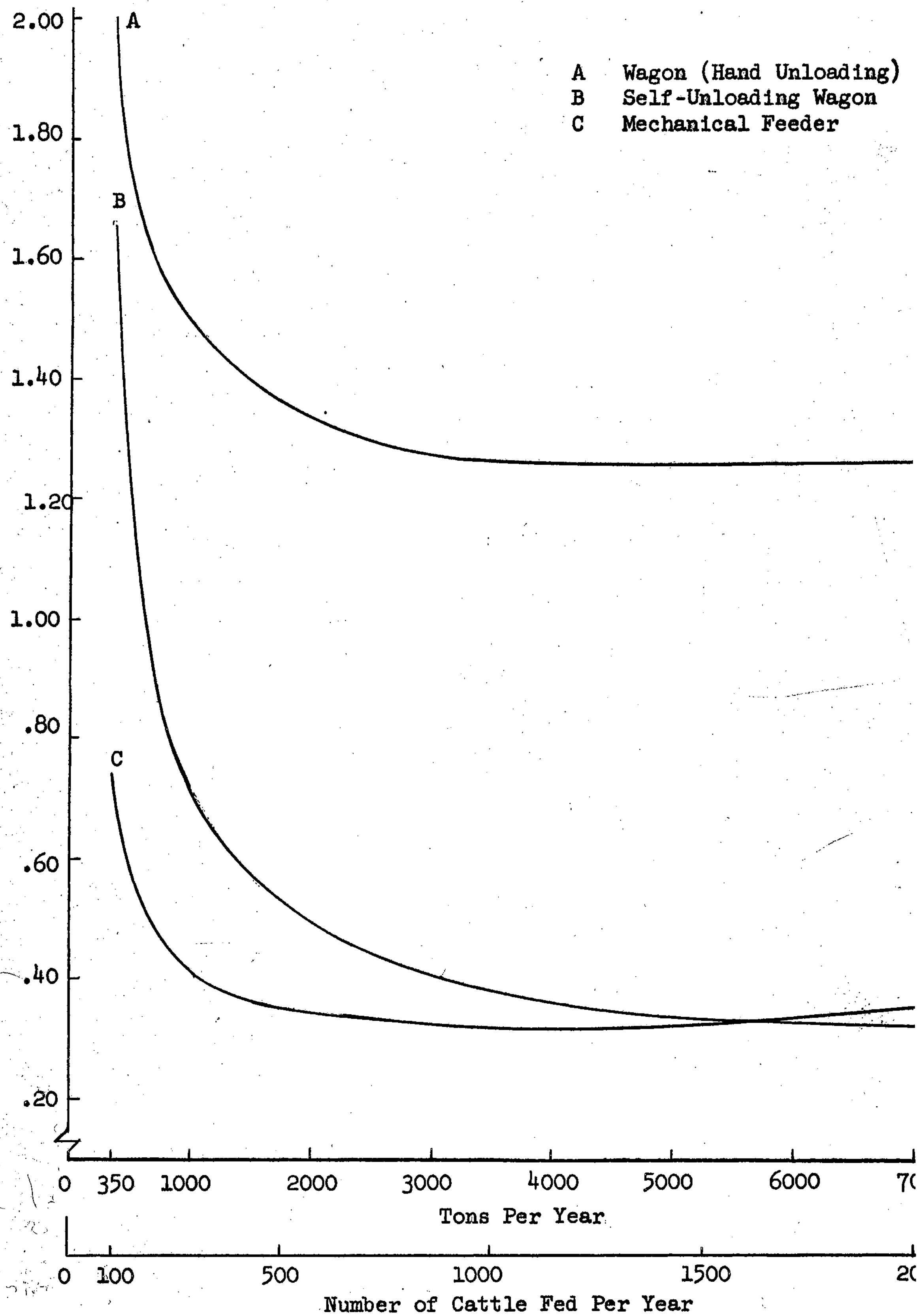

Figure 13. Cost of Distributing Feed by Three Alternative Methods Assuming A Short Planning Horizon with Labor at $2.00 Per Hour.

results in a minimum amount of travel from the storage area to the bu Many feed lots are, however, not arranged in this optimum manner. In this case an appropriate adjustment must be made in the performance r and labor requirements used in computing cost. As the distance trave increases, the performance rate (i.e., tons handled per hour) must be decreased and the labor requirement increased.

The self-unloading wagon can be used with either the horizontal the upright silo. When it is used with the horizontal silo, the labc requirement for loading silage is included in silage removal (Table I When it is used with the upright silo and hand unloading, the labor r ment is again included in silage removal. However, when the self-unl ing wagon is used with the upright silo and surface unloader, the ent labor requirement for loading silage is not included in silage remova In this case the man operating the self-unloading wagon must wait whi the automatic surface unloader fills the wagon. Even when the 30 foc unloader is used, it takes 45 minutes to fill the wagon, unless an overhead bin is used.

Mechanical Feeder

Several types of mechanical feeders are available. The most com types include the auger tube feeder, the open auger feeder, and the chain drag feeder. In general the auger tube feeder is the most expensive type, however it does a better job of mixing the silage and concentrates. For this reason it is used in this study.

In the auger tube feeding system, the auger tube is mounted appr mately 18 inches above the bunk and runs the entire length of the bun The auger pushes the feed the length of the auger housing. As it mov along the auger housing, the feed drops through controlled openings a intervals along the length of the bunk. The mechanical feeder can be used satisfactorily only with upright silos. In some cases the hoppe on the end of the feeder is located under the silo chute. In many ca however, the end of the feeder is located some distance from the silo and an auxiliary auger is used to convey the silage from the silo to feeder. In this study, the feeder is assumed to be 15 feet from the thus a 15 foot auxiliary auger is used. This auger can be moved from silo to another permitting the use of more than one silo. The storag bin for processed concentrates is located adjacent to the hopper on t end of the feeder. A metering device is used to add the desired amou of concentrate into the feeder.

When the fence-line bunk is used, one and one-half feet of bunk space is provided for each animal and the cattle are fed 2 times each Less bunk space per head is required when the mechanical feeder is us because it can be operated several times a day, if needed, with littl increase in labor. One foot of bunk space is provided for each anima and since the cattle feed from both sides of the bunk, only one-half linear foot of feeder space is needed per animal, (e.g., a 50 ft. mechanical feeder is used to feed 100 head of cattle).

The basic unit of the mechanical feeder includes a drive unit po by an electric motor and a feed hopper. The length of the feeder can increased by adding 10 foot sections of auger tube. Most manufacture recommend a maximum length of 200 feet, therefore an operation feeding over 400 cattle at one time requires two separate feeders. For operat feeding over 800 cattle at one time, three separate feeders are needed Cross conveyors must also be added when more than one feeder is used.

The components of cost are listed in Table IV for seven sizes of cattle feeding operations. Part of fixed cost is computed on an annu basis and the remaining portion is computed on per ton basis. Annual fixed cost (K) includes fixed cost of the basic drive unit and hopper For the first four mechanical feeding units listed in Table IV, only basic unit is required; therefore the annual fixed cost is the same f each of these four sizes. For the fifth and sixth sizes with capacit of 600 and 800 head respectively, two units are required. For the largest size considered with a capacity of 1000 head, three separate are required. Since the length of the feeder depends on the number c cattle to be fed, the fixed cost of the auger tube and bunk are compu on a per ton basis (F in Table IV).

The average cost curves for the specified planning horizons and labor costs are represented by line C in Figures 10, 11, 12, and 13.

Comparison of Feed Distribution Methods

The method using a wagon and hand unloading is relatively expen when labor is charged at either $1.00 or $2.00 per hour. Throughout entire range of sizes considered, this method has a higher average co than either of the other two methods (Figures 10, 11, 12, and 13).

When the horizontal silo is used, it is not technically feasibl to use the mechanical feeder. The self-unloading wagon is therefore least-cost method for the entire range of operations when the horizo silo is used.

It is technically possible to use either the mechanical feeder the self-unloading wagon to distribute feed when the upright silo is Figures 10, 11, 12, and 13 show the mechanical feeder to be the leas method at low levels of use and the self-unloading wagon to be the l cost method at higher levels of use. These cost curves include only feed distribution cost. The cost of loading silage was included in silage removal.

When the self-unloading wagon is used with the upright silo and surface unloader, the man operating the self-unloading wagon must wai while the automatic surface unloader fills the wagon. It might be possible for this man to do other feeding jobs while waiting and no additional charge would be made for this extra labor.

In this study the assumption is made that the worker is idle whi the wagon is being filled. The cost of this additional labor is ther added to the cost of distributing feed with the self-unloading wagon. This shifts the average cost curve for the self-unloading wagon compl above the average cost curve for the mechanical feeder. The mechanic feeder is now the least-cost method for entire range of operations wh the upright silo is used.

In the next chapter the cost of feed processing, silage removal, feed distribution are combined. When the horizontal silo is used, th self-unloading wagon is used for feed distribution over the entire ra of operations. When the upright silo is used, the mechanical feeder used for feed distribution for all sizes of operation considered.

CHAPTER VI

SUMMARY AND CONCLUSIONS

In the last three chapters the costs of performing three feed processing and handling operations were analyzed and compared. The following summary briefly describes the results that were obtained. Following this summary, the costs of the three operations will be co in order to draw conclusions concerning the overall implications of feeding mechanization.

Summary

The primary purpose of this study was to obtain information on cost of alternative methods of processing and handling feed, and to mine the least-cost method for different sizes of feeding operations Average cost curve analysis was used to determine least-cost methods break-even points. Cost equations were used in estimating points or average cost curves. The effects of different length planning peric and labor costs were also demonstrated.

The feeding operation was divided into three operations: (1) g processing, (2) silage removal, and (3) feed distribution. Alterna methods for performing each of the three operations were specified the costs of the alternative methods were compared.

Three alternative grain processing methods were compared: (1) mill and mixer, (2) grinder-blender, and (3) custom processing. At levels of use the $3.00 custom rate proved to be the least-cost metho As the size of the operation was increased, the mill and mixer became least-cost method. At still higher levels of use the grinder-blender be justified.

Of the two methods considered for removing silage from horizonta silos, the front-end tractor loader proved to be the least-cost metho at low levels of use. The horizontal silo unloader became the least-cost method at higher levels of use. Hand unloading was the least-cc method of removing silage from upright silos at low levels of use. T surface silo unloader became the least-cost method at higher levels c

A comparison was made between the annual storage cost of horizon and upright silos. The horizontal silo had a constant annual storage cost per ton. The annual storage cost per ton for the upright silo decreased as the diameter of the silo increased.

The final operation was feed distribution. Three alternative me were considered: (1) wagon with hand unloading, (2) self-unloading wa and (3) mechanical auger tube feeder. The cost of using the wagon wi hand unloading was greater than the cost of either of the other two m for the entire range of operations considered. Since it is not technically feasible to use the mechanical feeder with the horizontal sil the self-unloading wagon was the only feed distribution method used w the horizontal silo. It is possible to use the self-unloading wagon the upright silo. However, when the extra labor involved was added, cost of using the self-unloading wagon was greater than the cost of u the mechanical feeder over the entire range of sizes considered.

Conclusions

In general, the initial investment for a high level of mechaniza is more than the initial investment for a lower level of mechanizatio When the change is made from the infinite planning horizon to the sho planning horizon, the cost of the method with the high initial invest will increase more than the cost of the method with the lower initial investment. This causes the break-even point between the two methods occur at a higher level of use for the short planning horizon.

To get an estimate of the total annual cost involved in the feed processing and handling portion of the beef cattle feeding industry, the costs of the three operations are combined. For a given size operation, the average costs for the least-cost method of grain proce silage removal, and feed distribution are added together. In order to get total cost of the feed processing and handling portion of beef cat feeding, the cost of processed feed storage and silage storage are included. The average total cost is computed on a per head basis (Tab V).

Average total cost curves for all feed processing and handling ar shown in Figure 14 for the infinite planning horizon and in Figure 15 the short planning horizon. When the infinite planning horizon is use and horizontal silo spoilage is assumed to be 7%, the combined cost of methods using the upright silo is less than the combined cost of metho using the horizontal silo for all size operations considered. However when a spoilage loss of 6% is used for the horizontal silo, the combin cost of methods using the horizontal silo becomes least-cost at approx mately 1200 head per year. This points out the tremendous effect of t

TABLE V

COST PER HEAD FOR FEED PROCESSING, STORAGE, AND HANDLING OPERATIONS

Type of Silo	Planning Horizon	Cattle Fed Per Year (no./Yr.)	Grain Processing[1]	Processed Feed Storage[2]	Silage Storage[3]	Silage Removal[4]	Feed Distribution[5]	TOTAL
			Cost Per Head (for a 140 day feeding period & 2 lots per year)					
			- Dollars -					
Horizontal	Infinite	100	2.10	.20	2.51	1.45	4.74	11.00
"	"	500	1.03	.04	2.51	1.02	1.46	6.06
"	"	1000	.72	.04	2.51	.78	.95	5.00
"	"	1500	.61	.04	2.51	.64	.88	4.68
"	"	2000	.56	.04	2.51	.57	.84	4.52
Horizontal	Short	100	2.10	.25	2.62	1.50	5.07	11.54
"	"	500	1.09	.05	2.62	1.06	1.67	6.49
"	"	1000	.74	.05	2.62	.83	1.14	5.38
"	"	1500	.61	.05	2.62	.68	1.05	5.01
"	"	2000	.57	.05	2.62	.59	.98	4.81
Upright	Infinite	100	2.10	.20	3.33	.93	2.03	8.59
"	"	500	1.03	.04	2.58	.76	1.07	5.48
"	"	1000	.72	.04	2.30	.56	1.00	4.62
"	"	1500	.61	.04	2.30	.67	.98	4.60
"	"	2000	.56	.04	2.30	.57	1.03	4.50
Upright	Short	100	2.10	.25	5.94	.93	2.29	11.51
"	"	500	1.09	.05	4.51	.82	1.17	7.64
"	"	1000	.74	.05	3.92	.59	1.10	6.40
"	"	1500	.61	.05	3.92	.70	1.10	6.38
"	"	2000	.57	.05	3.92	.59	1.16	6.29

(Footnotes on Following Page)

TABLE V (Continued - Footnotes)

[1]The cost of grain processing per ton was computed by using the values in Table I. Cost was then converted to a per head basis by multiplying cost per ton by .7 which is the number of tons of grain fed per steer during the 140 day feeding period.

[2]The cost of processed feed storage was calculated on an annual basis and then converted to a per head basis by dividing by the number of head fed per year.

[3]The silage storage cost per head was computed by multiplying the storage cost per ton in Table III by 2.8 which is the number of tons of silage fed per head during the 140 day feeding period.

[4]The cost of silage removal per ton was computed by using the values in Table II. Cost was then converted to a per head basis by multiplying the cost per ton by 2.8 which is the number of tons of silage fed per steer during the 140 day feeding period.

[5]The cost of feed distribution per ton was computed by using the values in Table IV. Cost was then converted to a per head basis by multiplying the cost per ton by 3.5 which is the tons of feed fed per steer during the 140 day feeding period.

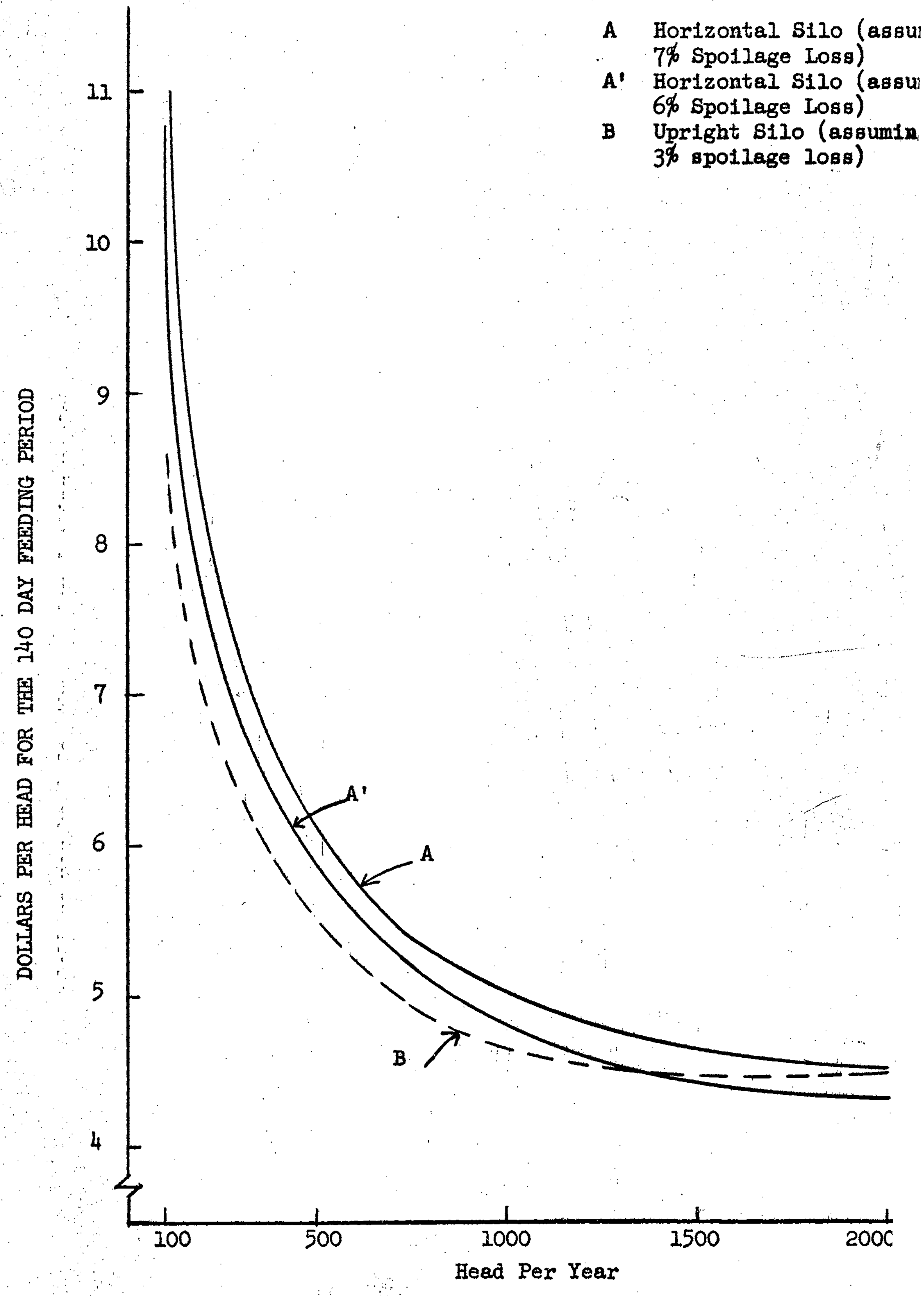

Figure 14. Combined Costs of Grain Processing, Processed Fee
Storage, Silage Removal, and Feed Distribution
(Infinite Planning Horizon with Labor at $1.00 Pe

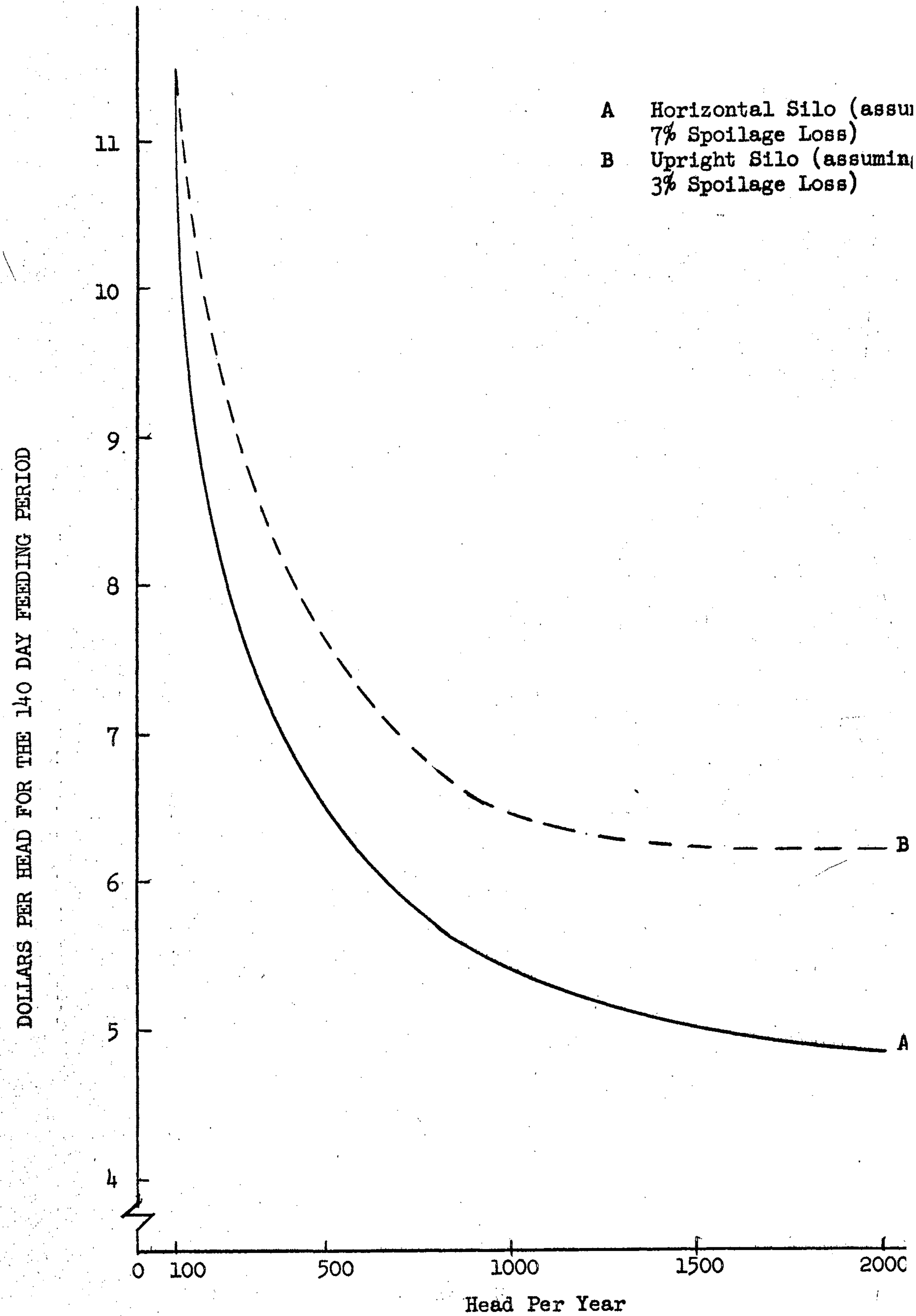

Figure 15. Combined Costs of Grain Processing, Processed Feed Storage, Silage Storage, Silage Removal, and Feed Distribution (Short Planning Horizon with Labor at Per Hour).

percentage assumed for spoilage loss. If a lower percentage of spoil
(e.g., 4%) was assumed for the horizontal silo, the methods using the horizontal silo would become least-cost for much smaller feeding oper

When the short planning horizon is used, the combined costs of m using the horizontal silo and methods using the upright silo are approximately equal when 100 head are fed per year. However, as the of head fed per year increases, the combined cost of methods using th horizontal silo becomes the least-cost of the two.

This analysis points out the importance of the length of the pla period in choosing between systems using horizontal silos and systems upright silos. In general the shorter planning periods favor the hor silo and the longer planning period favors the upright silo. The per age assigned to spoilage loss can also be a deciding factor.

Cost per head can be converted to cost per pound of gain if the average amount of gain per head per day is known. For example, if th tle gain an average of 2 pounds per head per day, the cost per pound gain would be approximately 4¢ when 100 head are fed per year, 2¢ wh 500 head are fed per year, and 1½¢ when 2000 head are fed per year. is important to note that the above cost does not include all non-fe cost. It includes only the labor and equipment cost for grain proce processed feed storage, silage storage, silage removal, and feed dis tion.

Additional research is needed to determine other non-feed costs as marketing, other feed lot equipment, veterinary expenses, cleanin repairing pens and cattle handling. Results from this study could b combined with estimates of other non-feed costs to get total non-fee Feed handling and processing costs for other feeding systems are als

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APPENDIX

APPENDIX TABLE I

COEFFICIENTS USED IN COMPUTING COSTS FOR GRAIN PROCESSING METHODS[1]

Component	Size	Use Range (Tons/Yr.)	Initial Invest-ment ($)	Perfor-mance Rate (Tons/Hr.)	Repair Cost Per Hour As % of New Cost (%)	Power Require-ment (Horsepower)	Labor Require-ment (Hrs./Ton)
Roller Mill	10" X 10"	70-840	715	2.6	.012	5 H.P.	
Vertical Mixer	1 Ton	70-840	825	2.6	.012	5 H.P.	
Augers	6" X 33'	70-840	322	15.0	.010	2½ H.P.	
Combination	--	--	1,862	--	--	12½ H.P.	.576
Roller Mill	10" X 18"	840-1400	1,282	3.6	.012	7½ H.P.	
Vertical Mixer	1½ Ton	840-1400	1,071	3.6	.012	7½ H.P.	
Augers	6" X 39'	840-1400	374	15.0	.010	2 3/4 H.P.	
Combination	--	--	2,727	--	--	17 3/4 H.P.	.417
Grinder-Blender	--	70-1400	807	3/4	.010	2 3/4 H.P.	
Elevator Leg	30 Ft.	70-1400	775	10.0	.005	1½ H.P.	
Storage Bins	20 Ton	70-1400	1,212	--	--	--	
Combination	--	--	2,794	--	--	4¼ H.P.	.150

[1]The coefficients came from various references listed in Selected Bibliography.

APPENDIX TABLE II

COEFFICIENTS USED IN COMPUTING COSTS FOR ALTERNATIVE SILAGE REMOVAL METHODS[1]

Component	Size	Use Range (Tons/Yr.)	Initial Investment[2] ($)	Performance Rate (Tons/Hr.)	Repair Cost Per Hour As % of New Cost (%)	Horsepower Requirement (Horsepower)	Labor Requirement (Hrs/Ton)
Front End Loader	41"	280-5600	477	8.85	.007	--	.113
Horizontal Silo Unloader	--	--	1789	--	.010	--	--
Used Tractor	3 Plow	--	1134	--	.020	--	--
Combination	--	280-5600	2923	22.5	--	--	.067
Surface Unloader	16'	280-750	1329	3.0	.010	5	.054
Surface Unloader	20'	750-1180	1549	4.5	.010	7½	.027
Surface Unloader	24'	1180-1700	1725	5.0	.010	7½	.023
Surface Unloader	30'	1700-3180	2164	6.0	.010	7½	.018

[1]The coefficients came from various references listed in the Selected Bibliography.

[2]The initial investment for the surface unloader includes the cost of electric motor and $75.00 for electrical wiring.

APPENDIX TABLE III

COEFFICIENTS USED IN COMPUTING COSTS FOR FEED DISTRIBUTION METHODS[1]

Component	Length[2] Of Bunk (Ft.)	Level Of Use (Tons/Yr.)	Initial[3] Invest-ment ($)	Perfor-mance Rate (Tons/Hr.)	Repair Cost Per Hour As % of New Cost (%)	Power[4] Require-ment (Horsepower)	Labor Require-ment (Hrs./Ton)
Wagon and Bunk	75	350	568.75	2.19	.005	--	.457
	150	700	812.50	2.79	.005	--	.358
	300	1400	1300.00	3.08	.005	--	.325
	900	4200	3250.00	3.47	.005	--	.288
	1500	7000	5200.00	3.47	.005	--	.288
Self-Unloading Wagon and Bunk	75	350	2303.75	5.0	.010	--	.200
	150	700	2547.50	10.0	.010	--	.100
	300	1400	3035.00	15.0	.010	--	.067
	600	2800	4010.00	20.0	.010	--	.050
	900	4200	4985.00	25.0	.010	--	.040
	1200	5600	5960.00	25.0	.010	--	.040
	1500	7000	6935.00	25.0	.010	--	.040
Mechanical Feeder	25	350	1096.25	4.5	.007	2	.080
	50	700	1502.50	4.5	.007	2	.040
	100	1400	2315.00	4.5	.007	3	.020
	200	2800	3940.00	4.5	.007	4	.010
	300	4200	6155.00	9.0	.007	6	.010
	400	5600	7780.00	9.0	.007	8	.010
	500	7000	10255.00	13.5	.007	13	.010

APPENDIX TABLE III (Continued - Footnotes)

[1]The coefficients came from various references listed in the Selected Bibliography.

[2]One and one-half feet of fence-line bunk per head for methods using wagon and unloading wagon. One-half foot of linear bunk space per head for mechanical feeder (since animals feed from both sides of bunk, this allows one foot per head).

[3]Initial investment for the first method includes cost of wagon and fence-line bunk, for the second method cost of self-unloading wagon and fence-line bunk and for third method cost of conveyor, drive unit, motor, electrical wiring, auger tube, and bunk.

[4]A medium size (three-plow tractor) is used to pull the wagon and self-unloading wagon.

APPENDIX TABLE IV

YEARS OF USEFULNESS, HOURS TO WEAR OUT, AND SALVAGE VALUES USED FOR EACH COMPONENT OF EQUIPMENT

Component	Years Until Obsolete	Hours To Wear Out[1] (Hrs.)	Salvage Value: Infinite Planning Horizon (%)	Salvage Value: Short Planning Horizon
Roller Mill	12	5000	5	30
Vertical Mixer	12	5000	5	30
Grinder-Blender	12	5000	5	30
Elevator leg	12	5000	5	30
Storage Bins	12	--	5	20
Front End Loader	10	6000	5	20
Used Tractor	10	5000	5	10
Horizontal Silo Unloader	10	5000	5	20
Surface Silo Unloader	10	6000	5	20
Trench Silo	10	--	0	0
Concrete Stave Silo	25	--	0	0
Wagon	15	6000	5	30
Unloading Wagon	10	6000	5	20
Mechanical Feeder	10	6000	5	20
Feed Bunk	15	--	0	0

[1]Hours to wear out came from various references listed in the Selected Bibliography.

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